Magnesium intake and bone mineral density in young adult women

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Abstract. The purpose of this study was to determine a possible association between magnesium intake and bone mass in young adult women. Subjects consisted of 106 female university students aged 19-25 years. Calcium and magnesium intakes were evaluated using the duplicate sampling method on three weekdays. Spinal and femoral bone mineral density (BMD) was measured by dual energy X-ray absorptiometry. Mean magnesium intake was 139 mg/day (median 127, SD 54). The correlation between magnesium intake and BMD was of borderline significance (r = 0.175, p = 0.073) for the femoral neck, and was insignificant (r = 0.084, p = 0.391) for the lumbar spine. However, the partial correlation between magnesium intake and BMD of the femoral neck (r = -0.027, p = 0.788), adjusted for calcium intake, was not significant. In conclusion, we did not find an association between magnesium intake and bone mass in young women, and calcium intake needs to be included as an important, potential confounding factor when exploring such an association.

Key words: bone density, diet, magnesium, young women

Young women are considered to be at high risk of having eating disorders [1]. They often have lifestyles that are characterized by irregular food intake patterns, skipping meals, and dieting [2], which may cause poor-nutrition-related disorders. Regarding skeletal health, low intakes of minerals and protein in young people may adversely affect the attainment of maximal peak bone mass and, consequently, may contribute to osteoporosis risk in later life. We recently showed that female university students tend towards dieting in which low consumption amounts of calcium (median calcium intake, 332 mg/day) were associated with low bone mass of the femoral neck, according to the duplicate sampling method [3].

Rude and Gruber [4] suggest that low magnesium intake affects maintenance of normal bone homeostasis and is a possible risk factor for low bone mass. Despite such suggestions, there exist no studies to our knowledge that have examined this possible association between magnesium intake and bone mass, nor that have determined whether low magnesium intake adversely affects maximal peak bone mass in young women.

This study used dietary samples preserved from our previous study on calcium and bone health in young women [3] to measure magnesium content in the same sample. The purpose of this study was to determine a possible association between magne-
sium intake and bone mass in young adult women using the duplicate sampling method, one of the reliable methods to assess dietary minerals.

**Subjects and methods**

We invited all 148 second- and third-year female students in the Nursing Course at Niigata University School of Medicine, of which 112 (75.7%) agreed to participate in this study. Six of the 112 women were excluded from statistical analysis: two women receiving corticosteroid hormone therapy, two women consuming special meals for strict dieting purposes during the study period, and two older women (29 and 32 years of age). In effect, data from 106 women aged 19-25 years were analyzed. Detailed information on this study population has been published previously [3]. Written informed consent was obtained from all of the subjects. The study protocol was approved by the Ethics Committee of Niigata University School of Medicine.

Dietary nutrients were measured by direct analysis of meal samples using the duplicate portion sampling method. Subjects were asked to provide duplicates of all meals, drinks, and snacks that they had consumed on three consecutive weekdays prior to the day of the health examination. The 3-day food samples were fully mixed with a food blender and dried at 110°C. Calcium levels in the dried samples were determined with an atomic absorption spectrophotometer (NAC Company, Ltd., Tokyo, Japan) and magnesium was determined using the inductively coupled plasma-atomic emission spectrometry (Japan Food Research Laboratories, Tokyo, Japan). The intra- and inter-assay coefficients of variation (CVs) were 1.1% and 2.6%, respectively, for calcium, and 2.1% and 1.2% for magnesium.

Bone mineral content (BMC) and bone mineral density (BMD) in the lumbar spine and the femoral neck were measured using dual energy X-ray absorptiometry (QDR-2000, Hologic Inc. Bedford, MA, USA). The height and weight of the subjects were measured, and their body mass index was calculated by dividing the weight by the square of the height. The detailed processes of subject recruitment and the duplicate portion sampling method have been described elsewhere [3].

Given that data for dietary calcium and magnesium, BMC of the lumbar spine and femoral neck were skewed toward higher values, these measurements were logarithmically transformed for the purpose of statistical analyses. The Pearson’s product moment correlation coefficient and partial correlation coefficient were calculated to test for linear correlations between pairs of continuous variables. A p-value of less than 0.05 was considered statistically significant. The SAS system (release 8.02) was used to conduct all statistical tests.

**Results**

The mean age, height, weight, and BMI of the subjects was 20.5 years (SD 0.8), 158.9 cm (SD 5.0), 52.6 kg (SD 6.1), and 20.8 kg/m² (SD 2.2), respectively. The mean calcium and magnesium intake and total energy of the subjects’ diet was 380 mg/day (median 332, SD 208), 139 mg/day (median 127, SD 54), and 1339 kcal/day (SD 331), respectively. Figure 1 illustrates the frequency distribution of magnesium intake. The mean BMD of the lumbar spine and femoral neck was 1.013 g (SD 0.097) and 0.818 g/cm² (SD 0.100), respectively.

Table 1 shows the correlation between calcium or magnesium intake and BMC or BMD. Calcium intake correlated significantly with BMC and BMD of the femoral neck, whereas the correlation between magnesium intake and BMC and BMD of the femoral neck was of borderline significance (p = 0.087 and p = 0.073, respectively). However, the partial correlation between magnesium intake and BMC and BMD of the femoral neck was not significant after adjusting for calcium intake (p = 0.905 and p = 0.788, respectively) or adjusting for calcium intake, age, and weight (p = 0.576 and p = 0.582, respectively). The correlation between magnesium intake and BMC and BMD of the lumbar spine was not significant. Total energy did not correlate with any bone mass variables. An inter-correlation coefficient of calcium and magnesium intake was 0.613 (p < 0.001).

We also evaluated various calcium-regulating hormones (serum vitamin D metabolites and intact parathyroid hormone) and markers of bone turnover (serum osteocalcin and bone alkaline phosphatase, and urinary deoxypyridinoline and type I collagen cross-linked N-telopeptides) in this population [3], but none of these parameters was significantly correlated with magnesium intake.

**Discussion**

Mean calcium intake, magnesium intake, and total energy of the subjects were all lower than the national averages for people in their 20s (457 mg/day, 211 mg/day, 1 683 kcal/day, respectively) [5]. Also, the mean magnesium intake was lower than the
recommended dietary allowance (RDA) for magnesium for adult females (270 mg/day in Japan and 310 mg/day in the USA) [6, 7]. Therefore, an association between magnesium intake and bone mass parameters was expected.

The present study failed to demonstrate an association between magnesium intake and bone mass in young women, and the association has remained controversial. There have been a few magnesium intervention studies in young populations, but their results were also conflicting. Dimai et al. [8] have shown that magnesium supplementation of 364 mg/day may suppress the rate of bone turnover in healthy young adult men, whereas Doyle et al. [9] have not shown a beneficial effect of 250 mg/day magnesium supplementation on bone metabolism in young adult women.

The sample size needed to detect potential correlations between magnesium intake and bone mass parameters is an issue. In order to detect a low corre-

**Figure 1.** A frequency distribution of the subjects’ magnesium intake. Mean and median values were 139 mg/day and 127 mg/day, respectively.

**Table 1.** Pearson’s correlation coefficient (r) between calcium intake, magnesium intakes, or total energy and bone mineral content (BMC) or bone mineral density (BMD).

<table>
<thead>
<tr>
<th></th>
<th>Calcium intake</th>
<th>Magnesium intake</th>
<th>Total energy</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p-value</td>
<td>r</td>
</tr>
<tr>
<td>BMC of lumbar spine</td>
<td>0.185</td>
<td>0.058</td>
<td>0.127</td>
</tr>
<tr>
<td>BMD of lumbar spine</td>
<td>0.106</td>
<td>0.230</td>
<td>0.195</td>
</tr>
<tr>
<td>BMC of femoral neck</td>
<td>0.038</td>
<td>0.001</td>
<td>0.093</td>
</tr>
<tr>
<td>BMD of femoral neck</td>
<td>0.331</td>
<td>0.001</td>
<td>0.175</td>
</tr>
</tbody>
</table>

a Variables logarithmically transformed.
b Adjusted for the log-transformed calcium intake.
c Adjusted for the log-transformed calcium intake, age, and body weight.
lation coefficient of 0.3 with a statistical power of 90%, a total of 92 subjects is required [10]. This suggests that our sample size was appropriate.

This study showed that there was borderline significance in the correlation between magnesium intake and bone mass in the femoral neck, but no correlation after adjusting for calcium intake. Since the correlation coefficient between calcium and magnesium intake was relatively high (r = 0.613), calcium intake was considered to be a confounder.

Some epidemiologic studies have shown an association between magnesium intake and BMD [3]. However, these positive results may have been confounded by calcium intake, which is difficult to estimate accurately.

In conclusion, this study did not find an association between magnesium intake and bone mass in young women. Calcium intake needs to be included as an important, potentially confounding factor when exploring such an association.

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