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Mercury Concentration Change in Human Hair After the Ingestion of Canned Tuna Fish

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The concentration of mercury in the hair of man has been conveniently used as an indicator of environmental exposure to mercury (Nord et al. 1973; Giovanoli-Jakubczak et al. 1974; Gonzalez et al. 1985). In particular, studies concerning the relationship between the concentration of mercury in the hair and the dietary intake of mercury have revealed that the amount of fish consumed significantly affects the mercury concentration in the scalp hair (Birke et al. 1972; Yamaguchi et al. 1975; Turner et al. 1980; Kyle and Ghani 1982). However, the quantitative relationship between the mercury concentration in the hair and the dietary intake of mercury has been scarcely proven (Kershaw et al. 1980; Phelps et al. 1980; Sherlock et al. 1982). This is because mercury concentration in hair sampled reflects the degree of exposure from diet in the past, and because the dietary measurements of mercury generally depend on individuals remembering accurately or having recorded their intake of fish in the past.

In an attempt to elucidate this problem, we assessed the mercury concentration in the hair of human subjects who ingested a certain amount of canned tuna fish.

MATERIALS AND METHODS

Canned tuna flakes from the same batch were obtained from a supermarket and used in this experiment.

Four healthy male volunteers (Subject A : 41years, weighing 85kg, Subject B : 31years; 63kg, Subject C : 27years; 60kg, and Subject D : 33years; 60kg), who were members of our laboratory staff , participated in this study. All the subjects were requested not to consume excessive amounts of marine foods throughout the experiment. For two consecutive weeks, subjects A, B, and C ingested 80g, 60g and 27g of tuna flakes per day respectively, in addition to their ordinary meals. Thereafter, the ingestion of tuna flakes was inter-

rupted for two weeks and then continued for two more weeks in the same way. The tuna flakes ingested in the experiment were not cooked, but rather straight from the can. Subject D served as a control, having only ordinary meals. To know their daily intake of mercury from usual meals, a duplicate diet study was also performed on the samples of A, B and C's daily diet on seven different days during the experiment.

All four subjects who participated in this study cut their hair as close to the scalp as possible with barber's clippers on the day prior to beginning the ingestion of tuna fish. On that occasion, a bundle of hair strands was collected from A, B and C, and these samples were analyzed "longitudinally", in order to know the level of mercury concentration in their hair arising from usual meals eaten in the past. i.e., the hair samples were cut into 5mm segments from the root and the mercury concentration was determined for each segment. Hair samples in the time course of this experiment were collected every two weeks, during a 10 or 12-week period. Each time, the hair was cut as short as possible in the same way as on the day prior to beginning the ingestion of tuna fish.

The hair growth rate was determined in the following manner; several days after cutting the hair, 5 to 10 hair strands including radix pili among the remaining hair were pulled out at random. This was repeated after each hair-cut, and the growth rate was calculated from the difference in the lengths over the time span between pullings.

Total mercury concentration in the diet and hair samples were analyzed by using the method of Nord et al(1973) ; samples were digested with conc. HNO_3, conc. H_2SO_4 and $KMnO_4$ and the amount of mercury in the digests was determined using the cold vapor method. The spectrophotometer used in the determination was Model UV-201, Shimazu Co, Kyoto, Japan and the absorbance at 253.7nm was measured.

RESULTS AND DISCUSSION

Prior to this experiment, the total mercury concentration of tuna flakes used in this study was analyzed and found to be 0.43μg/g. Moreover, in order to confirm the accuracy of the total mercury concentration in the hair, we analyzed hair samples ten times and we found an average total mercury concentration of 4.4μg/g with a coefficient of variation of 3.7%.

No subjects complained of any disorder in their bodies during the experiment.

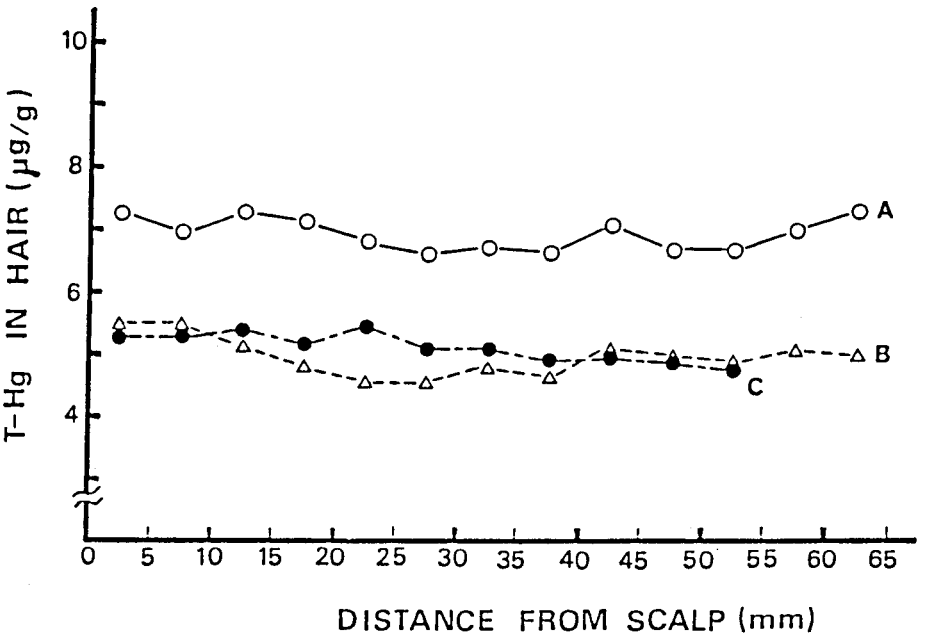

Figure 1. Total mercury concentration (T-Hg) measured in sequential segments of the hair from subjects A, B and C.

From the duplicate diet study on 7 different days during the experiment, the mercury intake per day from ordinary meals of subjects A, B, and C were assumed to be 24.4±24.0μg(mean+S.D.), 7.0±6.2μg, and 20.6±12.1μg, respectively, although considerable variation was observed. The results of longitudinal analysis of hair samples collected at the beginning of this study from subject A, B, and C is shown in Fig. 1. Variation in the mercury concentration along each hair for A, B and C was very small with the means and standard deviation for each were 6.9±0.3μg/g, 4.9±0.3μg/g, and 5.1±0.2μg/g , respectively. When we compared these concentrations with the amount of mercury intake mentioned above, the mercury concentration in hair for each subject was not completely proportional to the amount of mercury intake. In particular, the mercury concentration in the hair of subjects B and C were almost the same level, although a considerable difference between the two was seen in the amount of mercury intake through their diets. To elucidate this conflict, the growth rate of hair for each subject was measured since the growth rate of the hair could affect on the concentration of mercury in the hair. The growth rate of hair for subjects A, B, C, and D were 5.6mm, 5.3mm, 6.5mm and 6.5mm per 2 weeks, respectively. These results indicate that the rela-

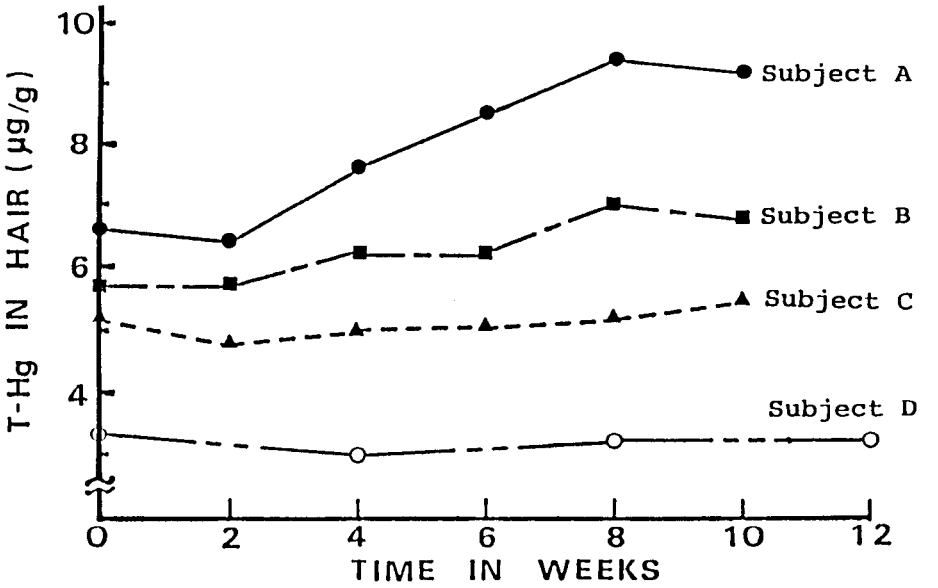

Figure 2. Periodical change in the total mercury concentration (T-Hg) in the hair from subjects A, B and C, who consumed various amounts of tuna flakes in addition to their ordinary meals, and subject D, who ate only his ordinary meals. (See MATERIALS AND METHODS)

tively low concentration of mercury in the hair of subject C, may be due to the fast growth rate of his hair.

The periodic change in the total mercury concentration in the hair following the ingestion of tuna flakes is shown in Fig. 2. In this figure, it should be noted that each point for the mercury concentration in the hair reflects the average amount of mercury consumed during the 2-week period commencing 4 weeks before. This is because time must be allowed for hair originating in the follicle to appear above the scalp. Even if the hair is cut as close to the scalp as possible with barber's clippers, about 5mm of hair remains. It takes about 2 weeks for hair to grow 5mm. Therefore, the effects of the first and third 2-week period, during which tuna was consumed, appears in the hair cut at the 4th and 8th week, respectively.

An apparent increase in the mercury concentration in the hair due to the consumption of tuna was seen in subjects A and B who consumed 80g and 60g of tuna flakes, respectively, but not in subject C. Subject A, consumed 80g of tuna flakes per day (total mercury content was estimated 34.4μg), in addition to his ordinary meals (total mercury content, 24.4±24.0

μg/day). His concentration continuously increased and reached a maximum level of 9.4μg/g at the 8th week, which was 3μg/g higher than that at the initial stage.

On the other hand, subject B consumed 60g of tuna flakes per day (total mercury content, 25.8μg) in addition to his ordinary meals (total mercury content, 7.0±6.2μg /day). His increase was 1.3μg/g of hair.

It is interesting that there was a different pattern of the mercury increase in subjects A and B, following the tuna consumption or interruption of tuna intake. The increase for subject A was linear and that for subject B stepwise. This might be due to the kinetics of mercury excretion from the human body, which depends upon the amount of mercury intake (Birke et al.1972).

For subject C, who consumed 27g of tuna flakes per day (total mercury content, 11.6μg) added to his ordinary meal (total mercury content, 20.6±12.1μg/day) and for subject D, who ate only ordinary meals, no appreciable changes were seen during the experiment, although a very slight increase (approximately 0.6μg/g) was detected in subject C. The changes in the mercury concentration in the hair for both subjects C and D lay within the range of mercury concentration considered normal for each when they were ingesting ordinary meals.

From these results, it was clearly shown that the increase in the mercury concentration in the hair was approximately proportional to the amount of tuna flakes consumed in addition to ordinary meals. This indicates that hair could be conveniently used as an indicator medium in assessing the intake of mercury from food.

Mercury compounds are highly toxic substances for humans. In particular, methyl mercury compounds produce irreversible neurological damage in humans, as noted from the Minamata and Niigata disasters in Japan(Tsubaki and Irukayama 1977). Much attention has been paid to dietary intake of methyl mercury compounds in the population as a whole. Because fish contains a relatively high concentration of methyl mercury compounds, those populations consuming fish in large quantities should be monitored in order to prevent mercury poisoning.

The Joint FAO/WHO Expert Committee on Food Additives (WHO 1972) proposed a provisional tolerable weekly intake of 300μg of total mercury per person of which no more than 200μg should be present as methyl

mercury.In this study, the weekly intake of total mercury for subject A was roughly estimated to be 300ug during the period of tuna consumption. So, it would seem that the total mercury concentration in his hair of 9.4μg/g, which was reached following the consumption of tuna, might be regarded as the level of total mercury concentration in the hair when a person takes "a provisional tolerable weekly intake of total mercury per person" proposed by the FAO/WHO committee. Therefore it would seem that an effective way of monitoring the intake of mercury from food for individuals, especially those consuming large amounts of fish, might be to measure the mercury content in the hair, using the figure of 9.4μg/g as a guideline for a tolerable weekly intake.

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