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ORIGINAL PAPER

Vitamin D levels in children of asylum seekers in The Netherlands in relation to season and dietary intake

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Abstract Low dietary intake and limited sun exposure during Dutch winters, in particular when combined with highly pigmented skin, could compromise the vitamin D status of asylum seekers' children in The Netherlands. We determined the vitamin D status of children living in The Netherlands, but originating from Africa, Central Asia, or Eastern Europe. In a subgroup, we reassessed the vitamin D status after the summer, during which the children had been assigned at random to remain unsupplemented or to receive vitamin D supplementation. In total 112 children (median age 7.1 yr, range 2–12 yr) were assessed for serum concentrations of 25-Hydroxyvitamin D [25(OH)D], intact parathyroid hormone (I-PTH) and plasma alkaline phosphatase (ALP). Vitamin D deficiency (VDD) and hypovitaminosis D were defined as 25(OH)D below 30 or 50 nmol/L, respectively. Dietary intake of vitamin D and calcium was estimated using a 24 h recall interview. In mid-spring, 13% of the children had VDD, and 42% had hypovitaminosis D. I-PTH and ALP levels were significantly higher in children with VDD. The dietary intake of vitamin D was below 80% of the recommended daily allowances (RDA) in 94% of the children, but the dietary calcium intake was not significantly related to the s-25(OH)D levels found. After the summer, median s-25(OH)D increased with +35 nmol/L (+85%) and +19 nmol/L (+42%) in children with or without supplementation, respectively. The effect of supplementation was most prominent among African children. VDD and hypovitaminosis D are highly prevalent in mid-spring among asylum seekers' children in The Netherlands. Although 25(OH)D levels increase in African children during Dutch summer months, this does not completely correct the compromised vitamin D status. Our data indicate that children from African origin would benefit from vitamin D supplementation.

Keywords Asylum seekers' children · 25-Hydroxyvitamin D deficiency · Hypovitaminosis D · Hyperparathyroidism · Dietary intake

Abbreviations

25(OH)D	(serum) 25-Hydroxyvitamin D
VDD	Vitamin D deficiency
ALP	(plasma) alkaline phosphatase
I-PTH	(serum) intact parathyroid hormone
RDA	recommended daily allowance

Introduction

Vitamin D is important for calcium homeostasis in the body. VDD and hypovitaminosis D, with secondary hyperparathyroidism, decrease bone mineralization and have been associ-

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ated with increased susceptibility for infections, dental caries, and autoimmune disorders [23, 25, 42]. Severe and prolonged vitamin D deficiency can lead to rickets. The prevalence of rickets, biochemical VDD and hypovitaminosis D is associated with lack of supplement use, increased skin pigmentation and limited sun exposure [14, 17, 19]. Urbanisation, migration and changing dietary habits contribute to an increased incidence of rickets over recent decades [1, 2, 30, 33, 37]. Recently several cases of rickets among migrant children were reported in The Netherlands [39]. Vitamin D can be obtained from the diet, from supplements and via synthesis in the skin under the influence of the ultraviolet radiation. Synthesis of vitamin D is very limited between September and April in the north of The Netherlands (53–53° 30′ N.Lat.) [41]. The capacity of the skin to synthesize vitamin D is reduced by pigmentation [8]. Reduced synthesis of vitamin D increases the dependence on adequate dietary or supplemental intake of vitamin D.

The vitamin D status of asylum seekers' children in The Netherlands has not been systematically analyzed, despite their theoretically increased susceptibility for VDD and hypovitaminosis D because of frequent occurence of dark pigmented skin, unfamiliarity with supplement use and relatively poor vitamin D diets. We studied the prevalence of VDD and hypovitaminosis D, the seasonal variation of 25(OH)D and the influence of supplementation during the summer in asylum seekers' children in The Netherlands.

Methods

The prevalence of VDD and hypovitaminosis D were estimated in a cross-sectional study among 2–12 year old children living in asylum seekers' centres in the north of The Netherlands. The study was approved by the Ethical Committee of the Medical Centre Leeuwarden. The children with their parents were invited to participate in the study by an information letter translated into their native languages. During the first visit, the procedure was explained with the use of an independent language interpreter and formal permission was obtained from the caregiver of each child to participate in the study. Non-fasting venous blood samples were collected at the laboratory ward of the hospital facility. The dietary assessment was based on a 24 h recall with language interpreters to minimise misunderstanding. In addition, pictures developed for dietary assessment of other migration populations and standardised samples were used to estimate the size of the portions eaten. From the dietary histories, food quantities were estimated using BECEL, a nutritional software package developed by the Unilever B.V., Vlaardingen, The Netherlands. The data were compared to the Dutch list of recommended daily allowance (RDA) for gender and age [16]. If the intake of vitamin D was below 80% of the RDA, it was graded as "marginal" [5].

The study subjects (n=135) were healthy children who were at least one year in The Netherlands. With regards to age, gender and region of origin, the studied children constituted a representative sample of the more than 12,000 children aged 2–12 years, remaining in Dutch asylum centres for at least one year. 123 children (91%) allowed blood withdrawal and a dietary history was taken of 116 children (86%). Results of 11 children were analyzed separately because they had used vitamin D supplements prior to the investigations. Children whose laboratory investigations were performed before June were requested to allow control blood sampling after three months, to estimate the effect of sun exposure during the summer on vitamin D status. For comparative analyses the geographical origin of the children was categorized into three regions: Africa, n=39; Central Asia, n=33; and, Eastern Europe, n=40; respectively. The length of stay in The Netherlands of children from Eastern Europe was longer than that of the African children (p<0.05).

All children were advised to expose their skin to the sun for at least 30 minutes daily and half of the children were randomly assigned to receive a supplement of 400 IU vitamin D daily for three months. Three months thereafter 56 children allowed blood withdrawal. Of these 56 children 26 confirmed the use of 400 IU vitamin D during the 3 months.

Vitamin D deficiency (VDD) and hypovitaminosis D were defined as 25(OH)D below 30 or 50 nmol/L, respectively. Levels of 25 (OH)D in serum (radio-immunoassay, DiaSorin; normal range 30–100 nmol/L), of intact PTH in serum (I-PTH, sandwich ECLIA Roche; normal range 1–7 pmol/L) and of alkaline phosphatase (ALP) in heparin-plasma (IFCC Roche; normal range<325 IU/L) were measured at the Department of Clinical Chemistry of the Medical Center Leeuwarden. Data were analysed using the SPSS statistical software package (SPSS 11.5 2003). The χ^2 test was used for the relations between origin, gender, age, or length of stay and the prevalence of vitamin D deficiency and hypovitaminosis D and between marginal vitamin D intake and hypovitaminosis D. The Mann-Whitney test was used to test for differences in levels of blood indices between different groups according to origin, age, gender, and length of stay in The Netherlands. Seasonal changes in concentrations of 25(OH)D, I-PTH and ALP between supplemented and non-supplemented children were evaluated by Mann-Whitney test. A p-value of 0.05 was taken as threshold for statistical significance.

Results

To estimate the prevalence of clinical VDD all children were examined for corresponding clinical signs. None of the children showed classical symptoms of VDD such as bowed legs, swelling of wrists, rickets rosary or muscle weakness. The children had at least 30 minutes of outside activities per day, based on specific questioning, and did not wear a veil or other forms of sun protection. Six percent of the parents reported that their child frequently complained about joint pains. However, the vitamin D levels of these children were similar to those of children without these complaints (mean values: 48±16 vs. 49±9 nmol/L, respectively).

Table 1 shows the prevalence of VDD, hypovitaminosis D and levels of I-PTH and ALP above the upper limit of the reference values in mid spring, according to origin, gender, age group, and length of stay of the children in The Netherlands. African children had a higher prevalence of VDD, secondary hyperparathyroidism and increased levels of ALP. Hypovitaminosis D was found more frequently in girls than in boys ($p<0.05$). Secondary hyperparathyroidism was mainly found among children above 6 years of age. Children with VDD had higher I-PTH and ALP levels compared to children with 25(OH)D levels above 30 nmol/L (each $p<0.01$). Seventy five percent of the children with elevated serum levels of I-PTH and ALP had serum vitamin D level below 50 nmol/L.

The values of 25(OH)D and ALP in mid spring were significantly higher in children from Eastern Europe than in children from Central Asia ($p<0.05$) and Africa ($p<0.01$), respectively.

Figure 1 shows the 25(OH)D levels of the children relative to age and origin. 25(OH)D levels in African children above 6 years (mean 35±13 nmol/L) were profoundly lower than in those below 6 years (mean 51±15 nmol/L, $p<0.01$) or in children above 6 years of Eastern Europe (mean 52±16 nmol/L, $p<0.01$). The mean I-PTH values of the children above 6 years of age were 7.3±3.0 pmol/L for the African children and 5.5±2.1 pmol/L for the children from Eastern Europe ($p<0.05$).

25(OH)D levels before and after the summer with or without supplementation, were obtained from 57 children. At the end of the summer, none of these children had biochemical VDD, but three non-supplemented children had hypovitaminosis D. The increase of 25(OH)D between spring and autumn was +19 nmol/L (42%) in children without supplementation (n=31) and +35 nmol/L (85%) (p=0.01) in children with supplementation (n=26). Figure 2 shows the increase of 25(OH)D levels during the summer in relation to origin and supplementation. The increase of 25(OH)D among supplement users did not significantly differ with origin (increase of children from Eastern Europe +30 nmol/l, Central Asia +34 nmol/L and Africa +40 nmol/L, respectively). The increase of 25(OH)D levels of the non-supplemented African children was significantly less (+16 nmol/L, +23%) than in the supplemented African children (+40 nmol/L, +103%, $p<0.05$).

In addition to supplement use and seasonal variation, 25 (OH)D levels are influenced by dietary intake of vitamin D.

Table 1 Prevalence of VDD, hypovitaminosis D and elevated I-PTH and ALP in mid spring

	Total (n)	VDD	hypovitaminosis D	I-PTH>7.0 pmol/L	ALP>325 U/L
Origin					
Eastern Europe	40	2*	13*	7	2**
Central Asia	33	3	18*	4*	5**
Africa	39	9*	16	14*	14*
Gender					
Female	47	7	24*	14	5
Male	65	7	23*	11	16
Age					
2–6 yr	48	3	19	5**	8
7–12 yr	64	11	28	20**	13
Length of stay					
1–3 yr	60	12*	21	11	14
>3 yr	52	2*	26	14	7
Total	112	14 (13%)	47 (42%)	25 (22%)	21 (19%)

Excluded 1 unexplained very high Alkaline Phosphatase
VDD: 25(OH) D≤30.0 nmol/L (12 ng/ml)
Hypovitaminosis D: 30.0 nmol/L(12 ng/ml)<25(OH) D<50.0 nmol/L(20 ng/ml)
Statistical analyses to origin, gender, age, and length of stay were all based on χ^2 test
*=$p<0.05$
**=$p<0.01$
African origin in detail: children from Angola n=16, Somalia n=16, Sudan n=7
Central Asian origin in detail: children from Afghanistan n=15, Iraq n=8, Iran n=6, and others n=4
Eastern European in detail: children from Azerbaijan n=12, Yugoslavia n=14, Russia n=12 and others n=2

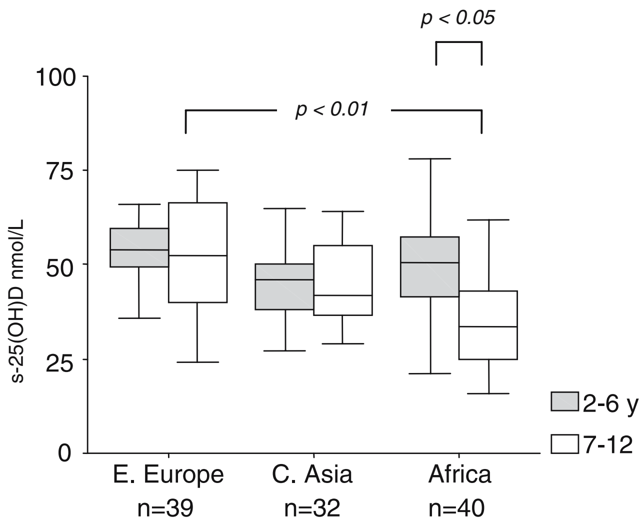

Fig. 1 Serum 25-hydroxy-vitamin D [s-25 (OH)D] concentrations in asylum seekers' children in The Netherlands according to their geographic origin and age (2–6 years, 7–12 years) during mid spring. Box plot represents first and third quartile s-25(OH)D plus 3rd and 97th centiles. Statistical analyses were based on Mann-Whitney testing

The RDA of vitamin D for children in the Netherlands is 5.0 μg in children below 4 years of age and 2.5 μg in the older children [16]. The dietary intake of vitamin D was marginal (80% of the RDA) in 94% of the children studied. The estimated vitamin D intake ranged from 0.1 μg to 6.0 μg (median 1.2 μg). Only one African child had an adequate dietary vitamin D intake, and this child had 25 (OH)D levels above 50 nmol/L. Fifty nine percent of the

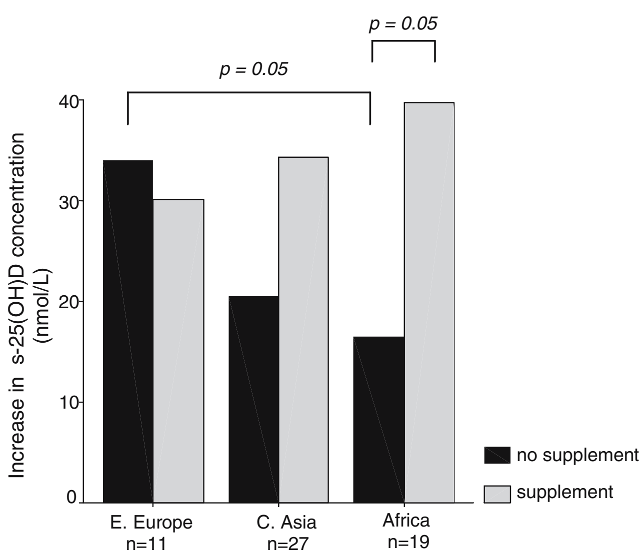

Fig. 2 The effects of vitamin D supplementation on the increase of serum 25-hydroxy-vitamin D [s-25 (OH)D] concentrations during the summer season in asylum seekers' children in the Netherlands according to their geographic origin. Vitamin D was supplemented daily for three months (dosage 400 IU per day). Statistical analyses were based on Mann-Whitney testing

children with a marginal vitamin D intake had hypovitaminosis D. The prevalence of hypovitaminosis D in children with marginal dietary vitamin D intake was significantly less in children from Eastern Europe (n=12) than in those from Asia (n=19) or Africa (n=24) (p<0.05). The dietary intake of calcium was normally distributed with a mean intake of 683±309 mg, and no significant differences to age group or region of origin were found (data not shown). Children with a dietary calcium intake below 500 mg did not have lower 25(OH)D levels than children with a higher calcium intake (mean 25(OH)D 46±13 nmol/L vs. 47±15 nmol/L, respectively). More details on the dietary intake of asylum seekers' children are described elsewhere [36].

Discussion

In the presented study we report a high prevalence of VDD and hypovitaminosis D among asylum seekers' children in The Netherlands in mid spring. The compromised vitamin D status could be attributed to a marginal dietary vitamin D intake, to geographic origin of the children (most likely related to skin pigmentation), to seasonal variation and finally to lack of supplement use.

Compromised vitamin D status among dark skinned migrants and a seasonal variation of 25(OH)D levels in autochthonous children have been reported in several northern European countries with higher latitude than The Netherlands [6, 10, 29]. The high prevalences are mainly explained by insufficient sun exposure in winter, total skin cover (veiled), indoor living and low dietary intake of vitamin D. Vitamin D status in Moroccan and Turkish children in The Netherlands was reported compromised 15 years ago [21]. The vitamin D status of native Dutch children has shown to be appropriate [3, 34, 38]. The lowest 25(OH)D levels in children in The Netherlands are expected in February/March as skin synthesis of vitamin D in winter is negligible [34, 40]. Because 25(OH) levels can be expected to improve after 3 weeks of adequate sun-exposure, our results obtained in mid-spring could have underestimated the prevalence of compromised vitamin D status, since April and May 2003 were relatively sunny in the study area.

High risks of nutritional VDD have been reported in infants with prolonged breast feeding without supplementation, in children with specific diets or with gastrointestinal or metabolic diseases and in adolescents with insufficient dietary intake [4, 7, 9, 12, 13, 28, 30, 32]. The children we studied, however, did not belong to any of these nutritional risk groups.

Our food analyses showed a low dietary intake of vitamin D, particularly in the children from Africa or Asia.

Yet, low dietary intake *per se* does not necessarily lead to a compromised vitamin D status, as reported on children in the besieged city of Sarajevo [20]. It is strongly suggestive that the skin colour is of additional major influence, in consideration of the light skin colour of most children in Sarajevo and of the latitude of Sarajevo, which is much further south than the north of The Netherlands.

The analyses of the seasonal variation in our study demonstrate the dependence on the synthesis of vitamin D in the skin by sun exposure. The improvement of 25(OH)D levels of African children during the summer without supplements was incomplete, in line with lower synthesis rates in individuals with darker skin pigmentation. This indicates that asylum seekers' children of African origin are likely to benefit from vitamin D supplementation, with respect to the biochemical parameters of the vitamin D metabolism. Recurrently compromised vitamin D status accelerates bone resorption and is suggested to contribute to a low mineral bone mass in preadolescent girls [18, 22, 27, 31, 35]. The increased levels of ALP and I-PTH among the children with VDD in our study indicate a disturbance of the bone homeostasis. To obtain optimal peak bone mass in puberty, the present vitamin D recommendations have been suggested to be too low [11]. A study among French male adolescents showed that vitamin D supplementation is effective to prevent or treat VDD or hypovitaminosis D [15]. The provision of a single dose of 3.75 mg vitamin D to 5–11 year-old children at the beginning of autumn has been shown to maintain appropriate vitamin D status during winter without inducing hypercalcaemia or hypercalciuria [26]. The risk of hypervitaminosis D through supplementation is probably low, since supplementation up to 100 µg daily has been shown to be well tolerated without serious side effects [24].

In our study the potency of vitamin D supplements could be confirmed in 11 children that were excluded from the present study, because of reported use of cholecalciferol prior to the investigations. The vitamin D levels of these supplemented children were significantly higher than those of the non-supplemented children (62±18 vs. 47±15 nmol/L, p=0.003).

In conclusion, our present data indicate a high prevalence of compromised vitamin D status asylum seekers' children in The Netherlands. The current relationships between compromised vitamin D status and geographic origin and dietary vitamin D intake allow identification of risk groups among asylum seekers' children, who are expected to benefit from vitamin D supplementation.

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