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Project Summary

Cadmium Intake Via Oysters and Health Effects in New Zealand: Cadmium Intake, Metabolism and Effects in People with a High Intake of Oysters in New Zealand

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The aim of this study was to confirm the high dietary intakes of cadmium and other trace elements from oysters in a population associated with the oystering industry, and to determine (i) the impact of those high intakes on cadmium concentrations in accessible tissues of the study subjects and (ii) the occurrence of health effects in the population resulting from their dietary exposure to cadmium.

Methods for the analysis of cadmium in whole blood, urine and hair by flameless atomic absorption spectrophotometry were established. The analysis of Bluff oysters (*Ostrea lutaria*) confirmed a high cadmium content (27 μg/g dry wt); the content of other trace elements (zinc, copper, manganese, selenium) was also determined, and differences in the proportions of the trace elements compared with other species of oysters and other shellfish found in New Zealand were observed.

Seventy-eight subjects participated; from forty-eight of them samples of faeces (3 day), blood, urine (overnight) and hair were obtained both pre-season and end-season (i.e., 6 months later). Questionnaires on oyster intake were administered; dietary and medical questionnaires were administered at the end of the season when height, weight and blood pressure were measured. The subjects were classified into four categories of oyster intake with average consumptions being <0.5, 0.5-<2, 2-<6 and ≥6 dozen/week for Categories I, II, III and IV, respectively. The faecal output of cadmium confirmed the high intakes; e.g., Category IV subjects were ingesting about 250 μg cadmium/day at the end of the season; calculated intakes for Categories I, II and III were 34 μg/d, 75 μg/d and 116 μg/d, respectively, at the end of the season. Intakes of zinc were also elevated, and selenium intake would have been doubled for those subjects consuming many oysters.

The concentration of cadmium in whole blood was higher in the smokers than in the non-smokers. In the non-smokers the increase in whole blood cadmium due to oyster consumption was only 1.2 ng/ml for Category IV. Whole blood selenium concentration also was higher in Category IV subjects but their serum zinc and copper concentrations were unaffected. The concentrations of cadmium, zinc and B_2-microglobulin in the urine were unaffected by oyster consumption; there was no indication of glycosuria or proteinuria that could have been attributed to a high intake of cadmium. Hair cadmium, zinc and copper also appeared to be unaffected by oyster consumption. There were no indications of any medical problems that could have

been attributed to a high cadmium intake; although the blood pressure of Category III and especially Category IV subjects was relatively higher than that for Categories I and II and they also had a greater body size.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

During recent years there has been a keen interest among researchers and public health administrators in the toxicity of cadmium, with particular reference to the possible increase of cadmium intake due to increased use of sewage sludge for soil treatment. The risk of an actual increase in the cadmium intake has been well documented and a major remaining question is whether such an increase is likely to lead to any health effects.

So far, only in Japan have population groups with exceedingly high cadmium intakes via food been found. In the high cadmium intake groups in Japan, the prevalence of cadmium-induced proteinuria might be as high as 50% or more. Some studies in Japan demonstrate clear dose-response relationships and these data have been used to analyse the dose-response at relatively low dose levels. Calculations have been supported by metabolic models which involve a number of assumptions, and therefore uniform agreement on the health hazards involved with slight increases of average cadmium intake has not been reached.

Preliminary data from New Zealand indicated that the oysters had such high cadmium levels that a small subgroup of the population who consumed a large number of oysters annually, could have cadmium intakes as high as the affected populations in Japan. The present study endeavoured to document oyster intake in the group with the alleged high oyster consumption, their cadmium intake and also their cadmium concentrations in various biological media such as blood, urine and hair. As the oysters had relatively high levels of selenium, zinc, copper and manganese, these trace elements were also analyzed in most of the biological materials collected.

This New Zealand cadmium-exposed group is the only one found outside Japan with such high cadmium intake via food, and it is envisaged that further studies of this group will give valuable data for the explanation of the metabolism as well as the toxic mechanism of cadmium.

The aim of this study was to confirm the high dietary intakes of cadmium and other trace elements from oysters in a population associated with the oystering industry, and to determine (i) the impact of those high intakes on cadmium concentrations in accessible tissues of the study subjects and (ii) the occurrence of health effects in the population resulting from their dietary exposure to cadmium.

This project covered an initial 18-month period of which the specific aims were the following:

(a) to develop methods for cadmium analysis in the tissues studied.
(b) to evaluate the cadmium content of various shellfish in New Zealand and the daily cadmium intake in groups with a high shellfish consumption.
(c) to measure the individual and group-average daily cadmium intake of workers in a New Zealand oyster industry.
(d) to measure the interrelationship of cadmium concentrations (and of other trace metals) in serum, blood, urine and hair in the group with a high cadmium intake from oysters and to measure the effect of seasonal variations on the cadmium intake and tissue concentrations.
(e) to measure the occurrence of tubular proteinuria in the group with a high cadmium intake.

Procedure

About 70 male and female workers are employed in the oyster canning industry and 50 male fishermen are involved full time in the fishing during the season from March to August. In addition, there are 50 retired workers from this industry still living in the same area. Meetings were held with the oyster fishermen and canning workers in the fishing port of Bluff before the season started in 1981, and everyone was encouraged to take part in the study. As the study involved the collection of faeces, urine, blood and hair samples as well as keeping dietary records, etc., it was not expected that everyone would be willing to participate.

The aim was to find a same-sized reference group of meat industry slaughtermen with a low oyster intake, but it turned out that many of these workers in the area also had a high oyster intake, and furthermore, it was even more difficult to convince them to take part as they had no personal involvement with the oyster industry.

A number of people were found in Bluff and in small communities adjacent to Bluff with a low oyster intake but with similar living conditions, etc., to the oyster fishermen; these people were included in the group as a reference. All in all, 76 people were selected and they were classified according to average oyster consumption during the season into 4 groups. All these people lived in the Bluff or Invercargill areas. An additional reference group for the study of blood cadmium and urine cadmium was found in the city of Dunedin.

Samples were collected at two times, and for a subgroup of 18 people at three times. The first samples of faeces, urine, blood and hair were collected in the week before the season started on March 1, 1981. However the equipment on the oyster fishing boats is checked in the presence of a Ministry of Agriculture and Fisheries Inspector in the few days preceeding the opening of the season. Since the oysters reputedly taste better at the beginning of the season some fishermen had already eaten a few oysters in that week preceeding the official opening of the season, and their faecal output of cadmium reflected that intake. In the middle of the season in July 1981 additional samples of blood and a faecal specimen were collected from 18 people who were keen to cooperate; they also kept a daily diary of oyster intake from then until the next sampling. Finally, at the end of the season in August 1981 a full set of faeces, urine, blood and hair samples were collected again, as well as an interview to obtain a dietary history and a medical history.

With this design of the study, we could evaluate the relationship between oyster intake and cadmium intake on a quantitative basis and we could study its time relationship, because at the beginning of the season the intake was likely to be less than in the middle or the end of the season. The group studied covered the age range 20-75 years and it included 57 men and 19 women. Since we were describing mainly the short-term relationship between cadmium intake and cadmium in tissues it was con-

sidered that any age effect on the cadmium concentration in tissues was not likely to cause bias in the results.

In order to evaluate the possible effects of cadmium, urinary beta-2-microglobulin as well as total proteinuria and glycosuria were measured, blood pressure was measured and the medical history was recorded in an interview.

Faeces were analyzed for cadmium, zinc, copper, and manganese. Urine was analyzed for pH, specific gravity, cadmium, zinc, creatinine, urea, glucose, protein, and beta-2-microglobulin. Blood was analyzed for packed cell volume, hemoglobin, cadmium, selenium, zinc, copper, and beta-2-microglobulin. Hair was analyzed for cadmium, zinc, and copper. Dietary history was evaluated for energy, protein, calcium, zinc, and iron.

Results and Conclusions

Methods for the estimation of cadmium in blood, urine and hair have been established, and to date appear to be reasonably accurate and reliable. Further inter-laboratory comparisons will be carried out.

Bluff oysters have a high cadmium content; although all species of oysters have a relatively high cadmium content compared to most other foodstuffs, different species show large differences in concentrations of cadmium as well as other trace elements. This is of great interest because a high consumption of different shellfish might reveal differences in cadmium metabolism due to interactions among the elements.

Intakes of cadmium in the population studies were high. Analysis of faeces confirmed the high intakes of cadmium based on analyses of cadmium concentration in oysters and estimates of daily consumption. There was a close agreement between the observed content of cadmium, zinc and copper in faeces and estimated output. Some of the subjects with the highest oyster consumption had daily cadmium intakes greater than 500 μg, which are higher intakes than those shown to be associated with a high incidence of renal tubular damage in people exposed to contaminated rice in Japan. The New Zealand oyster consumers also had intakes of zinc greater than twice the normal New Zealand intake, and intakes of selenium about twice a normal New Zealand intake. The limited data available indicate that the Japanese people with a high cadmium exposure also had intakes of zinc and selenium similar to those of the oyster consumers.

In spite of the very high intake of cadmium from oysters the concentration of cadmium in whole blood was not increased greatly in proportion to the increased intake. The data clearly show increased blood cadmium concentrations due to smoking in the four groups with different levels of oyster consumption. Among non-smokers the increase in blood cadmium due to oyster consumption was only 1.2 ng/ml. There was a good correlation between blood cadmium concentration and oyster intake at the beginning as well as at the end of the oyster season. There were no observed changes during the season or between groups in urinary cadmium output or in hair cadmium concentration. There was a close correlation between blood cadmium and blood selenium concentration, whereas neither serum zinc nor serum copper concentration increased with an increasing blood cadmium concentration. There were no differences in hair zinc or copper concentration.

The dipstick proteinuria and glycosuria tests did not show any indication of cadmium-induced renal damage. The frequency distribution of urinary beta-2-microglobulin concentration was similar to "control groups" from other epidemiological studies, and none of the participants had a beta-2-microglobulin concentration higher than 250 μg/l (adjusted to specific gravity 1.025).

There was a tendency for higher blood pressures than expected in the groups with the highest oyster intakes. This tendency was influenced by smoking habits but an effect of cadmium on blood pressure could not be ruled out.

Finally, the present study showed that the cadmium in Bluff oysters does not appear to be absorbed to the extent that is considered normal for other foods. The mechanism for this diminished absorption could be interactions with selenium and/or other trace elements, but could also be unusual chemical speciation in oysters compared to other foodstuffs. It could also be that cadmium from oysters is metabolised differently from cadmium from other foods after it has been absorbed.

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The complete report, entitled "Cadmium Intake Via Oysters and Health Effects in New Zealand: Cadmium Intake, Metabolism and Effects in People with a High Intake of Oysters in New Zealand," (Order No. PB 86-219 144/AS; Cost: $16.95, subject to change) will be available only from:
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