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URINARY ESTIMATION OF OPTIMAL FLUORIDE DOSAGE WITH DOMESTIC SALT

by
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INTRODUCTION

Fluoridated domestic salt as an alternative or complement to fluoridated drinking water has certain theoretical advantages but also involves obvious problems. The theoretical advantages appear to be mainly the following:

1. Reasonable resemblance to the well-established fluoride supply with drinking water.
2. No limitation by water-work size and equipment.
3. No waste of fluorides, as with piped water.
4. Simple and cheap production and control.
5. Free choice for individual households, reduced psychological difficulties.

The main problems seem to be the following:

1. The distribution of the fluoridated salt must be limited to areas (households) with sub-optimal fluoride content in the drinking water.
2. The dosage has to be determined on the basis of thorough clinical studies of the total fluoride ingestion when using fluoridated salt.
3. Possible influences of the vehicle on the absorption and metabolism of fluoride should be known.
4. Possible influences of the vehicle on the intra-oral fluoride reactions should be known.

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5. The clinical caries-preventive effect should be known before large-scale use of the vehicle.

The objection has been raised against salt fluoridation that infants would receive too low a dose with this vehicle. This objection is to a great extent met by the recent finding that the modern infant feeding with water-diluted dry-milk formulas provides a high fluoride dose compared to breast-feeding or feeding with cow's milk, which is much less water-diluted (*Ericsson*, 1969; *Ericsson, & Ribelius*, 1970). In rat tests, the chloride of the salt reduces or delays the fluoride absorption to a limited extent (*Ericsson*, 1968), while in in-vitro tests the chloride considerably enhances the uptake of fluoride ions in human enamel surfaces (*Ericsson*, 1962).

In spite of the obvious problems some clinical investigations indicate that fluoridated domestic salt carries definite promise for mass-prophylaxis against caries (*Marthaler & Schenardi*, 1962; *Wespi & Bürgi*, 1970). However, the variation of food habits in different countries necessitates a thorough mapping of the nutritional utilization of fluoride supplied with this vehicle.

This investigation has aimed to provide the first clinical data necessary to determine the optimal fluoride concentration in household salt under ordinary Swedish conditions. Urinary fluoride excretion has been used as a convenient and satisfactory parameter of the total fluoride ingestion (*McClure & Kinser*, 1944; *Zipkin et al.*, 1956; *Rink & Twarock*, 1965, and others).

MATERIAL AND METHODS

The urinary concentration of fluoride was determined in a number of Swedish subjects before and after one week's use of household salt containing either 500 or 1,000 mg F as NaF per kg NaCl; this high ratio was indicated by preliminary tests with lower fluoride concentrations.

The subjects originally selected were divided into two groups, the so-called full-board group who took all their meals in their homes, and the so-called half-board group who had lunch outside their homes and thus without fluoridated salt. The half-board group on 500 mg F/kg NaCl comprised 27 subjects, the other groups 15—18 subjects each. The subjects' drinking water contained less than 0.3 ppm F, but some of the subjects were consumers of fluoride-rich tea. Later, a special full-board group of 13 men employed at a hydroelectric plant construction in Lapland was tested with 500 mg F/kg salt. These men were carrying out hard physical work in contrast to the majority of the other subjects. Their drinking water contained 0.1 ppm F.

24-hour urine was used throughout for determining fluoride concentrations. As a point of departure the urinary fluoride concentrations of persons residing in Uppsala were taken. Uppsala has a natural fluoride content in its drinking water that can be calculated to be about optimal for the climatic conditions in southern and central Sweden (*Galagan & Vermillion*, 1957).

The urine samples were collected in specially washed plastic bottles and preserved, in cases where transportation had to take place, with thymol. The fluoride analyses were initially made either with the Orion fluoride electrode*) or with diffusion and colorimetry according to *Bäumler* (1967, with some modifications), or with both methods, which gave similar results. Later only the fluoride electrode was used. A TISAB-CDTA buffer according to *Harwood* (1969), or a citrate buffer was employed to standardize pH and ionic strength and to complex bind interfering metal ions.

RESULTS

The results obtained in a number of Uppsala families appear in Table I. The relations between urinary fluoride concentrations in adults and children

Table I

Fluoride (ppm) in 24-hour urine samples from Uppsala residents and in tap water samples from their homes

Urine						*Water*		
Age 33—57 years			Age 8—19 years					
n	Av.	SE	n	Av.	SE	n	Av.	SE
19	1.08	0.077	18	0.80	0.117	16	1.16	0.016

in Uppsala and the local water fluoride content agree well with those reported from many other places in the world.

The results obtained with fluoridated domestic salt are presented in Figures 1—5. The urinary volumes were determined for a large number of the test-subjects; these were not statistically different before and after consumption of fluoridated salt.

*) *Orion Research* Inc., Cambridge, Mass. 02139, U.S.A.

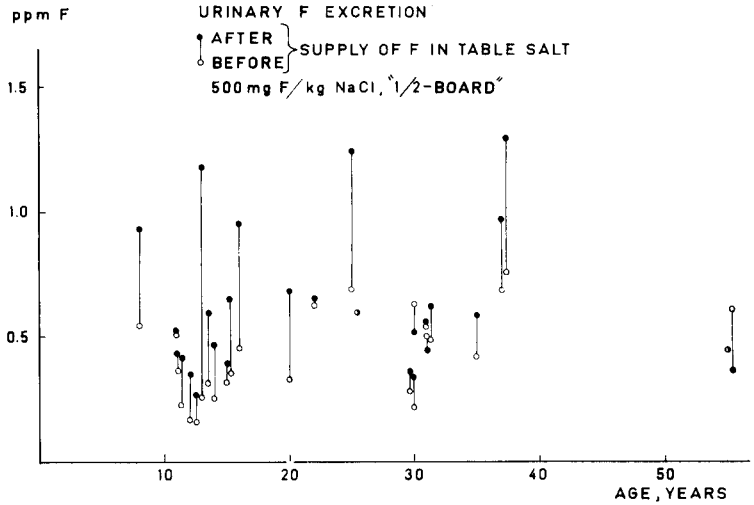

Fig. 1. Fluoride concentrations in 24-hour urine before and after the ingestion of table salt containing 500 mg F/kg. Half-board group.

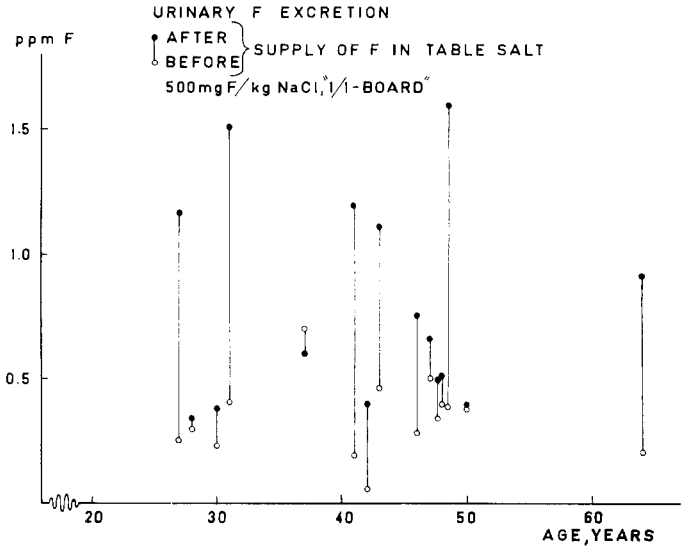

Fig. 2. Fluoride concentrations in 24-hour urine before and after the ingestion of table salt containing 500 mg F/kg. Full-board group.

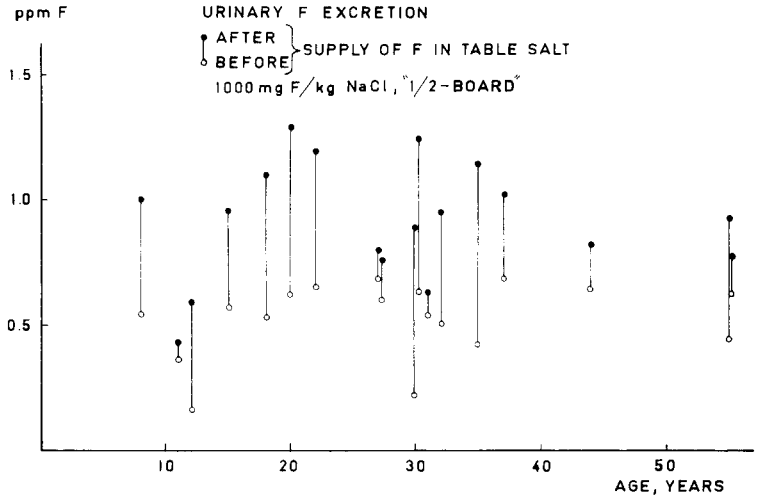

Fig. 3. Fluoride concentrations in 24-hour urine before and after the ingestion of table salt containing 1000 mg F/kg. Half-board group.

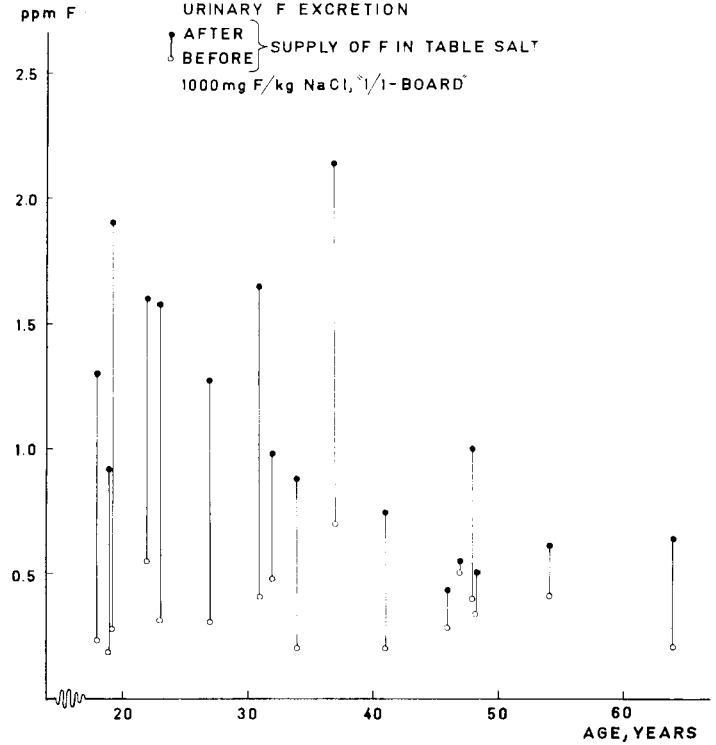

Fig. 4. Fluoride concentrations in 24-hour urine before and after the ingestion of table salt containing 1000 mg F/kg. Full-board group.

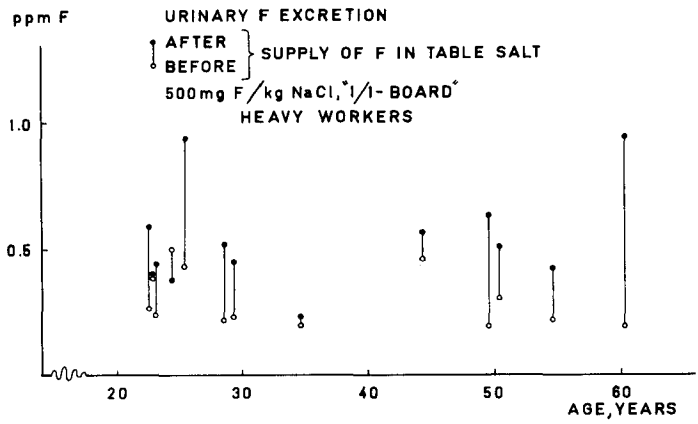

Fig. 5. Flouride concentrations in 24-hour urine before and after the ingestion of table salt containing 500 mg F/kg. Full-board group with hard physical work.

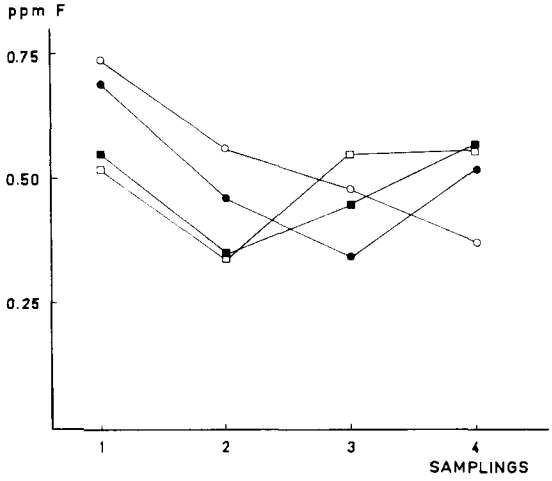

Fig. 6. Urinary fluoride concentrations in 4 24-hours samples from each of 4 subjects on 500 ppm F in the table salt. Half-board group.

Intra-individual variation was tested in four samplings of 24 hour urine taken at half-week intervals from each of four adult, healthy subjects on 500 ppm F in the salt (Fig. 6). The apparent drop of the values between the first and second sampling is believed to be accidental, since any delayed adaptation of the fluoride excretion to the increased ingestion would act in the opposite direction.

The results are commented upon in the following section.

DISCUSSION

Some general features are evident from the results.

1) The fluoride dose in the salt that gives a small to moderate urinary fluoride increase in persons on half-board gives a rather large increase in some of the persons on full-board, particularly in younger adults.

2) The great inter-individual variation of the urinary fluoride output may be due to variations of either the consumption of domestic salt, or the food/water consumption ratio, or both.

The majority of subjects appear to belong to one of two distinct categories, with high and low urinary fluoride rise, respectively, following the use of fluoridated salt. No common denominator has been found for any of these categories. A closer study might trace the cause of the variation to some distinct differences in food habits.

3) A much higher fluoride concentration in the domestic salt is necessary under Swedish conditions than has been calculated for Switzerland (250 mg F/kg NaCl, *Wespi & Bürgi*, 1971), in order to get the same urinary fluoride excretion as with optimal fluoride concentration in the drinking water. A fluoride concentration somewhere between 500 and 1,000 mg F/kg NaCl appears to be optimal for the majority of the tested subjects.

The causes of the great apparent difference between Switzerland and Sweden may be manifold. In 22 of the Swiss cantons the 1967 sale of packet salt corresponded to 5.36 g/person/day (*Wespi & Bürgi*, 1970) while *Ganzoni-Ziegler* (1965) found an average consumption of 6.3 g/person/day in 25 Swiss families, of which 4.18 g were ingested. Boiled potatoes, from which the salted boiling water is poured off and lost, seems to be much more common in Sweden, while the consumption of salt-rich soups is much higher in Switzerland. The corresponding sale in Sweden has been calculated to 5 g/person/day in 1968 while the actual ingestion is unknown. The meat consumption is reported to be higher in Switzerland while salted herring is a common dish in Sweden; the meat is probably, as a rule, salted in the individual household, the herring in the factory.

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SUMMARY

The fluoride concentrations in 24-hour urine samples were tested in Swedish subjects of different ages and working conditions before and after the use of fluoridated domestic salt for one week. The salt contained either 500 or

1,000 mg F as NaF per kg, and the subjects were divided into two groups according to whether they took all their meals or only breakfast, dinner and possible evening snacks at home. Comparisons were made with the urinary fluoride concentrations of adults and children in Uppsala, whose drinking water contained about 1.16 ppm F. The results are given in diagrams which indicate that further clinical tests in Sweden should be made with domestic salt containing between 500 and 1,000 ppm F.

RÉSUMÉ

ESTIMATION URINAIRE DU DOSAGE OPTIMUM DE FLUORURE AVEC LE SEL DE CONSOMMATION

Les concentrations de fluorure dans des échantillons d'urines de 24 heures ont été recherchées chez des sujets suédois de différents âges et conditions de travail, avant et après usage pendant une semaine de sel de consommation fluoré. Le sel contenait soit 500 soit 1 000 mg F par kg sous forme de NaF, et les sujets ont été répartis dans les deux groupes suivant le nombre de repas pris à domicile, soit tous les repas, soit seulement le petit déjeuner, le dîner et éventuellement une collation du soir. Des comparaisons ont été faites avec les concentrations de fluorure urinaire chez des enfants et des adultes d'Uppsala, consommant une eau contenant environ 1,16 ppm F. Les diagrammes indiquant les résultats montrent que les essais cliniques ultérieurs devraient en Suède être faits en employant du sel de consommation contenant entre 500 et 1 000 ppm F.

ZUSAMMENFASSUNG

KOCHSALZFLUORIDIERUNG: SCHÄTZUNG DER OPTIMALEN DOSIERUNG DURCH URINANALYSEN

Die Fluorkonzentrationen im Tagesurin verschieden alter schwedischer Probanden wurden bestimmt vor und nach dem Gebrauch von fluoridiertem Küchensalz während einer Woche. Das Salz enthielt entweder 500 oder 1000 mg F als NaF pro Kg, und die Probanden wurden auf zwei Gruppen geteilt je nachdem sie alle Mahlzeiten zu Hause einnahmen oder nur Frühstück und Abendessen. Vergleiche wurden mit den Fluorkonzentrationen im Urin Erwachsener und Kinder in Uppsala gemacht, deren Trinkwasser etwa 1,16 mg F/L enthielt. Die Resultate werden in Diagrammen angegeben, welche zeigen, dass weitere klinische Versuche in Schweden mit einem Küchensalz, das zwischen 500 und 1000 mg F/Kg enthält, ausgeführt werden sollen.

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