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Original Article

Urinary Excretion of Calcium and Magnesium

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Urinary excretion of calcium and magnesium were measured in order to examine the possibility of biological monitoring of six males aged 29-49 years old. This study showed the possibility of estimating the amount of calcium intake by determining urinary excretion of calcium. In regard to magnesium, since there was little change within a day compared with calcium, the possibility was low. Amount of urinary calcium and magnesium excretion corrected for creatinine could also be estimated by the spot urine. Ca/Mg molar ratio in urine was smaller than one before eating meals and after a meal becomes larger than one.

Key Words: Calcium, Magnesium, Creatinine, Urine

Introduction

As for minerals, such as calcium, magnesium and phosphorus, constancy is maintained in the plasma concentration level. On the other hand, the influence of the amount ingested from a meal and the change resulting from bone absorption, bone formation, etc. exists, and the amount of excretion inside that urine tends to vary compared with plasma concentration.

Kerstetter et. al. concluded that at calcium and phosphorus intakes typically consumed by the American adult, increases in dietary protein do increase urinary calcium, resulting in a shift of calcium balance in a negative direction [1].

A high-protein diet has been shown in experimental human and animal studies to increase calcium excretion [2, 3]. It has been hypothesized that this is due to the increase in the glomerular filtration rate and the decrease in renal reabsorption of calcium [3].

Because intestinal calcium absorption is not increased with a high-protein diet [4], urinary calcium loss often leads to adverse calcium balance [5]. A diet rich in protein may lead to bone resorption, resulting in osteoporosis.

Magnesium has been used as a therapeutic drug against chronic degenerative diseases of unknown aetiology such as essential hypertension [6], ischemic heart diseases [7], atheroselerosis, non-insulin dependent diabetes mellitus [8] and so on in humans, and as an anti-stressor during transportation of livestock [9].

Low dietary calcium and magnesium intakes have been implicated in the etiology of several chronic diseases [3, 4]. Protein is one of a number of dietary components known to affect mineral utilization in humans. The calciuretic effect of dietary protein is well established [10]. Exposure to cold to measure physical stress and a math-drill to measure mental stress caused magnesiuresis accompanied with calciuresis whose urine Ca/Mg molar ratio was approximately one [11].

The present study was undertaken to examine the possibility that the amount of calcium and magnesium intake can be estimated by determining the amount of excretion in urine. The change of levels over a day was investigated, paying careful attention to the excretion ratio

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of calcium and magnesium.

Materials and Methods

Subjects

Volunteers for this study were all university staff. All subjects gave informed consent after a full explanation of all procedures. The subjects were six males aged 29-49 years old. Subjects were asked to collect the first morning urine and the urine of the 2 nd hour after lunch.

Daily meal pattern

The subject had meals at eight, twelve noon and six p.m.. The urine was collected at 2-hour intervals after the first urine at six o'clock from a healthy male adult (49 year-old).

Single meal pattern

A single meal was ingested at eight o'clock. The urine was collected at 2-hour intervals after the first urine at six o'clock from a healthy male adult (49 year-old)

Determination of urinary calcium

Urinary calcium content was determined colorimetrically. Urine specimen, standard and water (blank) of 0.03 ml were put into the appropriate test tubes. 5 ml of 0.88 mol/l monoethanolamine (pH 11.0) was added, after that 0.5 ml of color former, 0.63 mmol/l o-cresolphthalein complexion containing 8-hydroxyquinoline, were added to all tubes. They were mixed well and allowed to stand at room temperature for 5 minutes. The absorbance was measured at 570 nm against the blank within 2 hours.

Determination of urinary magnesium

Urinary magnesium content was determined colorimetrically. Urine specimen, standard and water (blank) of 0.02 ml were put into the appropriate test tubes. 2 ml of water was added, after that 3 ml of color former, 0.1 mmol/l of xylyazo-violet-1 containing 0.045 mmol/l glycoletherdiamine-N,N,N',N'-tetra acetic acid were added to all tubes. They were mixed well and allowed to stand at room temperature for 10 minutes. The absorbance was measured at 520 nm against the blank within 2 hours.

Determination of urinary creatinine

Urinary creatinine content was determined colorimetrically. Urine specimen, standard and water (blank) of 0.1 ml were put into the appropriate test tubes. 1 ml of 1% picric acid was added, after that 1 ml of 10% sodium hydroxide was added to all tubes. They were mixed well and allowed to stand at room temperature for 10 minutes. The absorbance was measured at 530 nm against the blank within 20 minuets.

Results and Discussion

Fig. 1 shows the time-dependent curves of urinary calcium and magnesium excretion for each measurement time in daily meal pattern. As for the measured value of urinary calcium and magnesium excretion, they were at the maximum values at 6:00. Since the value at 6:00 is a total amount from the previous night, naturally it becomes high.

Fig. 2 shows the time-dependent curves of urinary

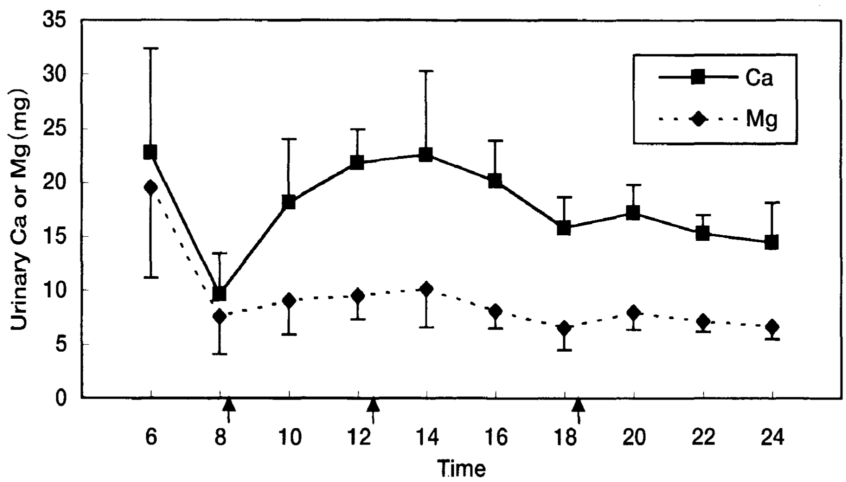

Fig. 1 Time-dependent curves of urinary calcium and magnesium excretion for each measurement time in daily meal pattern. Values are the mean ± SD (n = 3). Arrows express meals.

calcium and magnesium excretion corrected for creatinine for each measurement time in daily meal pattern. The amount of urinary excretion of creatinine is proportional to muscular growth and muscular movement, and is hardly influenced by urinary quantity or ingestion food. Since it is always excreted in urine at a fixed amount, if there is much urine, the concentration of creatinine will fall, and if there is little urine, creatinine concentration will rise. Therefore, when it is difficult to collect sufficient amounts of urine for the day, creatinine can be measured simultaneously with the quality of an object, it can ask for the initial concentration of an object/creatinine concentration ratio, and the quality of an object can be compared as a relative value. These results indicate that urinary calcium and magnesium excretion corrected for creatinine can also be estimated by their quantity in the spot urine.

Fig. 3 shows Ca/Mg molar ratio for all measurement times in daily meal pattern.

Ca/Mg molar ratios before breakfast were less than one, and the ratios after every meal were above one.

The correlation of urinary calcium and magnesium excretion was characterized in Table 1. No correlation

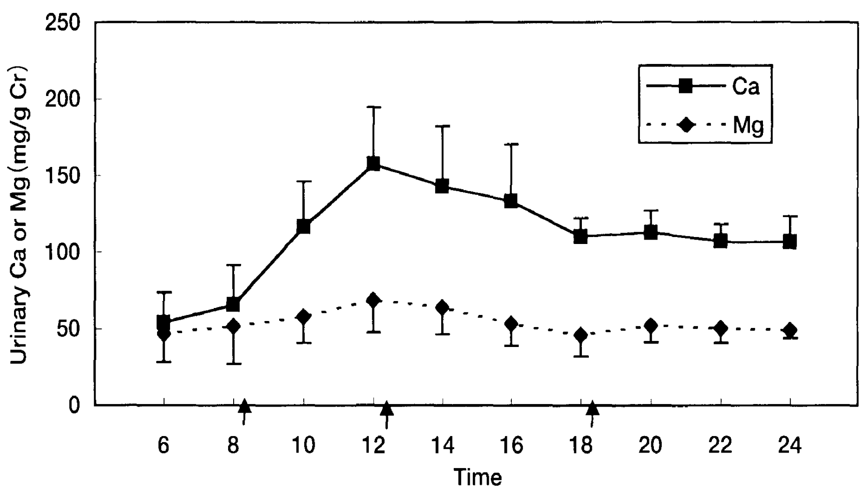

Fig. 2 Time-dependent curves of urinary calcium and magnesium excretion corrected for creatinine (Cr) for each measurement time in daily meal pattern. Values are the mean ± SD (n = 3). Arrows express meals.

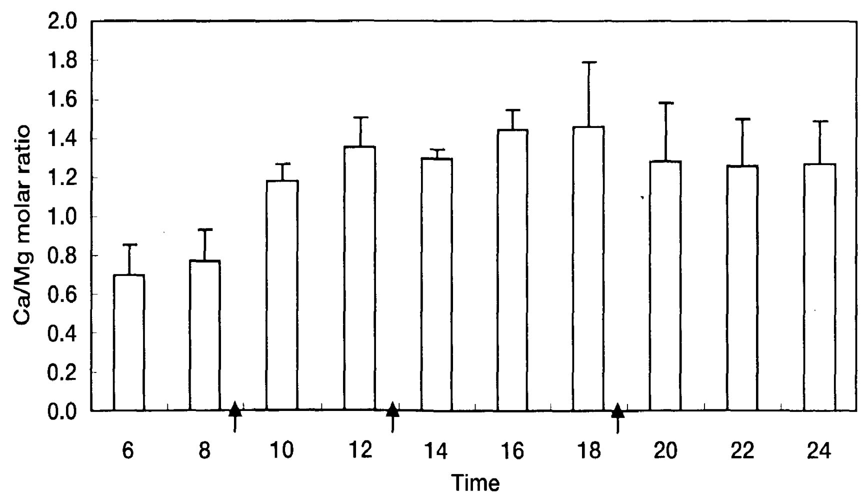

Fig. 3 Ca/Mg molar ratio for all measurement times in daily meal pattern. Values are the mean ± SD (n = 3). Arrows express meals.

was estimated between the urinary calcium and magnesium for the whole day, whereas the significant positive correlation was estimated before breakfast as shown in Fig. 4 ($r = 0.964$, $p < 0.01$) and after every meal as shown in Fig. 5 ($r = 0.916$, $p < 0.01$). This result was in agreement with the result of Nishimuta et.al. [12] in that Ca/Mg molar ratio was the same in regard to 24-hour urine, but there was a fluctuation in Ca/Mg molar ratio according to the time the sample was taken.

Fig. 6 shows the time-dependent curves of urinary calcium and magnesium excretion after a single meal. Urinary calcium excretion peaked 2 to 4 hours after the

Table I Correlation of urinary calcium and magnesium excretion for the whole day, before breakfast and after every meal

	regression equation	correlation coefficient	number	probability
whole day	$y = 0.552 \times - 0.568$	0.606	10	$p = 0.0633$
before brakfast	$y = 0.865 \times - 0.428$	0.964	6	$p = 0.0019$**
after every meal	$y = 0.402 \times + 0.855$	0.916	8	$p = 0.0014$**

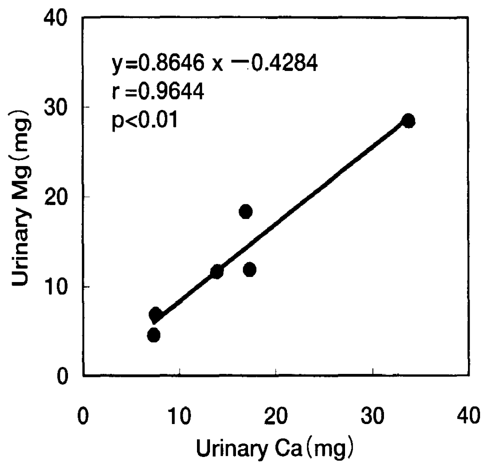

Fig. 4 Correlation of urinary calcium and magnesium excretion before breakfast.

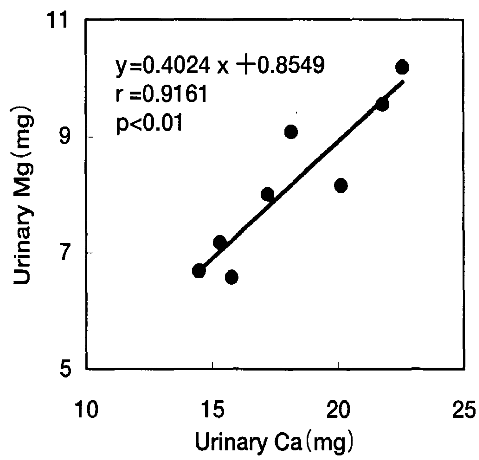

Fig. 5 Correlation of urinary calcium and magnesium excretion after every meal.

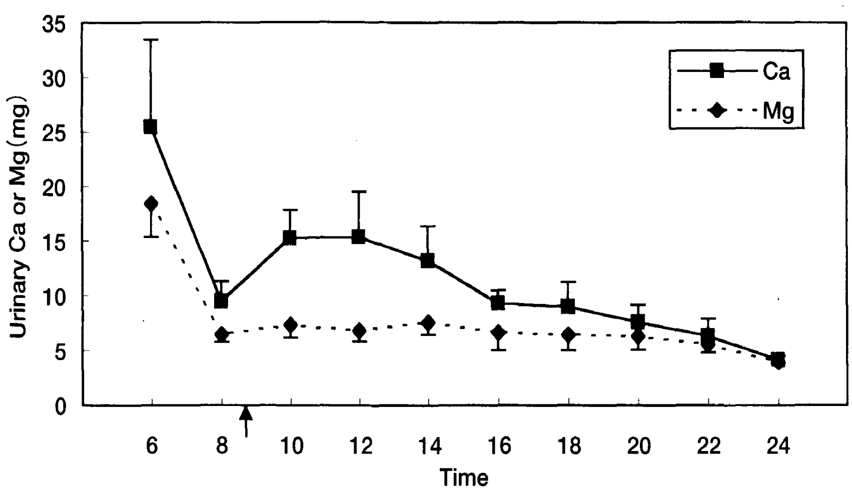

Fig. 6 Time-dependent curves of urinary calcium and magnesium excretion after a single meal. Values are the mean ± SD ($n = 3$). An arrow expresses a meal.

meal, and the minimum was reached 16 hours after the meal. Urinary magnesium excretion peaked in 6 hours after the meal, and the minimum was reached in 16 hours after the meal. Since the value before the meal is the total amount from the previous night, naturally it is high.

Fig. 7 shows the time-dependent curves of urinary calcium and magnesium excretion corrected for creatinine after a single meal. These results indicate that urinary calcium and magnesium excretion corrected for creatinine can also be estimate by measuring their quantity in the spot urine. These results indicate that it is possible to estimate the amount of calcium intake by determining the urinary excretion of calcium. In regard to magnesium, since there is little change within a day compared with calcium, the possibility is low.

Fig. 8 shows Ca/Mg molar ratio for all measurement time for a single meal. Ca/Mg molar ratios were above one in the urine of the first 6 hours after a meal, and less than one in the urine before breakfast and after the 6 hours following a meal.

Fig. 9 shows the comparison of Ca/Mg molar ratio in the urine before breakfast and the urine of the 2 nd hour after lunch from volunteers. There was a significant difference between Ca/Mg molar ratio in the first morning

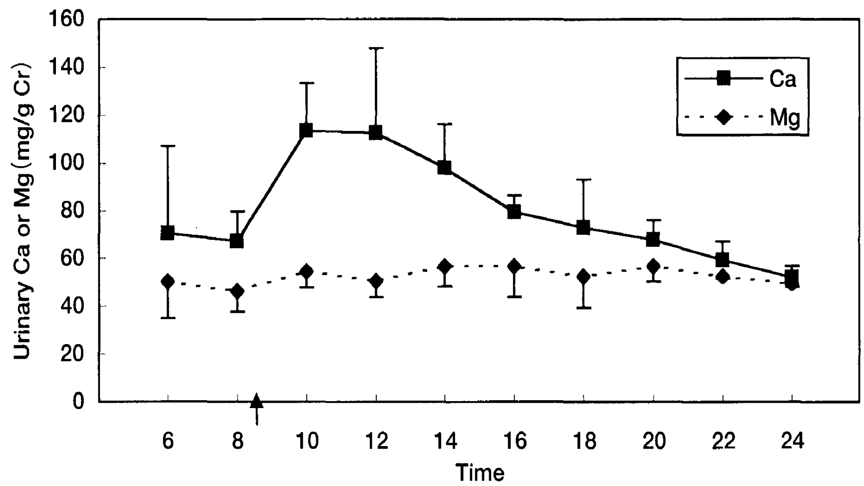

Fig. 7 Time-dependent curves of urinary calcium and magnesium excretion corrected for creatinine (Cr) after a single meal. Values are the mean ± SD (n = 3). An arrow expresses a meal.

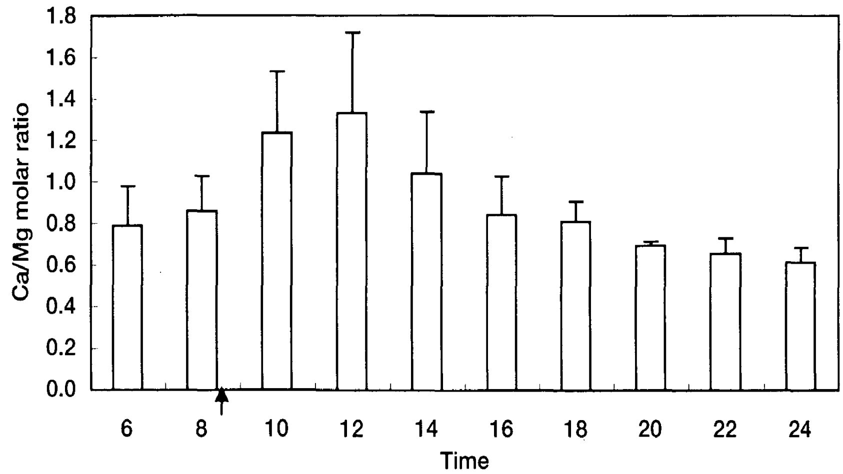

Fig. 8 Ca/Mg molar ratio for all measurement times in a single meal. Values are the mean ± SD (n = 3). An arrow expresses a meal.

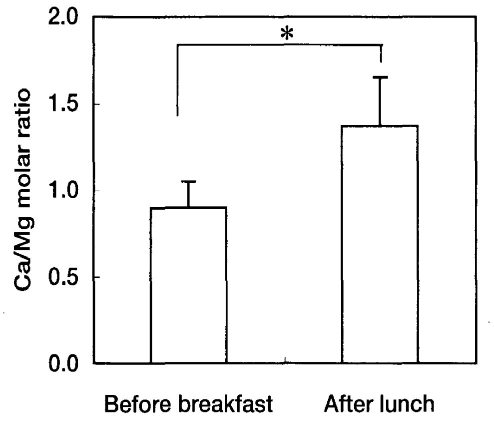

Fig. 9 Comparison of Ca/Mg molar ratio in the urine before breakfast and the urine of the 2 nd hour after lunch from volunteers. Values are the mean ± SD (n = 6).
*Significantly different at $p < 0.05$ (paired Student's t-test).

urine and that in the urine of the 2 nd hour after lunch by paired Student's t-test ($p < 0.05$).

These results indicate that Ca/Mg molar ratio in urine is smaller than one before a meal and after a meal becomes larger than one.

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