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The influence of chosen metals administration in drinking water on magnesium balance in rats

Chromium, lead and aluminium, because of their wide-spread application belong to environmental pollutants. Their presence in organism can produce many negative effects. Chromium occupational exposure causes allergic and cardiac disorders (4), although on the other hand, this element is used as a constituent of drugs (9). Lead is one of the most toxic metals. It plays no role in metabolism. Lead exposure conducts to nervous system disturbances, hepatic and renal disorders (3). Aluminium exerts neurotoxic influence and combines with biologically important compounds (5). The Al exposure is associated not only with its presence in food but also with the treatment of patients with antacids (5). Magnesium homeostasis keeping is the problem of great importance for organisms (15). It is the essential element in the cell metabolism. When the speed of metabolism increases, the organism requires larger amounts of this element (14). The reported facts and dependencies made us investigate the influence of chromium, lead and aluminium administration in drinking water on the magnesium level in serum and tissues of rats.

MATERIAL AND METHODS

Our study was carried out on two-months-aged, male Wistar rats (180–210 g). They were divided into four groups (12 animals each): III-Cr, II-Pb, I-Al – received water solutions of $Cr(NO_3)_3 \cdot 9H_2O$, $Pb(NO_3)_2$ and $Al_2(SO_4)_3 \cdot 18H_2O$ respectively, in the form of drinking water, at the concentration of 500 mg of metal $\cdot$ dm^{-3}; control group – received redistilled water.

A half of animals of each group were killed after three weeks and the rest after six weeks. Each time the rats were sacrificed under ketamine narcosis and blood from the heart as well as the tissues of the liver, kidney, femoral muscle, brain, spleen and heart muscle were collected. Serum was separated. Tissue homogenates 10% (w/v) were prepared in 0.1 mol $\cdot$ dm^{-3} Tris-HCl buffer, pH = 7.4. Supernatants were obtained by centrifugation at 5000 x g for 30 min.

In serum and supernatants magnesium concentration by the reaction with xylidyl blue (diagnostic set Liquick Cor-MG 60) was measured using the colorimetric method. Wave length was 520 nm. The assays were carried out with the help of SPECORD M40 (Zeiss Jena) spectrophotometer. Comparisons between control and tested groups were made using t-Student test. Values were considered significant with $p < 0.05$.

RESULTS

Magnesium level vs. control in serum was influenced mainly by aluminium enhanced after three weeks and decreased after six weeks. Pb intoxication increased Mg concentration vs. control after six weeks whereas Cr caused no changes (Table 1). In the liver Al decreased Mg level vs. control only after three weeks, lead and chromium enhanced it – Pb after six weeks, Cr – during all the experiment (Table 2). In the kidney chromium and aluminium influenced the Mg level vs. control only after six weeks – Cr depressed, Al enhanced. Pb increased Mg concentration vs. control after three weeks only (Table 2). In the brain only lead and aluminium affected the Mg level vs. control after six weeks – Pb depressed, Al enhanced (Table 3). In the spleen Pb and Al enhanced Mg concentration vs. control after

Table 1. Magnesium concentration in serum of rats receiving Cr, Pb and Al in drinking water

Group	Magnesium concentration mmol • dm^{-3}	
	after 3 w. mean ± SD	after 6 w. mean ± SD
III - Cr	1.17 ± 0.11	1.61 ± 0.14
II – Pb	1.18 ± 0.13	2.09 ± 0.22 *
I – Al.	1.32 ± 0.14 *	0.89 ± 0.12 *
Control	1.08 ± 0.11	1.46 ± 0.17

Statistical significance vs. control * $p < 0.05$

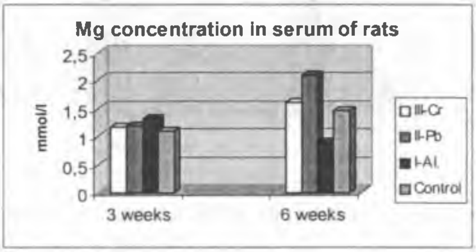
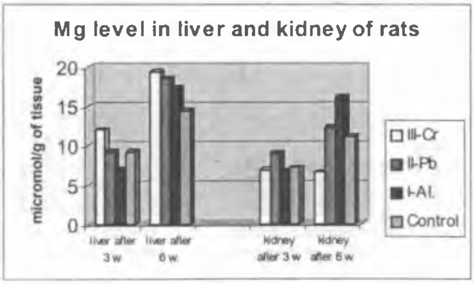


Table 2. Magnesium concentration in liver and kidney of rats receiving Cr, Pb and Al in drinking water

Group	Magnesium concentration µmol • g^{-1} of tissue			
	liver		kidney	
	after 3 w. mean ± SD	after 6 w. mean ± SD	after 3 w. mean ± SD	after 6 w. mean ± SD
III - Cr	12.0 ± 1.5 *	19.4 ± 2.0 *	6.9 ± 1.0	6.6 ± 0.9 *
II – Pb	9.2 ± 1.1	18.6 ± 1.8 *	9.0 ± 1.1 *	12.3 ± 1.4
I – Al.	6.9 ± 0.8 *	17.3 ± 1.8	6.7 ± 0.8	16.2 ± 1.4 *
Control	9.2 ± 1.1	14.5 ± 1.6	7.2 ± 1.0	11.2 ± 1.4

Statistical significance vs. control* $p < 0.05$



three weeks and diminished after six weeks. Chromium administration resulted in no changes (Table 3). In the femoral muscle Cr and Pb increased the Mg level vs. control after six weeks, Al decreased after three weeks. In the heart muscle Cr and Al enhanced Mg vs. control after six weeks, whereas Pb caused no changes (Table 4).

Table 3. Magnesium concentration in the brain and spleen of rats receiving Cr, Pb and Al in drinking water

Group	Magnesium concentration μmol • g^{-1} of tissue			
	brain		spleen	
	after 3 w. mean ± SD	after 6 w. mean ± SD	after 3 w. mean ± SD	after 6 w. mean ± SD
III - Cr	4.2 ± 0.6	12.3 ± 1.5	6.7 ± 0.9	14.2 ± 1.8
II – Pb	3.9 ± 0.6	10.2 ± 0.9 *	13.5 ± 1.8 *	12.4 ± 1.4 *
I – Al.	3.5 ± 0.6	15.3 ± 1.6 *	8.0 ± 1.0 *	10.3 ± 1.0 *
Control	4.5 ± 0.7	12.4 ± 1.4	6.5 ± 0.7	15.1 ± 1.4

Statistical significance vs. control* $p < 0.05$

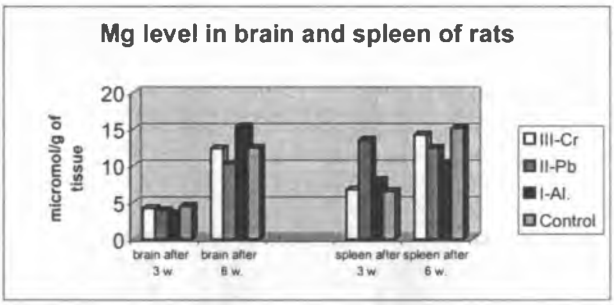
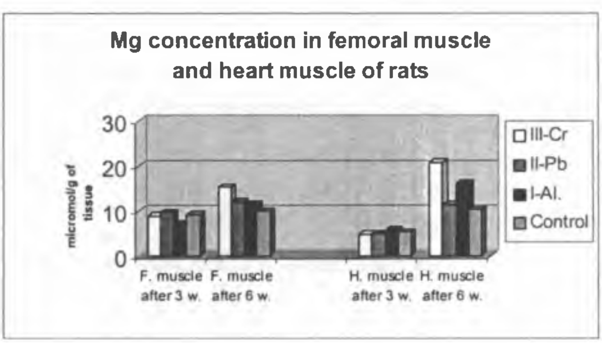


Table 4. Magnesium concentration in the femoral muscle and heart muscle of rats receiving Cr, Pb and Al in drinking water

Group	Magnesium concentration μmol • g^{-1} of tissue			
	femoral muscle		heart muscle	
	After 3 w. Mean ± SD	After 6 w. Mean ± SD	After 3 w. Mean ± SD	After 6 w. Mean ± SD
III - Cr	8.8 ± 0.7	15.3 ± 1.6 *	4.7 ± 0.6	20.8 ± 1.9 *
II – Pb	9.6 ± 1.0	12.0 ± 1.1 *	5.0 ± 0.6	11.4 ± 1.4
I – Al.	7.1 ± 0.7 *	11.4 ± 1.1	5.7 ± 0.5	16.1 ± 1.4 *
Control	9.2 ± 1.0	9.9 ± 0.9	5.3 ± 0.5	10.2 ± 1.0

Statistical significance vs. control* $p < 0.05$



DISCUSSION

In our investigations we observed that chromium administration influenced magnesium in tissues to some degree only. H a n s s o n et al. found that in patients with rheumatoic arthritis chromium blood level was significantly lower while magnesium was not different from the control group (8). In another study the goats received Cr-deficient diet during 84 weeks. The magnesium level in the liver was slightly decreased whereas in the kidney and rib it was increased. The changes, particularly in soft tissues, were not very remarkable (7).

The referenced investigations confirm our observations that chromium does not affect significantly the magnesium balance in the organism. It can be connected with the fact that magnesium supplementation causes the depletion of chromium contents in organism (4), so when the Mg level in the organism is sufficient, Cr can be excreted.

Lead influenced the magnesium level in serum and tissues particularly after six weeks. In the first part of intoxication Mg concentration was unchanged or enhanced (kidney, spleen). The longer intoxication caused the increase of serum Mg, whereas in tissues the concentration of this element changed in different ways. These dependencies point to lead administration-induced disturbances of magnesium balance.

S i n g h undertook the investigations on the influence of magnesium supplementation on lead toxicity in rats. The rats were given lead for 62 days and then the administration was over. A half of animals were killed while the rest was sacrificed after next 44 days without Pb intoxication. Mg content in tissues increased after discontinuation of Pb treatment (13). B r z ó s k a et al. studied the influence of lead exposure at the concentration of 500 ppm for six weeks. As a consequence of intoxication Mg concentration vs. control in serum and spleen was diminished, in the liver, kidney and femur remained unchanged (3). We noticed similar results in the case of the spleen and kidney after six weeks. B i e l a k et al. studied the influence of lead on magnesium balance in rats with alloxan diabetes. The combination of diabetes and Pb intoxication for four weeks caused the decrease of Mg level vs. diabetes group in serum and kidney and its increase in the liver (2). We obtained the same result in the liver after six weeks. P a s t e r n a k et al. studied in turn the effect of Pb administration for the period of four weeks on Mg concentration in serum and tissues of rats with hyperthyroidism. In serum, kidney, brain and liver Pb intoxication caused Mg level increase in comparison with thyroxine group, although in the case of serum and brain the changes were very slight (11). This work confirms our results observed after six weeks in the liver and after three weeks in serum and kidney. M o n i u s z k o - J a k o n i u k et al. studied the impact of Pb administration on status of chosen elements in rats. The water solution containing 500 ppm Pb was administered for 12 weeks. Mg concentration vs. control in serum, tissues (the same as in our work) and femur was not changed. Only in the liver a little increase was obtained but it was not significant (10). We obtained the unchanged Mg level after longer, six weeks' intoxication in the kidney and heart muscle.

Aluminium affected Mg concentration vs. control in serum and spleen during all the experiment – at first caused its increase and later decrease. In other tissues the Mg level was restored after decrease or enhanced after maintaining unchanged. It suggests that in most of the tissues Al administration contributed to the magnesium retention tendency. S á n c h e z et al. undertook studies on effects of aluminium administration for six and a half months on different elements levels in tissues of rats in relation to age. In young (21 days at arrival) rats Mg level was depressed in bone. In old (16 months at arrival) rats increased Mg concentration in the liver and spleen was observed. No changes were observed in adult rats (eight months on arrival) (12). Y a s u i and O t a studied the influence of low Ca, high Al diet on magnesium concentration in the bone and central nervous system. Their investigations indicated that such a diet diminished Mg in the bone and CNS (16). F i e j k a et al. studied the effect of intraperitoneal Al administration on Mg concentration in the liver. The five weeks' intoxication was followed by administration of 0.9% NaCl for two weeks. Mg level vs. control significantly enhanced (6). We observed the increased Mg vs. control in the liver after six weeks but it was not significant. Bellés et al. carried out the investigations concerning the impact of oral aluminium administration for 20 days on elements status in pregnant and nonpregnant rats. In nonpregnant rats the Mg level was unchanged in the liver, spleen, kidney and brain (1). After shorter, three weeks' intoxication we observed no change in Mg concentration in the brain and kidney. In the liver it was decreased and in the spleen enhanced but not very much.

CONCLUSIONS

1. Chromium influenced the Mg level only in some tissues, mainly as a consequence of longer, six weeks' administration, causing predominantly its increase.
2. Lead also influenced Mg concentration in serum and tissues particularly after six weeks. The changes were depending on tissue.
3. Aluminium influenced Mg concentration in serum and tissues, contributing the magnesium storage tendency in most of tissues as a consequence of longer, six weeks' intoxication.
4. The increase of the magnesium level in the tissues subsequent to the longer exposure to chromium and aluminium can be related to the preventing action of this element against the metals toxicity.

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SUMMARY

The aim of our study was to estimate the influence of chromium, lead and aluminium on the magnesium level in serum and tissues of rats. Male Wistar rats received Cr, Pb and Al at the concentration of 500 mg of metal • dm^{-3} in the form of drinking water for three or six weeks. After the period of administration the animals were sacrificed under ketamine narcosis and blood from the heart as well as the tissues of the liver, kidney, brain, spleen, femoral muscle and heart muscle were collected. Magnesium concentration was measured in serum and tissue homogenates. Chromium caused the increase of Mg level in some tissues after six weeks and no changes in serum. Lead influenced Mg level in serum and tissues mainly after six weeks but the changes were more diverse and depending on the tissue. After six weeks' administration aluminium caused the magnesium release from serum and its storage in tissues.

Wpływ podawania wybranych metali w wodzie pitnej na homeostazę magnezu u szczurów

Celem pracy była ocena wpływu chromu, ołowiu i glinu na poziom magnezu w surowicy i tkankach szczurów. Samce rasy Wistar otrzymywały roztwory Cr, Pb i Al o stężeniu 500 mg metalu • dm^{-3} w postaci wody pitnej przez okres trzech lub sześciu tygodni. Po zakończeniu intoksykacji zwierzęta usypiano ketaminą, a następnie pobierano do badań krew i tkanki wątroby, nerki, mózgu, śledziony, mięśnia uda i mięśnia sercowego. W surowicy i homogenatach tkankowych oznaczono stężenie magnezu. Chrom powodował wzrost poziomu Mg w niektórych tkankach po sześciu tygodniach, natomiast w surowicy nie zanotowano żadnych zmian. Ołów wpływał na poziom Mg w surowicy i tkankach głównie po sześciu tygodniach, ale zmiany były bardziej różnorodne i zależne od rodzaju tkanki. Glin po sześciu tygodniach spowodował spadek stężenia Mg w surowicy, natomiast w tkankach zaobserwowano tendencję do zatrzymywania magnezu.