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Bioavailability of Lead in Rats Fed "Human" Diets

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It has been recently recognized that dietary intake of inorganic elements and organic nutrients might influence the metabolism and toxicity of metals. For lead the nutritional interactions which are assumed to be of greatest importance are those of calcium and iron. Low dietary levels of calcium and diets insufficient in iron were shown to cause enhanced lead absorption (SIX and GOYER 1970, 1972). However, milk which was previously recommended as an antidote in lead poisoning because of its high calcium content was found to greatly enhance lead absorption (KELLO and KOSTIAL 1973).

Most of the published data on the effect of dietary factors on intestinal lead absorption were obtained by varying separately various nutritional components in rat diet. Because of the complicated nutritional interactions this experimental approach is not likely to provide relevant data on the bioavailability of lead from diets as generally consumed by babies or adults. We therefore decided to study lead bioavailability in rats fed on "human" diets. We determined lead absorption by measuring the whole body retention after a single oral dose of radioactive lead. In rats fed "human" diets we found lead absorption values which were similar to values observed in humans.

MATERIAL AND METHODS

Some commercially available baby foods as Babymix-turkey, Babymix-vegetables, Frutamix-bananas, Frutolino-fruit, Babyron-S-26 (Pharmaceutical works-Pliva, Zagreb) and Truefood (Wrenbury, Cheshire, England) were fed to animals. The food was prepared by addition of water to form a paste which was dried overnight and was readily consumed by our animals in a cake form (except for Babyron-S-26 which was fed to rats as a fluid). Some animals were fed on cow's milk (pasteurized), brown bread or pig's liver (raw) as obtained on the market. Control rats were fed normal rat diet (Pliva, Zagreb). All animals received their diets ad libitum and drank tap water with the exception of animals on cow's milk and Babyron-S-26 which were on fluid diet and therefore received no additional drinking water. The amount of food consumed was not determined since it was previously shown that rats maintain an almost isocaloric intake regardless of the dietary regime (KELLO and KOSTIAL 1973).

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The experiment was performed on 6-week old albino rats which were divided into 10 groups of 8-10 animals and were fed on experimental diets for 9 days. Three days after the beginning of the experiment all animals received a single oral dose of radioactive lead by stomach tube (10 µCi in 1 ml of ^{203}Pb - supplied as a chloride in an almost carrier-free form from Gustaf Werner Institute, Uppsala, Sweden). Six days after the radioisotope application the whole body radioactivity was determined in a two sodium iodide crystal scintillation counter (Tobor, Nuclear Chicago). The results are expressed as the percentage of the oral dose and are presented in the Table as the arithmetic mean and standard error of the mean.

RESULTS AND DISCUSSION

Lead absorption in rats fed "human" diets varied from about 3 to 20% i.e. by a factor of about 6. Cow's milk caused a high lead absorption (17%), which is in agreement with our previous results (KELLO and KOSTIAL 1973). This could be due to trace element deficiency in cow's milk, especially in iron as compared to commercially available baby foods. High lead absorption (18-20%) was also observed in rats on fruit diets, possibly because of chelating properties of citric acid (JUGO et al. 1975). Rats on all other "human" diets absorbed between 3 and 8% of the radioactive lead dose. Only animals on rat diet showed values of lead absorption below 1%. This might be due to the high calcium (about 1%) and iron (0.4%) content in our commercial rat diet. However, lead absorption values in rats are generally lower than data obtained in humans (i.e. BARLTROP and KHOO 1975). This could indicate that differences between species might also be partly due to different nutritional habits. However it would be beyond the scope of this experiment to try to analyze single factors in each diet which might either increase or decrease the bioavailability of lead and therefore we avoided on purpose a detailed specification of our experimental diets.

Our average lead absorption values in rats fed "human" diets are in good agreement with values of about 10% absorption obtained in humans (KEHOE 1961, RABINOWITZ et al. 1974). We therefore assume that this experimental approach might be useful for obtaining preliminary data on bioavailability of metals from various foods.

It would be desirable of course to perform similar experiments in rats fed "human" diets with various levels of metal additives and for longer periods. It would be also highly desirable to obtain more results in humans since data on the bioavailability of lead in men are practically not available. These data are extremely important since it is now recognized that standards for human exposure to metals will have to take into consideration nutritional habits of various populations and population groups, especially of young children.

TABLE 1

Influence of "human" diets on intestinal lead absorption in rats.

Diets	^{203}Pb in whole body (% oral dose) Means ± S.E.
Babyron-S-26	10.48 ± 1.47 (10)
Babymix-turkey	5.35 ± 0.84 (10)
Babymix-vegetables	7.55 ± 0.99 (10)
Truefood	3.16 ± 1.08 (10)
Frutolino-fruit	18.24 ± 2.17 (10)
Frutamix-bananas	19.77 ± 3.68 (10)
Cow's milk	17.38 ± 2.41 (8)
Pig's liver	3.01 ± 0.32 (10)
Brown bread	5.13 ± 0.66 (10)
Rat food	0.44 ± 0.09 (10)

Six-week old females were on special diets for nine days; ^{203}Pb was given three days after the beginning of the experiment. The whole body radioactivity was determined six days after ^{203}Pb application.

SUMMARY

The bioavailability of lead was studied in rats fed various baby foods (Babymix-turkey, Babymix-vegetables, Frutolino-fruit, Frutamix-bananas, Babyron-S-26, Truefood), cow's milk, bread, liver and standard rat diet. Lead absorption was determined by measuring the whole body retention of ^{203}Pb 6 days after a single oral application. Highest absorption values ranging from 17 to 20% were obtained in animals fed cow's milk and fruit foods. Rats on other "human" diets absorbed between 3 and 8% of the radioactive lead dose. Only in animals on rat diet lead absorption was below 1%. It is concluded that rats fed "human" diets show absorption values similar to those in humans. This might indicate that the bioavailability of lead is primarily dependent on dietary habits. This experimental model, if confirmed by further work, might be useful for obtaining preliminary data on the bioavailability of metals from various foods.

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REFERENCES

BARLTROP, D. and H. E. KHOO: Postgrad. Med. J. 51, 795 (1975).

JUGO, S., T. MALJKOVIC and K. KOSTIAL: Toxicol. Appl. Pharmacol. 34, 259 (1975).

KEHOE, R. A.: J. Roy. Inst. Publ. Health Hyg. 24, 81 (1961).

KELLO, D. and K. KOSTIAL: Environ. Res. 6, 355 (1973).

RABINOWITZ, M., G. W. WETHERILL and J. D. KOPPLE: Environ. Hlth. Perspec. 7, 145 (1974).

SIX, K. M. and R. A. GOYER: J. Lab. Clin. Med. 76, 933 (1970).

SIX, K. M. and R. A. GOYER: J. Lab. Clin. Med. 79, 128 (1972).