Diet of 3 and 4 year olds in Dunedin: relevance to dental caries

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Abstract

Diet plays a central role in the development of dental caries. A number of cross-sectional studies have, however, not been able to establish any relationship between nutritional deficiencies and increased caries activity. This study was designed to determine and analyse the nutrient intake of caries-free and caries-active children longitudinally over a period of 12 months. Sixty six children aged between 3-4 years who were caries free (dmf = 0) and those who had caries (dmf = 3) were selected at random from 21 School Dental Clinics located in Dunedin, New Zealand. The children were monitored for caries activity and nutrient intake for 12 months. Diet record sheets indicating the type and amount of all food and drinks that the child had ingested over a period of 24-hours were collected at intervals of 6 months. The 24 hour diet records showed no statistically significant differences in the mean intake of any of the nutrients between children who remained caries-free and those that developed caries after 12 months. The mean daily intake of all sugars in this study was 115 g/day and the mean sucrose intake was 64 g/day (56%) which is approximately 23kg/year from all food sources. The sources of carbohydrate for children in this study were quite different from those in the Pacific islands.

Introduction

Diet plays a central role in the development of dental caries[1]. Six main nutrients namely carbohydrates, fats, proteins, vitamins, minerals, and water are essential in a well-balanced diet. A number of animal and human studies have shown that dietary carbohydrates (namely sugars and starch) are caries-conducive and that they exert their cariogenic effect locally on the tooth surface[2,3,4].

Sucrose is one of the many types of sugars which is broken down by oral bacteria to acids such as lactic, formic, and acetic acids which cause decay in teeth. Sucrose refined from sugar cane or sugar beets is the most common dietary sugar and is more cariogenic than any of the other sugars[5]. It is present in sweet confectionery and in fruits, drinks, breakfast cereals, and even in items such as ketchup and salads. Starch-containing foods such as bread, biscuits, and potato chips can also cause a pH drop in saliva similar to that caused by sugars[6]. In animal experiments, mixtures of starch and sucrose (such as sweetened cereals, cookies, biscuits, and cakes) have been found to be more caries-inducing than sucrose alone, probably due to prolonged retention in the mouth[6,7].

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Many studies have attempted to measure the ability of different carbohydrates to cause caries with variable results. In one study, foods such as sucrose, granola cereal, french fries (due to presence of starch), bananas, cupcakes, and raisins were found to have the highest cariogenic potential index (CPI) whereas peanuts, gelatin dessert, corn chips, and yoghurt had the lowest CPI[8]. In general, foods which result in a drop in the pH of plaque to below 5.5 - 5.7 are considered to be detrimental to teeth [9].

A number of animal and human studies have found a substantial reduction in caries by the addition of sodium fluoride (NaF) to high-sugar cariogenic diet[10,11]. Besides fluorides, inverse associations have been found between caries experience in individuals and concentrations of calcium, phosphorus, magnesium, strontium, and lithium in plaque[12].

In this study the total daily intake of water, energy, carbohydrates such as sugars (sucrose, lactose, glucose, fructose, and maltose) and starch, proteins and fats in 66 children aged 3 - 4 years in New Zealand is reported.

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Table 1. List of some major food items constituting each of the 21 food groups in the database

BAKERY PRODUCTS	Biscuits, Breads, Buns, Cakes, Crispbreads, Doughnuts, Pies, Rolls
BEVERAGES (non-alcoholic)	Bournvita powder, Cocoa powder, Horlicks powder, Milo powder, Ovaltine, Coca Cola, Cordial, Syrup, Juice, Lemonade, Ribena, Tea, Just Juice, Vitamin C
BREAKFAST CEREALS	Bran cereal, Cornflakes, Muesli, Porridge, Granola, Honey Puffs, Weetbix
CEREALS AND PSEUDO-CEREALS	Custard powder, Flour, Macaroni, Rice, Rolled Oats, Rye, Soya, Spaghetti
DAIRY	Butter, Cheese, Cream, Ice cream, Milk, Milk shakes, Yoghurt, Milk Soya
EGGS	
FAST FOODS	Burgers, Coleslaw, McDonald's, Kentucky, Pies, Pizza, Potato fries, Sausages, Saveloys, Fish and chips
FATS AND OILS	Margarine, Spreads (low fat), Vegetable oils
FRUIT	Fresh and dried fruits, fruit salads
MEAT	
MEAT PRODUCTS	Cornish pastie, Canned meat, Luncheon meats, sausages, pies, saveloys
MISCELLANEOUS	Pepper, Salt, Vinegar, Bovril, Marmite, Vegemite
NUTS	Almonds, Cashews, Coconut (desiccated), Peanut butter, Peanuts
RECIPES	Stewed mince, Lasagne, Macaroni cheese, Casseroles, Chilli Con carne, Quiche, Scones, Tarts, Homemade biscuits, Meringue, Pudding, Jam
SAUCES AND CONDIMENTS	Piccalilli, Pickle (sweet), Tomato ketchup
SNACK FOODS	Muesli bars, Potato crisps, Cheese straws, Rashuns
SOUPS	
SUGAR AND HONEY CONFECTIONARY	Boiled sweets, Chocolate bars, Chocolates, Chewing gum, Honey, Ice cream, Marmalade, Sugar, Toffees, Popcorn, Marshmallow
VEGETABLES	
TINFISH	Cod, Pilchards, Salmon, Tuna
SHELLFISH	Mussels, Lobsters, Oysters, Paua

Methods

The study population was drawn from 21 School Dental Clinics located in fluoridated (F) and neighbouring non-fluoridated (NF) areas of Dunedin in the South Island of New Zealand. Children aged between 3-4 years who were caries free (decayed, missing, and filled surface - dmf = 0) or had caries (dmf = 3) were selected at random. Children were monitored for caries activity for 12 months. Written informed consent was obtained from the 66 parents agreeing to participate in the study.

The parents were instructed to write down on diet record sheets the time, type and amount (in household measures i.e. teaspoons, cups) of all food and drinks that the child ingested over a period of 24-hours. The 24 hour diet records were collected three times during the year at intervals of 6 months. The importance of maintaining a normal or usual dietary pattern was stressed. This was part of a larger study where duplicate amounts of all foods and drinks ingested by the child over a period of 24 hours was collected and analysed for fluoride.

Diet records were analysed for nutrient intake using a computer program. At first, the weight of each food item listed in household measures was converted into milligrams or grams. The particular food item consumed by the child was selected from "FOOD files" the computer version of the New Zealand food composition table compiled by the then Biotechnology Division of Department of Scientific Industrial Research (DSIR)[13]. A list of some of the major food items constituting each of the food groups in 'FOOD files' is shown in Table 1. The type and amount (mg/g) of food ingested was entered into a 'Diet Entry & Storage' computer program.

The dietary data was then analysed for the intake of water, energy, carbohydrates, starch, total sugars, sucrose, lactose, glucose, fructose, and maltose, fats and proteins with the "Diet Cruncher©" program, a batch processing diet analysis system, written by Ross Marshall in 1991, in Hypercard (version 2.0). Analysis of variance (ANOVA) was used to determine differences in mean intake of the nutrients by age, sex, and area. The proportion of energy, carbohydrates, sugars, starch, sucrose, lactose, glucose, fructose, and maltose derived from different food sources was also calculated.

Table 2. The mean (± standard deviation) intake of nutrients of males and females aged 3 - 4 years

Nutrient	Sex (Males = M) (Females=F)	Total (n=37 M) (n=29 F)	Significance of the difference between males and females (p values)
Water (ml)	M	981 ± 212	0.21
	F	904 ± 232	
Energy (kJ)	M	6835 ± 1,310	0.04*
	F	6117 ± 1,159	
Protein (g)	M	51 ± 14	0.07
	F	45 ± 10	
Total Fat (g)	M	64 ± 15	0 20
	F	58 ± 13	
Carbohydrates (g)	M	226 ± 52	0 04*
	F	202 ± 45	
Total sugars (g)	M	119 ± 38	0.39
	F	110 ± 37	
Starch (g)	M	106 ± 27	0 01*
	F	91 ± 22	

** Differences are significant at the 0.05 level*

Results

There were no statistically significant differences in the mean intake of any of the nutrients between those children who remained caries-free and those that developed caries after 12 months. The mean daily intake of water, energy, protein, fat, and carbohydrates (sugars and starch) according to sex is shown in Table 2. Males had a significantly higher mean intake of energy (p=0.04), carbohydrate (p=0.04), and starch (p=0.01) than females. Carbohydrates provided approximately 55% of the energy; fats approximately 35%; and proteins approximately 10%. The average amount of water ingested was approximately 950 ml/day (Standard deviation SD = 220).

Starch and sugars were the two main forms of carbohydrates ingested. The mean intake of all sugars in the two sexes combined was 115 g (SD=38). The mean intake of sucrose was 64 g (SD=28) and was the highest form of sugar consumed. The mean intake of glucose, lactose, and fructose was very similar and ranged from 15 to 17 g (SD=6 to 8). The mean intake of maltose was the lowest and was 2.7 g (SD=1).

The proportion of nutrient intake derived from the different food groups is shown in Table 3. The three main sources of energy were bakery (22%) and dairy products (19%), and beverages (9.3%). Intake of sucrose was also mainly derived from bakery (23%) and dairy (13%) products, and from beverages (11%). Glucose was mainly derived from fruits (23%), beverages (22%) and confectionery (10%).

Discussion

Epidemiological surveys, most of which have been cross sectional, have not been able to establish any relationship between nutritional deficiencies and increased caries activity[14, 15]. This lack of correlation is thought to be because the dietary data obtained by questionnaires, 24-hour recall, or diet history interviews cover only a short period (1 day to 1 month), whereas the caries data are the total caries experience accumulated over years. However, two large scale longitudinal dietary studies[16, 17] also failed to find any significant relationship between caries increment in the low and high caries groups and dietary variables. In this longitudinal study as well, there were no statistically significant differences in the mean intake of nutrients between caries-free and caries-active children.

Carbohydrates, fats, and proteins are the three main sources of energy. In the South Pacific Islands, carbohydrates provide nearly 60% of the total energy and are derived mainly from plant foods like yam, taro, cassava, breadfruit, fruits, and sugar cane[18]. In this study as well, carbohydrates were the main source of energy for children aged 3-4 years and provided nearly 55% of the energy. However, in this population bakery and dairy products and beverages were found to be the three main sources of energy. These results confirm that the sources of carbohydrate for children in New Zealand are quite different from those in some other South Pacific Islands such as Fiji, Samoa, Papua New Guinea, and Tonga. This has relevance to oral health of individual migrants from Pacific Island nations to New Zealand.

Table 3. Proportion of energy, sucrose, glucose, and fat derived from the different food sources

Food sources	Energy (%)	Sucrose (%)	Glucose (%)	Fat (%)
Bakery	22*	23*	4	16*
Beverages	9*	11*	22*	1
Breakfast cereals	4	5	4	3
Cereals	1	<1	<1	<1
Confectionery	4	6	10*	1
Dairy	19*	13*	9	28*
Eggs	<1	<1	<1	<1
Fast foods	5	7	4	9*
Fats and oils	1	<1	<1	5
Fruit	4	<3	23*	1
Meat	8	5	<1	1
Meat products	1	3	<1	3
Miscellaneous	<1	<3	<1	1
Nuts	<1	<1	<1	2
Sauces	<1	<1	1	<1
Snack foods	4	2	4	5
Soups	<1	<2	<1	1
Vegetables	6	6	6	3

* *The three main sources of each nutrient*

As reported in other studies, sucrose was the main type of sugar ingested in this study as well. The main sources of sucrose for this population were bakery and dairy products and beverages. The mean daily intake of all sugars was 115 g/day and the mean sucrose intake was 64 g/day (56%). The national estimates of refined sugar consumption in New Zealand in 1978 was approximately 104 g/day/person whereas in Fiji it was slightly higher and was approximately 118 g/day/person[19]. There are no recent data available on the national estimates of sugar consumption of individuals in the South Pacific Islands.

Different foods vary greatly in initial oral carbohydrate concentration and clearance times[20, 21]. The clearance time of most sugar containing foods such as fruits, drinks, chocolate, and toffees ranges from 5-20 minutes, and starch products such as potato, spaghetti, bread, chips, and crackers have longer clearance times of 15-30 minutes[20]. The longer the clearance time the greater is the risk of developing dental caries[6]. Traditionally, fruits and nuts used to be common snack foods in the Pacific Islands. Today, sugary snack foods made mostly from sugar, fat and flour are consumed which tend to stay in the mouth for a longer time and promote dental decay[22].

It has been suggested that to protect teeth from dental decay one should "not eat sweet and soft or sticky foods, like sweet biscuits, scones, cakes, doughnuts, cordials, ice blocks, sweets (candies) or lollies, chocolates, and ice cream or drink soda, sweet cordials, sweet tea or coffee and that it is best to eat fresh fruits and vegetables and unsweetened fruit juice, vegetable juice, fresh milk, coconut juice or plain water"[22]. However, although there is controversy concerning the relative destructiveness of different fresh fruits to tooth enamel, there is general agreement that various fruits (such as apples, grapes, bananas) have the potential to cause demineralisation of enamel[23]. Dried fruits such as raisins, figs, dates and others are even more cariogenic due to higher sugar content and a longer retention time[5, 24]. Packaged fruit juices including those marked 'no sugar added', contain substantial quantities of sugar and can cause rapid falls in pH[25]. Tiegen and his colleagues showed that vegetarian diets containing large amounts of fruits and vegetables have a high cariogenic potential[26]. A few studies found that lacto vegetarians had greater dental caries and had lower salivary flow rates and pH[27, 28].

In addition to the chemical composition of foods, the particle size, solubility, adhesiveness, texture, and taste are important for cariogenicity because they influence oral clearance of foods[20, 29]. The interactions of the cariogenic potential of foods, the physical state of the diet, and the frequency of eating among other local factors seem to contribute independently and in unison to the carious process[29, 30]. The rate of clearance of oral carbohydrates and the pH can both be increased by eating tough or highly flavoured foods such as fresh fruit (low sugar-containing), raw vegetables, sugar-free gum, or peanuts and cheese at the end of meals as well as by toothbrushing[5].

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