

The prevalence of vitamin D deficiency and its relationship of bone health and glucose metabolism in Korean children and adolescents

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There has been great interest in the role of vitamin D on multiple health outcomes. Vitamin D has been traditionally known as essential for skeletal health, but there has been increasing evidence linking vitamin D deficiency with nonskeletal health outcomes, such as metabolic syndrome and cardiovascular disease.

In 2011, The Endocrine Society published "evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline". The Society recommended screening for vitamin D deficiency in individuals at risk for deficiency and did not recommend population screening for vitamin D deficiency in individuals who were not at risk. They recommended using the serum circulating 25-hydroxycholecalciferol [25(OH)D] level, measured by a reliable assay, to evaluate vitamin D status in patients who were at risk for vitamin D deficiency. They defined the level of 25(OH)D below 20 ng/ml as vitamin D deficiency and a level of 25(OH)D of 21-29 ng/ml as insufficiency. The Society suggested that daily reference intakes (DRIs) for infants and children aged 0-1 yr were at least 400 IU/d of vitamin D and for children 1 yr and older were at least 600 IU/d to maximize bone healthy. They also suggested that whether 400 and 600 IU/d for children aged 0-1 yr and 1-18 yr, respectively, were enough to provide all the potential nonskeletal health benefits associated with vitamin D to maximize bone health and muscle function was not known. However, they recommended at least 1000 IU/d of vitamin D to raise the blood level of 25(OH)D consistently above 30 ng/ml.

However, the DRI for vitamin D for Korean children was reduced from 400 IU/day in 2005 to 200 IU/day in 2010 by the Korean Nutrition Society, based on little evidence about the role of vitamin D on health outcomes in Korean children and adolescents and the assumption that exposure to sunlight guarantees adequate vitamin D status in childhood and adolescence.

Despite growing evidence that hypovitaminosis D is prevalent among healthy children worldwide, little is known about the prevalence of vitamin D deficiency in Korean children and adolescents. In addition, there has been a paucity of data on the importance of vitamin D status for health outcomes as well as on the predictors for vitamin D deficiency in Korean children and adolescents. Thus, we analyzed the prevalence and predictors of vitamin D deficiency and its relationship with bone and glucose metabolism.

Based on the Korea National Health and Nutrition Examination Survey (KNHNES) 2008–2009, the prevalence of vitamin D deficiency was 89.4% in spring, 57.8% in summer, 64.4% in fall and 92.2% in winter among 1,510 healthy adolescents (mean age 14.7 ± 1.9 years, 806 males). Wintertime, older age, female, obesity, a lack of vitamin D supplementation and lower milk intake (<200 ml/day) were unadjusted predictors (all $P < 0.05$) for vitamin D deficiency.

We also evaluated the risk factors for low 25(OH)D status and its relationship with bone health in prepubertal and early pubertal nonobese children living in Seoul or Gyeonggi

Province. One hundred nonobese children (mean age 9.3 years, 71 prepubertal, 45 boys) participated in the winter ($n = 38$) and summer. Twenty-nine percent of children (47.4% in winter, 17.7% in summer) were vitamin D deficient [25(OH)D level of <20 ng/mL]. In winter, low vitamin D intake ($P = 0.019$) and fewer sunlight exposure ($P = 0.015$) were associated with low 25(OH)D levels. Simultaneously, Body composition and bone mineral density were measured by dual-energy X-ray absorptiometry (DXA). The 25(OH)D levels were positively correlated with bone mineral content (BMC), total body bone mineral density (BMD), and lumbar spine BMD (all $P < 0.05$), independently of sex, puberty, fat mass, lean mass, physical activity, and calcium intake. Fat mass was independently correlated with BMC, lumbar spine BMD ($P < 0.001$ for both), and total body BMD ($P = 0.037$). Adequate vitamin D status and adiposity contributed to good bone health in nonobese children.

We also examined the association between vitamin D status and the markers of insulin resistance (IR) and the prevalence of impaired fasting glucose (IFB) in Korean adolescents aged 10-19 years. Serum 25(OH)D levels were temporarily stratified into the three categories; lowest (<15 ng.mL), 15 to <20 , and ≥ 20 ng/ml (highest group). Insulin resistance was estimated by homeostatic model assessment for IR (HOMA-IR) and quantitative insulin sensitivity check index (QUICKI). Z-scores for total body fat (g), % body fat, and body fat mass index measured by DXA were used to adjust adiposity in multivariate analysis. After adjusting the age, sex, physical activity, and adiposity, the risk of IFB and IR indices were inversely related to the levels of 25(OH)D.

These Korean results suggest that vitamin D deficiency was highly prevalent in Korean adolescents. Almost half of peripubertal nonobese children were vitamin D deficient in winter. In winter season, older age, lower milk and vitamin D intake, and fewer sunlight exposure were risk factors for vitamin D deficiency. At the same time, Vitamin D deficiency is associated with low bone density and a disorder of glucose metabolism in Korean children and adolescents, which could complicate into the metabolic syndrome.

Considering the high prevalence of vitamin D deficiency and its detrimental roles in bone health and glucose metabolism, current dietary recommendations regarding vitamin D for Korean children and adolescents need to be reevaluated.