Effect of Mg Deficiency on Blood Pressure in Rats Treated with Cadmium

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(Received May 8, 1987)

Summary Forty male STD-Wistar rats, weighing about 210 g on the average, were divided into two dietary groups. These were further subdivided into the following eight groups: 1) control rats fed the normal diet (N rats: group #1), N rats treated with 0.1 mg Cd (group #2), 0.5 mg Cd (group #3), and 1.0 mg Cd (group #4); 2) Mg-deficient rats (D rats: group #5), D rats treated with 0.1 mg Cd (group #6), 0.5 mg Cd (group #7), and 1.0 mg Cd (group #8). Before Cd treatment the rats were given the normal diet or the Mg-deficient diet for 14 consecutive days (day -14). Subcutaneous injection of 0.1 ml of cadmium chloride (CdCl₂) in the backs of the animals given a normal diet or a Mg-deficient diet at the three doses of 0.1, 0.5, and 1.0 mg/kg body was performed twice a day (12-h intervals) (time-zero) for 7 consecutive days and then these animals were maintained without Cd treatment for an additional period of 20 days (+28 days). Body weight gain in Mg-deficient rats (D rats) was significantly decreased. The effects of Cd treatment in the rats fed the normal diet (N rats) were also significant. Mg deficiency enhanced the decreased body weight gain in D rats treated with Cd on day 24 though no enhancement of the decreased food consumption in those rats was observed. Mg deficiency lowered the blood pressure in rats and this response was more pronounced in D rats treated with Cd. The increased urinary Na excretion and the decreased water retention were not observed in the D rats; this response was not pronounced in the D rats treated with Cd. These results suggest that an enhancement of the decreased blood pressure in Cd-treated rats by the Mg deficiency is not responsible for the decreased water retention. Ca concentration in the heart and aorta of D rats was within the same range as that of N rats. Mg deficiency increased Ca concentration in the heart and aorta of the D rats treated with 0.5 and 1.0 mg Cd though Cd itself did not affect the Ca and ATP concentrations, Ca and Mg balance (Ca/Mg), and heart weight in the heart of N rats.

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These results suggest that Mg deficiency may increase the overload of Ca in the heart and aorta of D rats treated with Cd, which may in turn lead to enhancement of the Cd-induced cardiotoxic effects. The decrease in urinary total Ca and Cd excretion of D rats treated with Cd may result from the increased Ca and Cd concentrations in body burden. Enhancement of Cd-induced cardiotoxic effects by Mg deficiency may be factors for the pronounced lower blood pressure in D rats treated with Cd.

**Key Words** Mg deficiency, blood pressure, cadmium, tissue metal concentrations, male rat

Epidemiological studies have associated the exposure to increased Cd levels with hypertension (1, 2). In experimental animals, Cd increases the blood pressure of short-term and long-term exposed rats (3-6). Chronic life-long daily intake of Cd affects the metabolism of the heart and impairs the functional status of the myocardium (7, 8).

There is growing evidence that inadequate magnesium (Mg) intake is a risk factor for coronary artery disease (9). In experimental animals, hypertension or hypotension has been shown to develop in Mg-deficient rats (10, 11). Some workers have postulated that this Mg effect is caused by either an effect on the coronary arteries themselves, or by an effect on myocardial vulnerability to injury (12). Smetana and Glogar (13) have reported the patients with idiopathic dilated cardiomyopathy show a significant elevation in blood Cd and the lower serum and urine concentrations of Mg. These findings suggest that Mg deficiency varies the blood pressure in Cd-treated rats since both Mg and Cd affect the functional status of myocardium and blood vessels.

The present study was then carried out to help elucidate the effect of Mg deficiency on blood pressure in Cd-treated male rats.

**MATERIALS AND METHODS**

**Diets.** The basal composition of the experimental diet is given in Table 1. The normal diet was supplemented with MgO to provide 0.08 g per 100 g of diet (normal diet, N diet). Mg-deficient diet did not contain MgO (Mg-deficient diet, D diet). The Mg and Ca concentrations in the basal experimental diet are similar to those recommended by the American Institute of Nutrition (AIN-76) (14). The level of Mg, Ca, Fe, Zn, and Cu in the diet were verified with a flame atomic absorption spectrophotometer as previously reported (15). Mg concentrations in the N diet and D diet were 0.05 g/100 g of diet and 0.001 g/100 g diet, respectively. Ca concentration in the N diet and D diet was equal to 0.12 g/100 g of diet

**Cd treatment.** Forty male STD-Wistar rats, weighing about 210 g on the average, were purchased from the Shizuoka Laboratory Animal center, and divided...
Table 1. Composition of purified basal diet.

| Ingredients                      | Percentage in diet |
|----------------------------------|--------------------|
| Sucrose                          | 50.0%              |
| Casein                           | 20.0               |
| Purified starch                  | 15.0               |
| Cellulose                        | 5.0                |
| Olive oil                        | 5.0                |
| Vitamin mix¹                     | 1.0                |
| Mineral mix²                     | 3.5                |
| DL methionine                    | 0.3                |
| Choline hydrochloride            | 0.2                |

¹ Vitamin per 100 g vitamin mix.: thiamine 100 mg, riboflavin 150 mg, pyridoxin-HCl 100 mg, nicotinamide 1,000 mg, d-panthionate 500 mg, folic acid 50 mg, vitamin B₁₂ 0.1 mg, vitamin A 2.5 × 10⁵ IU, vitamin E 100 mg, calciferol 2 × 10⁴ IU, vitamin C 3.7 × 10³ mg.² Mineral per 100 g mineral mix.: NaCl 7.4 g, K₃C₆H₅O₇·H₂O 22 g, K₂SO₄ 5.2 g, CaHPO₄ 50 g, FeC₆H₅O₇·5H₂O 0.6 g, MnCO₃ 0.35 g, CuCO₃ 30 mg, CrK(SO₄)₂·12H₂O 55 mg, CoCl₂·6H₂O 10 mg, KI 1 mg, ZnCO₃ 160 mg.

into two dietary groups (eight subgroups): 1) control rats fed the normal diet (N rats, group #1), N rats treated with 0.1 mg Cd (group #2), 0.5 mg Cd (group #3), and 1.0 mg Cd (group #4); 2) Mg-deficient rats (D rats, group #5), D rats treated with 0.1 mg Cd (group #6), 0.5 mg Cd (group #7), and 1.0 mg Cd (group #8). The rats were placed in a plastic cage in groups of five. They were housed in a temperature (25°C) and light-controlled room (12 h light) as previously reported (6). Before Cd treatment the rats were given the normal diet or the Mg-deficient diet for 14 consecutive days (day −14). Subcutaneous injection of 0.1 ml of cadmium chloride (CdCl₂) in the backs of the animals given a normal diet or a Mg-deficient diet at the three doses of 0.1, 0.5, and 1.0 mg/kg body was performed twice a day (12-h intervals) (time-zero) for 7 consecutive days and then the animals were maintained without Cd treatment for an additional period of 20 days (+28 days). Food and distilled water were given ad libitum. Body weight was recorded on day −14, −5 (before treatment), 0, 3, 8, 24 days.

Blood pressure. Systolic blood pressure was measured between 0900–1200 am on conscious rats, after 10 min in a 30°C environment with a programmed electrosphygmomanometer system (Narco PE-300). The values reported were the average of 5 consecutive measurements on each animal as previously reported (15). Blood pressure was recorded on days −11, 0, 3, 8, and 24.

Daily urinary sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), and cadmium (Cd) excretion. The animals were placed in metabolic cages and urine was collected over a 24-h period on days 0, 3, 8, 24. Both Na and K concentrations in urine were determined with flame photometry. Urinary Ca, Mg, and Cd concentrations were determined with atomic absorption photometry.
daily water retention was measured on days 0, 3, 8, 24. The percent water retention was expressed according to the formula of Doyle et al. (16).

*Metal concentrations in organs.* Heart, abdominal aorta, lung, liver, and kidney of rats were removed on day 28, weighed and quickly frozen in liquid N₂ until assay. Ca, Mg, and Cd levels in the heart, lung, liver, and kidney were assayed with a flame atomic absorption photometer and those in the aorta were assayed with a flameless atomic absorption photometer (Hitachi polarized Zeeman atomic absorption spectro photometer (180-80) as previously related (15).

*ATP concentrations in heart.* ATP in the heart homogenized in Tris-HCl buffer (pH 7.4) was extracted by the methods of Glynn and Chappell (17). ATP was assayed by the bioluminescence method (18). Protein concentration in the heart was determined by the method of Lowry et al. (19).

*Food and water consumption.* Food and water consumption of all rats was recorded on days 0, 1, 5, and 24.

*Statistical analysis.* Data were evaluated by one-way and two-way analysis of variance for a 2 × 4 factorial design with randomized blocking by using a program BMDP 7D.

**RESULTS**

*Body weight gain* (Fig. 1)

Body weight gain in Mg-deficient rats (D rats) was significantly decreased from day 8. The effect of Cd treatment on body weight gain of the rats fed normal diet (N rats) were significant on days 3, 8, and 24. The Cd × Mg deficiency interaction was

![Fig. 1](image-url)
Mg DEFICIENCY ON BLOOD PRESSURE

Table 2. Effect of Mg-deficient diet on food consumption in cadmium-treated male rats on days 3 and 24.

| Cd (mg/kg) | 3 days | 24 days |
|-----------|--------|---------|
|           | N\textsuperscript{a} | D | N | D |
| 0         | 15 ± 2  | 11 ± 1  | 12 ± 1 | 12 ± 1 |
| 0.1       | 16 ± 1  | 12 ± 2  | 14 ± 1 | 15 ± 1 |
| 1.0       | 8 ± 1   | 3 ± 1   | 15 ± 2 | 11 ± 1 |

Each value is expressed as food consumption (g) per 24h. The data are X ± SE of 5 animals at each time-point. N, the rats fed the normal diet; D, the rats fed the Mg-deficient diet. \textsuperscript{a}Effects of Cd treatment are significant at p > 0.01.

Table 3. Effect of Mg-deficient diet on blood pressure in cadmium-treated male rats.

| Cd (mg/kg) | 3 days | 8 days | 24 days |
|-----------|--------|--------|---------|
|           | N\textsuperscript{a} | D | N\textsuperscript{a} | D | N\textsuperscript{a} | D |
| 0         | 131 ± 4.8 | 132 ± 6.5 | 139 ± 3.4 | 121 ± 3.2\textsuperscript{b} | 129 ± 2.0 | 114 ± 3.3\textsuperscript{b} |
| 0.1       | 126 ± 4.1 | 123 ± 3.0 | 128 ± 3.4 | 127 ± 2.5 | 125 ± 5.4 | 112 ± 4.6 |
| 0.5       | 131 ± 2.7 | 119 ± 4.7 | 132 ± 4.7 | 115 ± 7.2 | 127 ± 2.7 | 98 ± 3.6 |
| 1.0       | 109 ± 4.6 | 99 ± 7.8 | 111 ± 5.2 | 99 ± 8.9 | 145 ± 2.1 | 100 ± 2.9 |

Each value is expressed as millimeters of mercury of systolic blood pressure. The data are X ± SE of 5 animals at each time-point. N, the rats fed the normal diet; D, the rats fed the Mg-deficient diet. \textsuperscript{a}Effects of Cd treatment are significant at p < 0.01. \textsuperscript{b}An effect of Mg deficiency is significant at p < 0.01. \textsuperscript{c}The interaction between Cd treatment and Mg deficiency is significant at p < 0.01.

not significant. Food consumption in D rats was within the same range as the N rats on days 3 and 24 (Table 2). The effects of Cd treatment in food consumption of N rats were only significant on day 3 but the Cd × Mg-deficiency interaction was not significant.

\textbf{Blood pressure (Table 3)}

Blood pressure in D rats was significantly decreased from day 8 to 24 (Table 3). The effects of Cd treatment in N rats were significant on days 3, 8, and 24. Blood pressure in rats treated with 1.0 mg Cd was decreased on days 3 and 8. Thereafter these levels increased and were higher than that in N rats on day 24. The Cd × Mg-deficiency interaction in blood pressure was significant only on day 24.

\textbf{Urinary total Na, Ca, Mg, and Cd excretion and water retention (Table 4)}

Urinary total Na excretion and water retention in D rats were within the same
Table 4. Effect of magnesium-deficient diet on urinary sodium, calcium, magnesium, and cadmium excretion and water retention in cadmium-treated male rats.

| Diet          | Cd (mg/kg) | Na (μg) | Ca (μg) | Mg (μg) | Cd (μEq) | Water retention |
|---------------|------------|---------|---------|---------|----------|-----------------|
| Normal        | 0          | 333 ± 38| 335 ± 79| 1,267 ± 180 | ND       | 0.81 ± 0.04     |
| Mg deficient  | 0          | 340 ± 74| 244 ± 40 | 588 ± 125  | ND       | 0.79 ± 0.04     |
| Normal        | 0.1        | 203 ± 52| 502 ± 87 | 1,462 ± 135| 0.12 ± 0.01| 0.78 ± 0.06     |
| Mg deficient  | 0.1        | 200 ± 43| 248 ± 23 | 631 ± 87  | 0.09 ± 0.01| 0.80 ± 0.02     |
| Normal        | 1.0        | 442 ± 14| 304 ± 21 | 1,906 ± 194| 0.40 ± 0.06| 0.76 ± 0.03     |
| Mg deficient  | 1.0        | 316 ± 49| 158 ± 14 | 656 ± 67  | 0.13 ± 0.01| 0.80 ± 0.02     |

Each value is expressed as total urinary Ca, Mg, Cd (μg) and Na (μEq) excretion per 24 h on day 24. The data are X ± SE of 5 animals. The value of water retention is expressed by the formula: water intake (ml) - urine output (ml)/water intake (ml). N, the rats fed the normal diet; D, the rats fed the Mg-deficient diet. b An effect of Mg deficiency is significant at p<0.01. c The interaction between Cd treatment and Mg deficiency is significant at p<0.01.

range as those of N rats. Urinary total Ca and Mg excretion in D rats was significantly lower than that of N rats. The effects of Cd treatment on urinary total Ca and Mg excretion of N rats were not significant. The Cd × Mg-deficiency interaction in urinary Ca and Mg excretion was not significant. Urinary total Cd excretion in D rats treated with 1.0 mg Cd was lower than that in N rats treated with 1.0 mg Cd. The Cd × Mg-deficiency interaction in urinary Cd excretion was significant.

Tissue metal concentration

Cadmium (Table 5). Cd concentration in the aorta of D rats treated with 1.0 mg Cd was higher than that of N rats treated with 1.0 mg Cd. The Cd × Mg-deficiency interaction in aorta was significant.

Calcium (Table 6). Ca concentration in the heart and aorta of D rats was within the same range as that of N rats. The effects of Cd treatment on Ca concentration in the heart and aorta of N rats were not significant. Ca concentration in the aorta and heart of D rats treated with 0.5 and 1.0 mg Cd was higher than that in N rats treated with 0.5 and 1.0 mg Cd. The Cd × Mg-deficiency interaction in the heart and aorta was significant. Ca concentration in the kidney of D rats was markedly higher than that in N rats but the Cd × Mg-deficiency interaction was not significant.

Magnesium (Table 6). Mg concentration in the aorta and heart of D rats was within the same range as that of N rats. The Cd × Mg-deficiency interaction in aorta and heart was not significant.

Ca and Mg balance (Table 7). The effects of Cd treatment on the heart of N rats were not significant. The Ca and Mg balance tended to increase with Mg.
Table 5. Effect of magnesium-deficient diet on cadmium concentration in aorta, heart, lung, kidney, and liver of cadmium-treated rats.

| Cd (mg/kg) | N    | D  | Df | N    | D  | D  |
|-----------|------|----|----|------|----|----|
| Aorta     | 0.1  | 0.1| 0.1| 1.5  | 1.5| 1.5|
| Heart     | 0.1±0.1| 1.1±0.1| 1.5±0.1| 1.1±0.1| 1.5±0.1| 1.5±0.1|
| Lung      | 0.2±0.04| 0.2±0.04| 0.2±0.04| 0.2±0.04| 0.2±0.04| 0.2±0.04|
| Kidney    | 0.3±0.02| 0.2±0.03| 0.3±0.02| 0.2±0.03| 0.3±0.02| 0.2±0.03|
| Liver     | 0.4±0.05| 0.4±0.05| 0.4±0.05| 0.4±0.05| 0.4±0.05| 0.4±0.05|

Each value is expressed as µg/g of wet tissue on day 28. The data represent X±SE of 3 animals. D, the rats fed Mg-deficient diet; Df, the rats fed the Mg-deficient diet; D, the rats fed the normal diet; N, the rats fed the normal diet. The interaction between Cd treatment and Mg deficiency is significant at p<0.01.

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Table 6. Effect of magnesium-deficient diet on calcium and magnesium concentrations in cadmium-treated male rats.

| Cd (mg/kg) | Metal Ca | Aorta | Heart | Lung | Kidney | Liver |
|-----------|----------|-------|-------|------|--------|-------|
|           |          | N     | D     | N    | D      | N     | D     |
| 0         | 68 ± 16  | 58 ± 9| 5.5 ± 0.03 | 6.2 ± 1.6| 19.5 ± 6.7 | 27.9 ± 5.4| 10 ± 1| 153 ± 22b| 6.1 ± 0.2| 8.1 ± 0.9|
| 0.1       | 39 ± 4   | 37 ± 1| 5.7 ± 0.3 | 8.5 ± 0.5| 25.2 ± 8.0 | 23.3 ± 4.5| 12 ± 2| 103 ± 21| 5.6 ± 0.7| 7.9 ± 1.0|
| 0.5       | 51 ± 10  | 113 ± 18| 4.1 ± 1.0 | 7.4 ± 0.6| 28.4 ± 5.8 | 25.2 ± 4.5| 7 ± 2| 182 ± 60| 5.7 ± 0.4| 5.1 ± 0.2|
| 1.0       | 61 ± 7   | 147 ± 30| 4.4 ± 0.5 | 6.8 ± 1.3| 20.2 ± 6.3 | 22.9 ± 5.2| 9 ± 1| 218 ± 90| 5.6 ± 0.4| 7.3 ± 0.5|

|           | Mg       | N     | D     | N    | D      | N     | D     | N     | D     |
|-----------|----------|-------|-------|------|--------|-------|-------|-------|-------|
| 0         | 247 ± 84 | 209 ± 42| 91 ± 11 | 88 ± 25| 198 ± 14 | 177 ± 33| 219 ± 4 | 185 ± 73| 279 ± 10 | 272 ± 38|
| 0.1       | 255 ± 79 | 114 ± 14| 98 ± 8  | 98 ± 5 | 166 ± 16 | 165 ± 18| 219 ± 5 | 209 ± 12| 261 ± 15 | 278 ± 28|
| 0.5       | 186 ± 33 | 307 ± 128| 80 ± 12 | 88 ± 5 | 164 ± 9  | 147 ± 10| 142 ± 16| 181 ± 5 | 251 ± 13| 230 ± 21|
| 1.0       | 304 ± 87 | 310 ± 143| 89 ± 9  | 86 ± 9 | 163 ± 16 | 152 ± 15| 216 ± 8  | 236 ± 39| 274 ± 3 | 271 ± 24|

Each value is expressed as μg/g of wet tissue on day 28. The data represent X ± SE of 5 animals. N, the rats fed the normal diet; D, the rats fed the Mg-deficient diet. b An effect of Mg deficiency is significant at p < 0.01. c The interaction between Cd treatment and Mg deficiency is significant at p < 0.05.
Table 7. Effect of magnesium-deficient diet on Ca/Mg, weight, and ATP concentration in the heart of cadmium-treated rats.

| Cd (mg/kg) | Ca/Mg | Weight | ATP |
|------------|-------|--------|-----|
|            | N: 6.3±0.7 | D: 7.3±0.8 | N: 0.85±0.01 | D: 0.64±0.06 |
| 0          | 6.3±0.7   | 7.3±0.8 | 0.85±0.01 | 0.64±0.06 |
| 0.1        | 5.9±0.4   | 8.6±0.3 | 0.89±0.01 | 0.74±0.05 |
| 0.5        | 5.2±0.4   | 8.5±0.7 | 0.90±0.03 | 0.78±0.01 |
| 1.0        | 5.0±0.3   | 8.3±2.2 | 0.82±0.04 | 0.70±0.02 |
|            | N: 16.2±2.3 | D: 10.3±3.0 | N: 44.0±5.3 | D: 13.4±3.5 |
|            | 16.2±2.3  | 10.3±3.0 | 44.0±5.3 | 13.4±3.5 |
|            | 12.0±1.1  | 9.4±0.8 |

Each value of Ca/Mg, weight, and ATP is expressed as %, g of wet tissue, and pmol per mg protein, respectively, on day 28. The data represent X±SE of 5 animals. N, the rats fed the normal diets; D, the rats fed the Mg-deficient diet. a Effects of Cd treatment are significant at p<0.05. b An effect of Mg deficiency is significant at p<0.01.

deficiency in the heart of D rats treated with Cd. However, the Cd × Mg-deficiency interaction in Ca and Mg balance was not significant.

Heart weight and ATP content (Table 7). Heart weight of D rats was significantly lower than that of N rats. The effects of Cd treatment in the heart weight of N rats were not significant. The effects of Cd treatment on ATP content were significant but the Cd × Mg-deficiency interaction in ATP content was not significant.

DISCUSSION

The present study demonstrated that Mg deficiency lowers the blood pressure in Mg-deficient rats (D rats) and this response is more pronounced in D rats treated with Cd. Mg deficiency enhanced the decreased body weight gain in D rats treated with Cd on day 24 though no enhancement of the decreased food consumption in those rats was observed. These results suggest that an enhancement of the decreased body weight gain by Mg deficiency in D rats treated with Cd cannot be ascribed to the decreased food consumption. It may be an enhancement of the reduced food efficiency in Cd-treated rats by Mg deficiency. Treatment with 1.0 mg Cd at first lowered blood pressure, but eventually produced an elevation of the blood pressure in the rats fed the normal diet (N rats). However, Mg deficiency protected against the increased blood pressure and lowered the blood pressure in N rats treated with 1.0 mg Cd on day 24. The mechanisms by which Mg deficiency enhances the decreased blood pressure of D rats treated with Cd remain unexplained. The regulation of blood pressure is a complex process, involving a variety of independent regulatory mechanisms. Water and sodium (Na) retention are important factors for controlling the blood pressure (20). In our present study, the increased urinary Na excretion and the decreased water retention was not observed.
in the D rats; the response was not pronounced in the D rats treated with Cd. These results suggest that an enhancement of the decreased blood pressure in Cd-treated rats by the Mg deficiency is not responsible for the decreased water retention.

Some workers have observed cardiotoxic effects in the rats with about 5 ppm Cd in cardiac tissue (21, 22). This value which may produce cardiotoxicity is higher than that of our present findings (1 ppm). Cd itself did not affect the ATP concentration, heart weight, and Ca and Mg balance (Ca/Mg) except for the ATP concentration in rats treated with 0.1 mg Cd. These results suggest that cardiotoxicity may not occur in Cd-treated rats. However, Jamall and Smith (21) have reported that Cd treatment of rats maintained on a low-selenium (Se) diet produces a significant increase in specific heart weight together with histopathological changes. Based on their studies, they have assumed that the absolute Cd concentration in the heart may not be as critical to the development of cardiotoxicity as the concentration of Cd relative to concentrations of Se and Cu and perhaps other essential trace elements. Myocardial calcification through Ca influx into the cardiac myocytes may be an important mechanism of cardiac injury (23). Increase in Ca/Mg in the heart produces myocardial necrosis but the decrease in this balance prevents the production of cardiac necrosis (24). In our present study, Mg deficiency increased Ca concentration in the heart and aorta of the D rats treated with Cd. Mg deficiency also increased Cd concentration in the aorta of D rats treated with 1.0 mg Cd. These results suggest that Mg deficiency may increase the overload of Ca in the heart and aorta of D rats treated with Cd, which may in turn lead to enhancement of the Cd-induced cardiotoxic effects though Cd concentration in the heart of D rats treated with Cd was within the same range as that of N rats treated with Cd. The decreased urinary total Ca and Cd excretion in D rats treated with Cd may result from the increased Ca and Cd concentrations in body burden. Enhancement of Cd-induced cardiotoxic effects by Mg deficiency may be factors for the pronounced lower blood pressure in D rats treated with Cd.

Several recent studies point to a causal relation between the decreased concentration of Mg$^{2+}$ ion in blood or tissue and hypertension (9). In experimental animals, Altura et al. (11) have reported that rats maintained for 12 weeks on Mg-deficient diet show reduced lumen sizes of terminal arterioles, precapillary sphincters, and venules which leads to the elevation of arterial blood pressure compared to control animals. However, Itokawa et al. (10) have showed that Mg-deficient diet significantly lowers the blood pressure in male rats. They have postulated that peripheral vasodilatation symptoms associated with their Mg deficient rats may be due to the increase in blood serotonin levels. We have already reported that the lowered blood pressure in Mg-deficient diets is probably associated with a marked decrease in total peripheral resistance (25). Our present study supports Itokawa’s findings. There is a discrepancy between the theories pointed out by others regarding these phenomena. Some workers have suggested that Ca and Mg balance plays a more important role than absolute Ca and Mg concentration in heart and aorta for the regulation of blood pressure (10, 26). There is a large differences in Mg
concentration between our Mg-deficient diet and Altura's diet. The Mg-deficient diet in our present study has a Mg concentration and Ca/Mg ratio of 0.001% and 108, respectively, (observed concentration) while Altura's diet contains 0.01% and 70. These large differences between our diet and their diet may be a factor in the discrepancy pointed out by others in Mg-induced alteration in blood pressure.

We thank Professor Yoshinori Itokawa and Associate Professor Mieko Kimura of Kyoto University for their advice in the preparation of the Mg-deficient diet. We also thank Professor John DeFeo of the University of Rhode Island for correcting the manuscript. We thank Associate Professor Hisakazu Ogura of Kochi Medical School for his advise regarding the computer program for the analysis of variance in the Center of Medical Information Science and Dr. Atuhiro Nakano of the National Institute for Environmental Studies for his advice in the assay of metals. This study was supported in part by a grant from the Ministry of Education, Science and Culture of Japan (# 59770366).

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