EFFECTS OF Mg AND K DEFICIENCY ON MALE AND FEMALE MICE

Momoko CHIBA*, Hiromi WATANABE*, Atsuko SHINOHARA*,
Yutaka INABA*, Samaisukh SOPHASAN** and Hitoshi ENDOU***

*Department of Epidemiology and Environmental Health, Juntendo University School of Medicine, Tokyo 113, Japan.
**Department of Physiology, Faculty of Sciences, Mahidol University, Bangkok 10400, Thailand.
***Department of Pharmacology and Toxicology, Kyorin University School of Medicine, Tokyo 181, Japan

Sudden unexplained death syndrome (SUDS) is characterized by prime healthy male adults. In 1980s, SUDS has attracted much attention in Singapore, because it happened among construction workers there. The major victims were foreign workers, e.g. villagers from north-east Thailand. We started collaboration of the research work with Thai physicians and scientists since 1991. At first we hypothesized K deficiency as a main cause. When this project was proceeded for a few years, however, we considered that Mg deficiency might play an important role in addition to K deficiency from our analytical results of human samples, food and environmental materials [1]. We tried, therefore, animal experiments to observe the effects of Mg and/or K deficiency on male and female mice.

MATERIALS AND METHODS

Male and female ICR mice were purchased at 7 weeks old. They were housed in the climatic chamber which was maintained at 23±0.5°C, 60±5% and 7:00-19:00 light, 19:00-7:00 dark cycle. After 1 week housing, both male and female mice were divided into 2 groups. Each group consisted of 10 mice. Mice in Group A were given Mg- and K-deficient diet and K was supplemented through drinking water, and those in Group B were given normal diet under pair feeding and deminerlalized water for drinking. The following parameters were determined; (a) mortality rate and body weight, (b) Mg, K, Ca, Co, Cu, Fe, Mo, and Zn concentrations in blood and various organs by atomic absorption spectrometry or microwave induced plasma mass spectrometry [2], (c) lipid peroxides in liver using the method of thioiberbituric acid [3], (d) Mn-SOD and Cu/Zn-SOD activities in liver using nitrous acid method [4], and (e) GSH and GSSG concentrations in liver by DTNB-glutathione reductase recycling method [5].

RESULTS AND DISCUSSION

Mortality rate and body weight

As shown in Fig. 1, male mice in Group A started dying after 1 week, and three of them survived after 2 weeks, whereas no female mice in this group died within 2 weeks. Ave- rage body weight in Group A decreased signif- icantly after one day of starting the experi- ments. In average body weight on the day 7th in Group A, females by 5 g and males by 6 g were smaller than those in the correspond- ing controls.

In a following series of the experiments, male and female mice on the day 7th in Group A were used for analyzing parameters. Mice on the 1st or 3rd days were also sacrificed, when the changing levels of the parameters were observed with a lapse of time.

Correspondence: Momoko CHIBA

Fig. 1. Survival rate of Group A.

Concentrations of elements

In Group A, Mg-concentrations were significantly low in plasma, RBC, and bone of both sexes, as well as in liver, brain, and muscle of males. No remarkable change was observed in kidney and heart in both sexes. This fact may explain that Mg might be mobilized mainly from bone to heart and kidney in which Mg has an important role. Mg concentrations in liver, muscle, and brain in males were significantly lower than that in
controls, while in females that in liver did not change, and that in brain and muscle showed tendency to decrease. The results are shown in Fig. 2 as the ratios to the values in controls. K concentrations were decreased in plasma and muscle of both sexes, and in liver and kidney of males (data not shown), although K was supplemented through drinking water. This result may explain that supplementation of K might be insufficient, and that mice might not take enough drinking water because of taste or the other reason. Water consumption in Group A was about 1 ml/mouse a day less than in Group B. This means that mice in Group A had partial K deficiency in addition to Mg deficiency. The concentrations of Co and Mo in liver of Group A were noticed; the former increased and the latter decreased significantly in both sexes. Concentrations of Cu, Ca and Mn in addition Mg in liver of Group A were significantly low in males only, that of Fe was significantly high in females only in comparison with those in Group B (control). In all element concentrations deter-

![Fig. 2](image1)

**Fig. 2.** Mg concentration ratio in various organs of Group A Significant difference to the controls m(male); p<0.05, f(female); p<0.05.

![Fig. 3](image2)

**Fig. 3.** Element concentration ratio in Liver of Group A.

![Fig. 4](image3)

**Fig. 4.** Lipid Peroxide in Liver of Group A (**p<0.01 to the controls).
mined in liver of Group A, the values in males were lower than in females (Fig. 3).

**Lipid peroxides**

As shown in Fig. 4, increase of lipid peroxides in liver of Group A was observed in both sexes, but in males it increased remarkably on the 1st day, then became to the normal level, and in females it increased on the 7th day. The values in the controls were kept almost the same level to the day 0 during observing period. Duration of maintaining the normal level after starting the experiment was longer in females than in males.

**Mn- and Cu/Zn-SOD**

Change of the activities of both Mn- and Cu/Zn-SOD in liver of Group A was not remarkable in both males and females (data not shown).

**GSH and GSSG**

GSH concentrations in liver of Group A on the 7th day decreased, and GSSG concentrations increased at the same period. Sex difference was not clear in both GSH and GSSG, although the probability levels in statistical analysis were different (Fig. 5).

It is estimated that the ability of antioxidative function was not severely impaired in the treated mice from the results of lipid peroxides, SOD activities, and GSH and GSSG. From the above findings including the changes of the levels of the element concentrations, it is considered that the function for homeostasis in males may be more frail than in females. As to the sex difference, our recent experimental results suggested participation of sex hormone, because the survival rates of both sexes were not different after castration of males and females. Further more, partial deficiency of K in addition to Mg deficiency was more serious than single Mg deficiency especially in males from our recent results, since the mortality rates of the male and female mice given single Mg deficient diet were identical.

Although at present, we cannot point out concretely what the cause of SUDS is, we recommend that in order to prevent the essential elements such as Mg and K must be supplied to maintain within the necessary levels in the body. Further works will enable this notion to be reliable.

**CONCLUSION**

1. In Mg- and K-deficient mice, decreases of Mg concentrations in blood and organs were more prominent in males than in females except heart and kidney.
2. The concentrations of transition elements such as Co, Fe, and Mo in liver were influenced by Mg and K deficiency.
3. Susceptibility to oxidative stress was more sensi-

![Fig. 5. GSH and GSSG on the Day 7th in Liver of Group A (*p<0.05, **p<0.01 to the controls).](image-url)
tive in males than in females.

4. Functions for keeping homeostasis were more friable in males than in females. These was correlated with the mortality rates.

REFERENCES


