Vitamin D Status of Females in an Elite Gymnastics Program

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Objective: Vitamin D plays an important role in calcium and bone metabolism. In Australia it has been assumed that all young athletes have good vitamin D levels. A survey of females in an elite gymnastics program was undertaken to determine their vitamin D and dietary calcium status.

Design: Cross-sectional survey.

Setting: Females in an elite gymnastics program at the Australian Institute of Sport.

Participants and Outcome Measures: Eighteen female gymnasts aged 10–17 years were assessed for vitamin D status (serum 25[OH]D) and dietary calcium intake.

Results: Fifteen were found to have levels below current recommended guidelines for optimal bone health (<75 nmol/L). Six had vitamin D levels below 50 nmol/L. Thirteen of the gymnasts also had daily dietary calcium intakes below the daily recommended intake for their age.

Conclusions: Gymnasts and possibly other indoor athletes should be carefully reviewed for vitamin D and calcium status.

Key Words: vitamin D, gymnastics, dietary calcium, elite athletes, females, adolescent athlete

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INTRODUCTION

Vitamin D has been recognized as having a role in calcium absorption, and lack of vitamin D may be associated with increased risk of cancer, cardiovascular disease, multiple sclerosis, rheumatoid arthritis, and Type 1 diabetes.[1] In athletes an improved understanding of the elements involved in bone physiology may assist in the prevention and rehabilitation of stress-related bone injuries. This is currently an area of increased interest and research.

Vitamin D is a fat-soluble vitamin that is predominantly produced in the body by exposure to sunlight. It is initially hydroxylated in the liver to 25-hydroxyvitamin D (25[OH]D) and then into the active component 1,25-dihydroxyvitamin D (1,25[OH]2D). Its main role is to maintain serum levels of calcium through intestinal calcium absorption.[2] Although severe deficiencies of vitamin D cause rickets or osteomalacia, recent evidence indicates that a mild deficiency (termed insufficiency) of vitamin D results in increased parathyroid hormone (PTH) levels, high bone turnover, and increased bone resorption.[3] This causes mainly cortical bone loss. Further, Lips has noted that there appears to be an inverse relationship between vitamin D and PTH levels, with serum PTH levels stabilizing when there is sufficient serum 25(OH)D at a serum level of >75nmol/L.[3] This is much higher than has been previously thought, resulting in recommendations to increase vitamin D levels by sun exposure and dietary means.[1,3]

Holick has suggested that vitamin D deficiency is an unrecognized epidemic in both children and adults in the United States.[1] In Australia, Pasco et al found in a population-based study of women older than 55 years of age that seasonal periodicity with reduced serum vitamin D in winter and increased PTH and bone resorption were associated with an increased proportion of falls resulting in fracture and an increased risk of hip and wrist fractures.[4] A recent meta-analysis concluded that vitamin D supplementation (700–800 IU) appeared to reduce the risk of hip and nonvertebral fractures in elderly persons.[5] Although high-impact loading (and particularly gymnastics) has been shown to improve bone mineral density,[6] a 3-year prospective study by Lehtonen-Veromaa et al found that independent of exercise, hypovitaminosis D may result in peripubertal girls not achieving maximum peak bone mass.[7] They noted the importance of an adequate vitamin D status during the phase of bone modeling and skeletal consolidation in the peripubertal years.

In a 10-year review of gymnastics injuries at this Institute, Dixon and Fricker found 6.7% of injuries to females were fractures or stress fractures.[8] Bone stress injuries in gymnasts, and in other athletes, result in significant time lost from sport and, anecdotally, often seem to occur with an increased workload in the lead-up to major competitions. After reviewing the many possible factors in a visiting gymnast with a recurrent stress fracture and finding a low vitamin D serum level, a survey was undertaken to assess the vitamin D status of all of the gymnasts in the Australian Institute of Sport (AIS) elite women's artistic gymnastics program. This was done in conjunction with a review of their dietary calcium intake.

METHODS

During early May 2007, all athletes in the AIS female artistic gymnastics program were screened for their vitamin D

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status. Vitamin D (25[OH]D) levels were determined by an outside laboratory using the DiaSorin vitamin D assay. If an athlete returned a vitamin D level <75nm/L, an intact PTH test was also done. Athletes' calcium levels were assessed by individual consultation and assessment with an AIS staff dietitian using a standard food frequency questionnaire. The AIS is situated in Canberra, Australia, at latitude 35.27 degrees S.

RESULTS

Eighteen female gymnasts were screened for their vitamin D and calcium status. The average age of the group was 13.6 years (range 10–17 years). No gymnast was taking a vitamin D or calcium supplement.

Vitamin D levels ranged from 29–84 nmol/L with a group mean of 56 nmol/L. One athlete had a level below 30 nmol/L, 5 were between 30 and 50 nmol/L, and 9 were between 50 and 75 nmol/L. Only 3 athletes had levels of 75 nmol/L or greater.

PTH levels were determined in the 15 athletes that had vitamin D levels below 75 nmol/L. Only 1 athlete had a raised PTH level, which was 11.0 pmol/L (normal laboratory reference range 1.5–7.6). This athlete had a vitamin D level of 49 nmol/L. One athlete had a low PTH level at 1.2 pmol/L; all others were in the normal reference range.

Daily dietary calcium intakes were found to be from 240 mg up to 1740 mg. Although the average for the group was 823 mg, 13 were noted to have dietary intakes below the daily recommended intake of 1000 mg for 9–11 years of age and 1300 mg for 12–18 years of age.[9]

The case notes of all gymnasts were reviewed for injuries over the previous 12 months and 13 gymnasts were found to have suffered from a bony stress injury diagnosed by clinical examination with radiologic investigation [plain x-ray, bone scan, and/or magnetic resonance imaging (MRI)]. Stress reactions were diagnosed in 12 gymnasts, and a stress fracture was diagnosed in 1 gymnast.

DISCUSSION

The current study was undertaken to determine if an Australian group of indoor athletes had normal levels of vitamin D. This survey found that this particular group of athletes had low vitamin D levels just 2 months after the end of the Australian summer season. Gymnasts at the AIS get minimal sun exposure. They train indoors in the morning and afternoon, and school programs occur between these sessions. It is interesting that most gymnasts reported that their schools now insist students wear hats and cover their arms and legs during lunch break to reduce sun exposure and thereby reduce the risk of developing skin cancer. Other studies have also found low vitamin D levels in children and adolescents in Europe, North America, and Asia, particularly during the winter season.[10–13]

Bone has a highly dynamic mechanical and metabolic function and constantly adjusts to the load and physiologic demands of the body while providing support for the bone and soft tissue structures that are essential for mobility. Many factors have been investigated in bone stress injuries; they are generally divided into intrinsic, extrinsic, biomechanical, hormonal, and nutritional risk factors. Hormones such as estrogen and PTH influence the rate of remodeling primarily by their effects on osteoclast and osteoblast apoptosis.[14] Nutritional factors such as calcium and vitamin D are important for bone metabolism and can improve bone mineral density,[15] whereas recent work indicates a potential role for vitamin D receptor gene polymorphism in determining adaptation to loading. Management of an athlete with a bony stress injury therefore would require review of many possible contributing risk factors.

In a study of 2591 Israeli soldiers Givon et al found several parameters can distinguish soldiers with high-grade stress fractures.[16] One of these was lower levels of vitamin D. In a prospective study evaluating stress fractures in male Finnish army recruits, high serum PTH levels were found to be a risk factor.[17] The same authors reported elsewhere on the high prevalence of vitamin D deficiency and hypovitaminosis D during winter in this same group.[18] They felt that secondary hyperparathyroidism resulting from vitamin D deficiency may have contributed to stress fractures in their study. Guillemant et al found that a wintertime vitamin D deficiency and increase in PTH in a group of adolescent males could be prevented with vitamin D supplementation.[19] They suggested that high levels of PTH could result in increased bone remodeling, increased bone fragility, and a future increased risk of fracture.

Although our main concern has been bone stress injuries, there is clear evidence that peripubertal girls with low vitamin D levels may not achieve their optimum bone mass.[7] In particular, Jones and Dwyer reported a significant association between physical activity and sunlight exposure with bone mass in prepubertal children in Australia.[20]

Following this study all gymnasts with low vitamin D levels (<75 nm/L) are now being supplemented with oral vitamin D_3 (1000 IU per day; Bischoff-Ferrari et al have recommended at least 700–800 IU)[5] and oral calcium if they were below recommended daily intakes. The number of bone stress–related injuries found was high, but this was predominantly bone stress reaction injuries diagnosed with MRI. This will be reviewed and monitored over the next 12 months.

Previously, particularly in Australia, vitamin D deficiency was only considered in the elderly population or in patients with chronic disease states. The results of this survey suggest that vitamin D and dietary calcium status should be considered, both in terms of bone metabolism (achievement of peak bone mass and the possible relation to bone stress injuries) and general health issues, in gymnasts and in other athletes who may be getting minimal sun exposure.

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