Skeletal Muscle Magnesium and Drinking Water Magnesium Level

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Zusammenfassung

Der Einfluß der Magnesiumkonzentration im Trinkwasser auf den Magnesiumgehalt des Körpers wurde in einer Studie an 49 Personen in 2 Städten mit unterschiedlichen Mg-Gehalten des Trinkwasser (5,7 bzw. 1,7 mg Mg/l) untersucht.
Die Magnesiumzufuhr über Lebensmittel, die mittels Fragebögen geschätzt wurde, war in beiden Gruppen gleich. Die Aufnahme von Magnesium mit dem Trinkwasser war signifikant höher in der Stadt mit höherem Magensiumgehalt. Die Magnesiumkonzentration der Skelettmuskulatur war signifikant höher bei Personen aus der Stadt mit dem höheren Trinkwassergehalt.

Summary

The importance of magnesium in drinking water for the magnesium content in the body was studied in 49 persons in 2 cities with 5.7 and 1.7 mg Mg/l in drinking water.
The intake of magnesium in food evaluated with a questionnaire was the same in the 2 areas. The intake of magnesium in drinking water was significantly higher in the area with higher water magnesium. Skeletal muscle magnesium levels ware significantly higher in the group living in the area with higher water magnesium.

Résumé

La contribution de la teneur en magnésium de l'eau potable au taux de magnesium de l'organisme humain a été étudiée chez 49 inhabitants de deux villes ayant des niveaux de magésium de 5.7 et 1.7 mg/l dans l'eau potable.
Grace à un questionnaire on a pu évaluer la consommation en magenesium dans la nourriture: elle était la même pour les habitants des deux villes. La teneur en magnesium d'une biopsie de muscle squelettique était significativement plus élevée dans le groupe de personnes habitant dans la ville avec le niveau de magnésium dans l'eau potable plus élevé.

Introduction

Several authors have demonstrated a relation between water hardness and cardiovascular death rates (3). It has been suggested that the reason for the higher death rate in cardiovascular disease in soft water areas is the lower amount of magnesium in the drinking water (11).
Magnesium is important for many enzymatic reactions in man (14) and the ion is essential for contractility in all muscle cell types. Magnesium is absorbed in the small intestine and to 60 % found intracellularly (1).
Magnesium in water accounts only for a small part of the total intake of magnesium which is particularly abundant in vegetables, cereals and certain specific food items such as nuts.
A pilot study was undertaken to evaluate the relation between the body content of magnesium and the intake via food or water. The body content of magnesium was determined using skeletal muscle biopsy (4) and food water intake of magnesium was determined using a simple food frequency questionnaire.

Material and Methods

Subjects

Fortynine healthy middle-aged men (n = 29) and women (n = 20), mean age 58.5 + 5.5 years participated in the study. 29 subjects (17 men and 12 women) lived in Gothenburg, Western Sweden, among whom 24 % were smokers. Twenty individuals (12 men and 8 women) lived in Malmö, Southern Sweden. There were 15 % smokers in this group. Nobody was on medical treatment or excessively physically active.
The amount of magnesium in food was estimated using a food frequency questionnaire. The participants were asked how often (seldom or never, one or a few times/month, one or a few times/week, every or almost every day, several times/day) they consumed 26 different food items of importance for the magnesium intake. The amount of magnesium was calculated using an index for each food item and a standard size portion as a baseline. An intake of less than 5 mg/day was given the index 0,5–9 mg/day the index 0.5 and more than 10 mg Mg/day 1 for each unit of 10/day.
The questionnaire asked for the number of glasses of water drunk every day — each glass was considered as 200 ml and the water intake of magnesium was calculated. Consumption alcohol was asked for but information of tea or coffee was not included. Average alcohol consumption was 33 cl beer with 1.8 vol.% alcohol content daily and 37 cl strong liquor per month. Nobody drank excessive amounts of alcohol or had

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alcohol problems. The amount of magnesium in the drinking water was obtained from the water works in the two cities.

Muscle biopsy technique and estimation of muscle magnesium

Needle muscle biopsies were performed under local anaesthesia in the left vastus lateral muscle (2). The muscle biopsy of 10-20 mg wet weight was freeze-dried, after which blood, connective tissue and fat were carefully removed and the specimen reweighed. Measurements of Mg in mmol/100 g fat-free dry weight was performed with an atomic absorption spectrophotometer (*Perkin Elmer,* 372, HGA-87B) at 8 a. m. the following day (13). The calculation and reproducibility have been described earlier (9).
The study was approved by the Ethical Committee of the Gothenburg University and all participants had given their consent.

Statistical methods

Mean values, standard deviations and linear regressions were calculated with conventional methods. Differences between groups were tested with Mann-Whitney U-test.

Results

The results are reported in tab. 1. The amount of magnesium in drinking water was 5.7 mg/l in Malmö and 1.7 mg/l in Gothenburg.
The water magnesium intake using data from the questionnaire was higher in the Malmö group than in the Gothenburg group ($p < 0.01$). There were no significant differences in food magnesium intake between the subjects in the 2 cities.
Skeletal muscle magnesium was higher in the group in Malmö as compared to the Gothenburg group ($p < 0.05$).
Regarding individual data, muscle magnesium was positively correlated to dietary magnesium intake, ($p < 0.05$) but not significantly correlated to water magnesium intake.
There were no significant differences between smokers and non-smokers concerning magnesium intake or skeletal muscle magnesium levels. Muscle magnesium was higher among women with 4.1 ± 0.2 mmol/100 g fat-free dry weight compared to men with 3.8 ± 0.3 mmol/100 g ($p < 0.01$). No differences were found between men and women concerning dietary or water magnesium intake.

Discussion

Muscle magnesium levels in this study were comparable to those among healthy subjects in other studies (13, 8, 5). The results show that the body content of magnesium was related to the magnesium intake via the food as evaluated with a single food frequency questionnaire but not to water. The precision of the questionnaire data for water intake is however uncertain as not questions were asked on coffee or tea consumption. Unusual food items not included in the questionnaire but containing magnesium could have been consumed by some test persons and influenced the results.
The major finding in the study is that 2 population groups living in areas with different content of water magnesium had significantly different levels of muscle magnesium. The differences were not large but the difference in water magnesium was also relatively small.

The reason why a relatively minor portion of the magnesium intake — that in water — can influence the body content of magnesium is not clear. Preliminary data demonstrate that within the variations in magnesium content of water found in this study, the magnesium content of water used for cooking food does not influence its content of magnesium (*Sandström* and *Bonevik,* unpublished).

A possible explanation is that magnesium in water is more readily absorbed whereas magnesium in food particularly in meals which account for a high proportion of food magnesium, is more tightly bound. It has previously been shown that the uptake of zink is higher from a water solution as compared to the uptake from food (12). Whether the same phenomenon applies for magnesium remains to be shown.

Magnesium influences the electrolyte exchange across the skeletal muscle membrane where sodium is exchanged for potassium via a magnesium dependent ATP-ase (14). Previous studies have shown a deteriorated sodium/potassium-ratio in the skeletal muscle in obese glucose intolerant men but not in women (10). The higher muscle magnesium among women compared to men in this study supports this finding. Also a disturbed sodium/potassium-pump is a major cause of serious cardiac arrhythmias and sudden deaths (6). A concomitant reduction of both muscle potassium and magnesium was associated with an impaired glucose tolerance (8). The link between glucose intolerance, hypertension and coronary artery disease is well known (7).

Tab. 1: Intake of magnesium in drinking water and food evaluated with questionnaires and skeletal muscle magnesium content. Mean values ± SD.

	GOTHENBURG	MALMÖ	
Number of persons	29	20	
Water magnesium intake mg/l	5.2 ± 3.4	14.2 ± 13.8	p < 0.01
Food magnesium index	19.5 ± 7.6	17.2 ± 6.1	ns
Muscle magnesium mmol/100g fat-free dry weight	3.9 ± 0.3	4.1 ± 0.2	p < 0.05

The higher incidence of cardiovascular deaths in soft water areas (low water magnesium) (3) and the benefit of magnesium substitution in magnesium depleted, diuretic treated hypertensive patients (5) further support the hypothesis of magnesium intake being essential for the homeostasis in man.

This study is based on a small material and the difference in magnesium levels in the drinking water between the two cities studied was relatively small. The results suggest however that water magnesium is of importance for the body content of magnesium. In view of the important implications for public health, further studies concerning this relationship are required.

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