Hypovitaminosis D among healthy adolescent girls attending an inner city school

G Das, S Crocombe, M McGrath, J L Berry, M Z Mughal

Aims: To determine the prevalence of hypovitaminosis D among healthy adolescent schoolgirls attending an inner city multiethnic girls’ school.

METHODS: Fifty one (28%) of 182 girls (14 white, 37 non-white; median age 15.3 years, range 14.7–16.6) took part in the study. Biochemical parameters, dietary vitamin D intake, muscle function parameters, duration of daily sunlight exposure (SE), and percentage of body surface area exposed (%BSA) were measured.

Results: Thirty seven (73%) girls were vitamin D deficient (25-hydroxyvitamin D (25OHD) < 30 nmol/l) and 9 (17%) were severely deficient (25OHD < 12.5 nmol/l). The median (range) 25OHD concentration of white girls (37.3 nmol/l (18.3–73.3)) was higher than that of non-white girls (14.8 nmol/l (5.8–42.8)). The median (range) concentration of parathyroid hormone in white girls (2.8 pmol/l (1.0–3.7)) was lower than that of non-white girls (3.4 pmol/l (1.7–34.2)). Serum Ca, inorganic phosphate, alkaline phosphatase, and 1,25-dihydroxyvitamin D were not different in white and non-white girls. For the whole group, 25OHD concentration was related to the estimated SE and %BSA, but not to estimated intake of vitamin D. In white girls, the estimated SE and %BSA were significantly higher than that of non-white girls. The median times taken to complete the Gower’s manoeuvre and grip strength were not different in the two groups; these variables were not related to serum 25OHD.

Conclusions: Hypovitaminosis D is common among healthy adolescent girls; non-white girls are more severely deficient. Reduced sunshine exposure rather than diet explains the difference in vitamin D status of white and non-white girls.

There has been a resurgence of vitamin D deficiency rickets among toddlers in the UK,8 and recently there have been reports of adolescents presenting with symptoms of vitamin D deficiency; carpopedal spasms, hypocalcaemic seizures, limb pains, muscle weakness, difficulty in walking/climbing stairs, and lower limb deformities.7 These subjects had low serum concentrations of 25OHD, and 9 (17%) were severely deficient (25OHD < 12.5 nmol/l). The median (range) 25OHD concentration of white girls (37.3 nmol/l (18.3–73.3)) was higher than that of non-white girls (14.8 nmol/l (5.8–42.8)). The median (range) concentration of parathyroid hormone in white girls (2.8 pmol/l (1.0–3.7)) was lower than that of non-white girls (3.4 pmol/l (1.7–34.2)). Serum Ca, inorganic phosphate, alkaline phosphatase, and 1,25-dihydroxyvitamin D were not different in white and non-white girls. For the whole group, 25OHD concentration was related to the estimated SE and %BSA, but not to estimated intake of vitamin D. In white girls, the estimated SE and %BSA were significantly higher than that of non-white girls. The median times taken to complete the Gower’s manoeuvre and grip strength were not different in the two groups; these variables were not related to serum 25OHD.

Conclusions: Hypovitaminosis D is common among healthy adolescent girls; non-white girls are more severely deficient. Reduced sunshine exposure rather than diet explains the difference in vitamin D status of white and non-white girls.
three consecutive measurements were taken and the mean value was used for analysis. The in-house CV of this method is less than 10%.

Serum concentrations of calcium adjusted for albumin (Ca) and inorganic phosphate (P), and alkaline phosphatase activity (ALP) were measured using the Hitachi 917 autoanalyzer (Hitachi, Tokyo, Japan). Serum intact parathyroid hormone (PTH) was measured using an immunoradiometric assay (Nichols Institute Diagnostics, San Juan, Capistrano, USA) (adult reference range: 1.1–6.4 pmol/l).

RESULTS

1. Age, height, weight, dietary vitamin D intake, duration of daily sunlight exposure, the percentage of body surface area exposed by the most commonly worn clothes during daytime, and biochemical parameters of white and non-white girls

<table>
<thead>
<tr>
<th></th>
<th>White girls (n = 14)</th>
<th>Non-white girls (n = 37)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>15.2 (14.8–16.6)</td>
<td>15.3 (14.7–16.3)</td>
<td>0.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>53.0 (45–76)</td>
<td>56.5 (42–78.5)</td>
<td>0.2</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>159.5 (150–170)</td>
<td>158.0 (148.7–168.7)</td>
<td>0.3</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>20.6 (17.8–30.8)</td>
<td>25.0 (17.0–31.8)</td>
<td>0.09</td>
</tr>
<tr>
<td>Dietary vitamin D intake</td>
<td>1.2 (0.5–3.5)</td>
<td>1.4 (0.4–6.0)</td>
<td>0.09</td>
</tr>
<tr>
<td>Daily sun exposure (min)</td>
<td>60 (34–60)</td>
<td>34 (15–60)</td>
<td>0.003</td>
</tr>
<tr>
<td>% Body surface area exposed</td>
<td>19 (9–33)</td>
<td>9 (7–43)</td>
<td>0.001</td>
</tr>
<tr>
<td>Time taken to perform the Gower’s test (sec)</td>
<td>6.4 (2.3–9.1)</td>
<td>6.7 (2.3–11.7)</td>
<td>0.06</td>
</tr>
<tr>
<td>Grip strength (kg)</td>
<td>1.6 (9–21)</td>
<td>16.7 (5.3–36.0)</td>
<td>0.6</td>
</tr>
<tr>
<td>Ca (mmol/l)</td>
<td>2.2 (2.6–2.6 mmol/l)</td>
<td>2.4 (2.2–2.7)</td>
<td>0.2</td>
</tr>
<tr>
<td>P (mmol/l)</td>
<td>0.1 (0.7–1.4 mmol/l)</td>
<td>1.0 (0.8–1.8)</td>
<td>0.5</td>
</tr>
<tr>
<td>PTH (pmol/l)‡</td>
<td>1.8 (0.3–3.7)</td>
<td>3.4 (1.7–32.4)</td>
<td>0.02</td>
</tr>
<tr>
<td>Alkaline phosphatase activity (IU/l)</td>
<td>232 (156–773)</td>
<td>226 (124–597)</td>
<td>0.6</td>
</tr>
<tr>
<td>25(OH)D (nmol/l)</td>
<td>37.3 (18.3–73.3)</td>
<td>43.8 (5.9–24.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1,25(OH)₂D (pmol/l)</td>
<td>87.6 (50.4–115.2)</td>
<td>93.6 (60–139.2)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*Data are presented as median (range) and the differences in the two groups were compared using the Mann-Whitney U test.

DISCUSSION

We found that hypovitaminosis D was common among healthy adolescent girls, with non-white girls being more severely deficient. This finding is in keeping with reports from European countries,15–17 the USA,18 and a sun-rich country like Lebanon.19 Furthermore, we found that reduced exposure of skin to sunlight rather than dietary vitamin D intake explained the difference in vitamin D status of non-white and white girls. This is in keeping with the fact that the main source of vitamin D is that produced by the action of solar ultraviolet B radiation on 7-dehydrocholesterol in skin; only small amounts are obtained from dietary sources. Avoidance of exposure to sunshine for religious and cultural beliefs that encourage wearing of concealing clothing and
restriction of outdoor activities has previously been reported as a risk factor for vitamin D deficiency in Saudi Arabian adolescents. Increased skin pigmentation is a further factor that might explain the difference in vitamin D status of white and non-white girls in our study. The most important function of vitamin D is to maintain serum calcium concentrations within the normal range by stimulating its absorption from the diet. In the early stages of vitamin D deficiency, plasma calcium concentration is low, with a normal plasma phosphate concentration. Hypocalcaemia leads to secondary hyperparathyroidism, which in turn results in an increase in plasma 1,25(OH)2D concentration, normalisation of plasma calcium concentration, and a decrease in serum phosphate concentration. At this stage, plasma 25OHD concentration is low and the concentration of 1,25(OH)2D is normal or high. This biochemical state is maintained at the expense of the stores. With regard to children, serum 25OHD concentrations <20 nmol/l were considered to have severe hypovitaminosis D, those with serum 25OHD concentrations 20–37.5 nmol/l to have moderate hypovitaminosis D, and those with 25OHD concentrations >37.5 nmol/l to have sufficient vitamin D stores. With regard to children, serum 25OHD concentrations of 27.5 nmol/l or 30 nmol/l are considered to be sufficient. Regardless of the level of 25OHD that is used to define vitamin D deficiency, hypovitaminosis D was common among adolescent girls in this study. While very low serum concentrations of 25OHD in the face of secondary hyperparathyroidism are associated with rickets and osteomalacia, there is poor understanding between the relationship of serum 25OHD concentration and other health outcomes, such as optimal skeletal mineralisation in a growing child. Over 35% of the peak bone mass of a mature adult is accrued during the four years surrounding the peak pubertal growth spurt, and it is widely accepted that subjects who attain a lower peak bone mass at maturity have a higher risk of sustaining osteoporotic fractures in later life. In 14–16 year old Finnish girls, Outila et al found lower (p = 0.04) mean radial bone mineral density (BMD) in those with serum 25OHD concentration <40 nmol/l, compared to those with serum 25OHD concentration >40 nmol/l. Lehtonen-Venomaa et al observed a positive relationship between serum 25OHD concentrations and lumbar spine and femoral neck BMD among peripubertal Finnish girls. Further studies are required to determine if subclinical vitamin D deficiency, by limiting gastrointestinal calcium absorption and causing secondary hyperparathyroidism and associated skeletal demineralisation, results in reduced bone mass accrual around puberty, and whether vitamin D supplementation can help to prevent this.

This study has a number of limitations. The estimated duration of subjects’ sunshine exposure and percentage of body surface area exposed apply only to early summer. The results of this study may not apply to adolescents from widely diverse ethnic communities within the UK. We did not enquire about the use of sunscreen creams, which are known to reduce cutaneous vitamin D synthesis. In conclusion, we found that subclinical hypovitaminosis D was common among healthy adolescent girls; Non-white girls were more severely deficient. Reduced sunshine exposure rather than diet explained the difference in vitamin D status of white and non-white girls. Vitamin D deficiency during childhood and adolescence might impair the acquisition of peak bone mass at the end of skeletal growth and maturation, thereby increasing the risk of osteoporotic fracture in later life.

ACKNOWLEDGEMENTS

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Competing interests: none declared

Table 2  Serum calcium (Ca), inorganic phosphate (P), alkaline phosphatase (ALP), 25-hydroxyvitamin D (25OHD), and 1,25-dihydroxyvitamin D (1,25(OH)2D) in three non-white girls with raised serum parathyroid hormone (PTH)

<table>
<thead>
<tr>
<th>Non-white girls</th>
<th>PTH* (1.1–6.4 pmol/l)</th>
<th>Corrected Ca* (2.2–2.6 mmol/l)</th>
<th>P* (0.7–1.4 mmol/l)</th>
<th>ALP† (IU)</th>
<th>25OHD (nmol/l)</th>
<th>1,25(OH)2D† (pmol/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.6</td>
<td>2.4</td>
<td>1.2</td>
<td>295</td>
<td>17.3</td>
<td>136.8</td>
</tr>
<tr>
<td>2</td>
<td>8.3</td>
<td>2.4</td>
<td>1.1</td>
<td>193</td>
<td>10.0</td>
<td>72.0</td>
</tr>
<tr>
<td>3</td>
<td>34.2</td>
<td>2.3</td>
<td>1.8</td>
<td>597</td>
<td>13.8</td>
<td>117.6</td>
</tr>
</tbody>
</table>

*Reference range in parentheses.
†Reference range of serum alkaline phosphatase activity depends on age and stage of pubertal development.
‡Adult reference range: 48–120 pmol/l.
There has been a resurgence of symptomatic vitamin D deficiency among adolescents of South Asian and Middle Eastern origin living in the UK.

Adolescent vitamin D deficiency is commonly associated with hypocalcaemic tetany and non-specific symptoms, e.g., limb pains, muscle weakness.

REFERENCES


