Effect of Sex Hormones on Bone Mineral Density in Children: Is the Increase in Bone Mineral Density during Puberty only due to Rapid Height Gain?

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Introduction

Bone mineral density (BMD) rapidly increases during puberty and this phenomenon is closely related to growth spurt(1-3). Several studies on postmenopausal osteoporosis and hypogonadism demonstrate that sex hormones are required to maintain BMD(4-7). However, the roles of sex steroids in the process of gaining BMD are still unclear(8). Thus, it is important to clarify whether the increase in BMD during puberty is due to the increased secretion of sex hormones as well as to rapid height or weight gain.

To elucidate the effect of sex hormones on BMD in children, we investigated the relationships of vertebral BMD to serum testosterone and estradiol levels.

Subjects and Methods

One hundred and twenty-two prepubertal children with normal short stature (75 boys and 47 girls, height<-2 SD, age 4-13 yr) were enrolled in this study. The BMD of the lumbar spine (L2-L4) was measured by dual energy X-ray absorptiometry. Serum testosterone level (T) was measured in boys and its sensitivity was 5 ng/dL. Serum estradiol level (E2) was measured in girls and its sensitivity was 5 pg/mL.

To eliminate the influence of constitution on BMD, the subjects were classified into 5 groups (Table). Furthermore, BMD/body mass index (BMI) was also analyzed for the same purpose.

Bone metabolic markers were also measured: serum carboxyterminal propeptide of type I procollagen (PICP) as a bone formation marker, serum pyridinoline cross-linked telopeptide of type I collagen (ICTP), urinary pyridinoline (PYR) and urinary deoxypyridinoline (DPYR) as bone resorption markers.

Table

<table>
<thead>
<tr>
<th>group A: height</th>
<th>weight</th>
<th>age</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-100 cm</td>
<td>10-15 kg</td>
<td>4-5 yr</td>
</tr>
<tr>
<td>group B: height</td>
<td>100-110 cm</td>
<td>15-20 kg</td>
</tr>
<tr>
<td>group C: height</td>
<td>110-120 cm</td>
<td>20-25 kg</td>
</tr>
<tr>
<td>group D: height</td>
<td>120-130 cm</td>
<td>25-30 kg</td>
</tr>
<tr>
<td>group E: height</td>
<td>130-140 cm</td>
<td>30-35 kg</td>
</tr>
</tbody>
</table>
Results

In group A, there were no significant differences in the BMD between boys and girls. In groups B and C, the BMD in girls was significantly higher than that in boys. In groups D and E, there were no significant differences in the BMD between boys and girls, though the BMD in boys showed a tendency to be higher than that in girls (Fig. 1).

Changes in the BMD/BMI in each group tended to be similar to that of BMD. In group B, the BMD/BMI in girls was significantly higher than that in boys (data not shown).

Although neither T nor E2 were detected in any child in group A, these were detected in half of the children in groups B and C. Because there was a significant difference in the BMD between boys and girls in groups B and C as cited above, we further classified these groups into four subgroups: T ≥ 5 ng/dL, T < 5 ng/dL, E2 ≥ 5 pg/mL, E2 < 5 pg/mL to evaluate the effect of both testosterone and estrogen on BMD. In boys, the BMD in subgroup (T ≥ 5 ng/dL) tended to be higher than that in subgroup (T < 5 ng/dL) in both group B and C. In girls, the BMD in subgroup (E2 ≥ 5 pg/mL) tended to be higher than that in subgroup (E2 < 5 pg/mL) in both groups B and C (Fig. 2). However, there were no significant correlations of either T or E2 versus BMD in groups B and C (data not shown).

Changes in the BMD/BMI in both groups were similar to that in the BMD. In group C, the BMD/BMI in girls whose E2 was above 5 pg/mL was significantly higher than that in those whose E2 was under 5 pg/mL (data not shown).

There were no significant correlations of both T and E2 versus any bone metabolic markers (data not shown).

Discussion

We demonstrated that there was a difference in BMD between boys and girls even before puberty when constitutional factors were eliminated, though some studies have reported that there was no significant difference between children under 9 years of age (2,
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3). Furthermore, the BMD in children whose T or E2 were high tended to be higher than that in those whose sex hormones were low. These results suggest that both testosterone and estrogen increase BMD even in prepubertal children.

However, there were no significant correlations of either T or E2 versus BMD and bone metabolic markers. Therefore, both sex hormones may affect BMD indirectly as well as directly.

In conclusion, the rapid increase in BMD during puberty could be due to the increased secretion of sex hormones as well as rapid height or weight gain.

References


