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Mini-Review

Vitamin D deficiency in children and adolescents; an international challenge

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Abstract

Low vitamin D level is an important international public health problem. Vitamin D deficiency and its consequences among children and adolescents could indeed be considered as one of the most important public health problems. In fact, low vitamin D levels were reported in both children and adolescents. Several reasons could be taken into account in this regard such as the possibility of the reduced intake or synthesis of vitamin D (due to having a vitamin D deficient mother or a dark skin color), abnormal intestinal function or malabsorption (in small-bowel disorders), or reduced synthesis or increased degradation of vitamin D (in chronic liver or renal disease). More importantly, many countries in developing world, are experiencing a substantial percentage of adolescent and youth population with their own health related problems which vitamin D deficiency could affect on their health. The association between obesity and overweighting and vitamin D deficiency has been reported by many researchers. Diabetes mellitus has also an association with vitamin D deficiency, for both type 1 and type 2 diabetes. Due to the importance of vitamin D deficiency and its negative health consequences, taking the vitamin D supplement seems to be necessary.

Keywords: Vitamin D, Hypovitaminosis D, Children, Adolescents

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Vitamin D deficiency in the world

Low vitamin D level is an important international public health problem (1-3). Vitamin D deficiency and its consequences among children and adolescents could indeed be considered as one of the most important problems. In fact, low vitamin D levels were reported in both children (4), especially obese children (5), and adolescents. For example, in a study, 9.9% of Korean adolescents had vitamin D deficiency (6). This deficiency was also common in Kuwait (7), Italy (2,8), Norway (9), Oslo (10), India (3), Japan (11) and the Netherlands (12). In addition, Palacios *et al.*, in a systematic review on world situation of vitamin D deficiency, from April to June 2013, found out that vitamin D deficiency could be considered as an international public health problem, especially in the Middle East area (1). More importantly, many countries in developing world, are experiencing a substantial percentage of adolescent and youth population with their own health related problems which could affect on their health (13).

Several reasons could be taken into account in this regard such as the possibility of the reduced intake or synthesis of vitamin D (due to having a vitamin D deficient mother or a dark skin color), abnormal intestinal function, malabsorption, reduced synthesis or increased degradation of vitamin D (in chronic liver or renal disease) (14). Valtueña *et al.* investigated vitamin D deficiency among European adolescents and reported that many factors could affect on vitamin D deficiency such as season, latitude, fitness, adiposity, sleep time and vitamin D supplement intake (15). Additionally, Oberg *et al.* studied on different factors related with vitamin D deficiency in Norwegian Adolescents (9). They found out a significant sex difference, the snuff usage, vitamin D fortified milk intake, using the cod liver oil and vitamin/mineral supplements, physical inactivity, taking a sunbathing holiday and usage of solarium in both school boys and girls. They also detected an inverse correlation between parathyroid hormone levels with vitamin D deficiency among adolescents. Moreover, in Italian healthy adolescents, the prevalence of vitamin D deficiency was about half of participants in the study of

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Implication for health policy/practice/research/ medical education

Vitamin D deficiency can play a role as a substantial international health related problem. The consequences of Vitamin D deficiency should be considered as an important priority.

Vierucci and colleagues (8). They showed an increased risk of hypovitaminosis D in winter-spring, overweight-obese, low sun exposure compared to summer-fall period, normal weight and moderate-good sun exposure, respectively. Even in countries with a lot of sunlight, vitamin D deficiency was prevalent in the study of Balasubramanian *et al.* (3). They suggested that the routine vitamin D supplement intake should start from neonatal period. In another study, the prevalence of vitamin D deficiency was higher among children and adolescents with kidney diseases (16).

Race has also been considered as an important factor related to vitamin D deficiency. For example, in comparison of children of US and Northern Territory, Dyson *et al.* reported the prevalence of vitamin D deficiency equal to 19% and 3.1%, respectively (17). Furthermore, in a study in Oslo conducted by Aggemoen *et al.*, the prevalence of vitamin D deficiency prevalence among new Asian and African immigrants was estimated (10). They found out that the prevalence depended on the origin country of immigrants; i.e., Middle East (81%), South Sahara Africa (73%), South Asia (75%) and East Asia (24%).

Vitamin D deficiency in obesity

The association between obesity and overweighting and vitamin D deficiency has been reported by many researchers. For instance, in the study of Radhakishun *et al.*, in the Netherlands, vitamin D deficiency was prevalent in treatment-seeking obese ethnic children (12). Likewise, Feng and colleagues studied on the relationship obesity and inflammatory cytokines with vitamin D deficiency in children and found out a negative correlation with body mass index (18). Van Grouw *et al.*, in an overview on childhood obesity reported that vitamin D supplementation may improve the metabolic risk factors among obese children considering higher doses for obese children to treat vitamin D deficiency (19). In addition, Au *et al.* reported that about 75% of overweight/ obese children were at risk of vitamin D deficiency (20). Gutiérrez-Medina *et al.* reported that vitamin D deficiency was common among obese children compared to normal weight children (21).

Vitamin D deficiency in diabetes mellitus

Diabetes mellitus has also an association with vitamin D deficiency, for both type 1 and type 2 diabetes. The association of vitamin D deficiency and type 1 diabetes mellitus with regards to frequency and severity of disease has been observed in the study of Azab *et al.* (22). Moreover, Liebeman *et al.* reported that vitamin D deficiency, in contrast with other studies, was similar among adolescents with and without type 1 diabetes mellitus (23). In a study on Korean girls, Jang *et al.* also found a relationship between vitamin D deficiency and increasing blood sugar and resistance to insulin (24). However, Poon *et al.* found out no correlation between vitamin D deficiency and diabetic retinopathy in young people with type 1 diabetes (25). In addition, the association between vitamin D deficiency and type 1 diabetes was approved focusing on the potential increasing of insulin resistance risk (26). Additionally, Gutiérrez-Medina *et al.* reported that vitamin D deficiency may play a role to develop resistance to insulin and type 2 diabetes mellitus among obese children (21).

Vitamin D deficiency in other diseases

Vitamin D deficiency has relationships with various other diseases. For example, Modan-Moses *et al.* reported that eating disorders may result in the higher prevalence of vitamin D deficiency among adolescents (27). Alyahya *et al.* also found a high prevalence of vitamin D deficiency among Kuwaiti adolescent girls which could affect on the mineralization of their bones (7). Non-alcoholic fatty liver disease (NAFLD) is also one important problem among adolescents, in the study of Black and colleagues, which was related with vitamin D deficiency; i.e., about 17% of the patients had both diseases (28). In another study, to assess the relation between vitamin D deficiency and attention deficit hyperactivity disorder (ADHD), Kamal *et al.*, conducted a case-control study and found out that among patients with ADHD, vitamin D deficiency was significantly higher (29). Furthermore, Baek and colleagues reported a positive and significant association between vitamin D deficiency and epilepsy and mental retardation (30). Ceroni *et al.* reported a significant association between fractures and vitamin D deficiency in children and adolescents in Swiss too (31).

Corticosteroids may also increase the risk of decreasing bone mineral density, which could be worsened by vitamin D deficiency; for instance, Esbenshade *et al.* found a vitamin D deficiency prevalence of 15.8% among cancer survivors (32). Helou *et al.* confirmed the relation between vitamin D deficiency and cancer among children (33). Chokephaibulkit *et al.* assessed the prevalence of vitamin D deficiency among HIV-infected Thai adolescents receiving antiretroviral therapy (34). They reported that adolescents with vitamin D deficiency had significantly higher parathyroid hormone levels. In addition, no associations were found between vitamin D deficiency and body mass index, bone mineral density, HIV RNA,

CD4 and self-reported sunlight exposure. Atkinson *et al.* examined the relationship between anemia and vitamin D deficiency among children and identified an association with increased risk of anemia in healthy US children with vitamin D deficiency, but not the same among different races (35).

Vitamin D deficiency may have some effects on the lung function and its ability to cope with infection, especially in cystic fibrosis (CF) patients which were approved by the study of McCauley and colleagues (36). Simmons *et al.* studied on the relationship between vitamin D deficiency and allogeneic hematopoietic transplant and increasing risk of low bone mineral density and suggested that these patients have to intake vitamin D supplements (37). Hossein-nezhad *et al.*, in their review, found out that vitamin D deficiency could affect on musculoskeletal, acute and chronic diseases among children, even in fetal period, and may be involved in some cancers, autoimmune, infectious and neurocognitive diseases, type 2 diabetes and mortality (38).

Vitamin D deficiency has association with children and adolescents who treated with antiepileptic medications due to its effects on bone metabolism and bone mineral density as well as higher fracture risk (30,39). Middleton *et al.* reported that low bone mineral density and vitamin D deficiency were associated with inflammatory bowel disease considering the difference among races (40). To find out the prevalence of vitamin D deficiency and its potential risk factors among children with osteogenesis imperfecta, Wilsford *et al.*, conducted a research and reported that education programs for patients are necessary (41). Heimbeck *et al.* investigated the association between vitamin D deficiency and atopic conditions and found an inverse relationship between vitamin D levels and eczema in German children and adolescents (42). Likewise, Reyman *et al.*, assessed the association between vitamin D deficiency and immunomodulatory functions among children 6-16 years and reported a relationship with enhanced systemic inflammation and reduced insulin sensitivity (43).

Significance of vitamin D supplementation

Due to the importance of vitamin D deficiency, taking the vitamin D supplement seems to be necessary. Vitamin D deficiency and its risk factors among Italian children and adolescents were assessed by Vierucci *et al.* (2). They found that the children and adolescents who were not receiving vitamin D supplementation had higher prevalence of vitamin D deficiency. Suzuki *et al.*, in a study on Japanese girl college students, also reported a high prevalence of vitamin D deficiency which could be decreased by taking vitamin D fortified milk (11). In addition, due to importance of vitamin D in bone and mineral metabolism in children and adolescents and potential effect of vitamin D level of mothers during pregnancy, the need for taking vitamin D supplements, especially for whom spent more time in outdoor activity, has been focused in the study of Shin and colleagues (44). Moreover, Wallace *et al.* have focused on the enough intake of vitamin D in all stages of life (45). They suggested that using vitamin D supplements should be focused on high risk groups such as low socioeconomic groups, overweight or obese people, especially children and adolescents. France has developed a routine vitamin D enrich program in French infants since 1992 which resulted in low prevalence of vitamin D deficiency among French infants (46). Vitamin D deficiency has also been reported in a country like India with a lot of sunlight in the study of Balasubramanian *et al* (3). They suggested that the routine vitamin D supplement intake should start from neonatal period.

Conclusion

Low vitamin D level is an important international public health problem. Vitamin D deficiency and its consequences among children and adolescents could indeed be considered as one of the most important health related problems. Due to the importance of vitamin D deficiency, taking the vitamin D supplement seems to be necessary.

Authors' contributions

All authors contributed to the paper equally.

Conflict of interests

The authors declare that they have no conflict of interests.

Ethical considerations

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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