



## SHORT COMMUNICATION

### ESTIMATION OF THE TOTAL SALIVA VOLUME PRODUCED PER DAY IN FIVE-YEAR-OLD CHILDREN

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**Summary**—Fifteen boys and 15 girls were asked to record for 2 days the time spent awake, eating meals or snacks, and sleeping. The salivary flow rates elicited by chewing foods were also determined. The mean flow rate ( $\pm$ SD) of unstimulated saliva was  $0.26 \pm 0.16$  ml/min and that of saliva while chewing six different foods was  $3.6 \pm 0.8$  ml/min. The mean times spent eating, and awake but not eating, were  $80.8 \pm 27.3$  and  $820 \pm 59$  min, respectively, and the volumes of saliva produced during those periods would average about 288 and 208 ml, respectively. If the flow rate is virtually zero during sleep, the estimated total salivary volume produced per day is calculated to be about 500 ml.

**Key words:** unstimulated salivary volume, stimulated salivary volume, chewing foods, children.

To estimate the total salivary flow per day, Watanabe and Dawes (1988) studied the effect of different foods on the flow rate of whole saliva and determined the length of time spent eating and awake each day. The estimated volume produced per day was about 570 ml. This is considerably less than the value of 1.5 l given in several textbooks of physiology or the value of 1 l estimated by Richardson and Feldman (1986). These studies were made on adults and there is little information about salivary flow rates in children. Marked differences were found between children and adults for such variables as the volume of saliva in the mouth before and after swallowing (Watanabe and Dawes, 1990), and the flow rates of unstimulated and stimulated whole saliva (Watanabe, 1992).

Fifteen boys and 15 girls who had a normal primary dentition were asked to record, for 2 days (week days), the time to the nearest minute spent eating meals or snacks, and sleeping. Their parents all consented to their participation in the study. All the children had a lunch at their kindergarten, and the time spent eating it was recorded by the class teacher. Other meals and snacks were eaten in their homes, and their mothers recorded the time. The results for the 2 days were averaged for each child.

At the beginning of the main study, unstimulated whole saliva was collected. The children were seated, with head down, and saliva was collected for 5 min by being allowed to drip off the lower lip into a weighed container. They swallowed immediately before the collection, and at the end forcibly spat out any saliva remaining in the mouth into the container, and the increase in weight was determined (Dawes, 1987). The children were watched closely so that swallowing did not occur during the 5-min collection period. The six representative foods were steamed rice, sausage,

mashed potato, cookie, apple and pickled radish. During the main study, the amount of a given food was weighed to the nearest 10 mg on a top-loading balance (FX3200, A & D, Japan). The participants took their usual bite-size portions and chewed until such time as they would normally have swallowed. However, instead of swallowing, they spat out the food bolus into a previously weighed container. The time required for all the food to be masticated and spat out was recorded. The volume of saliva secreted in that time was determined by subtracting the initial weight of the food from that of the food-saliva mixture.

A rest period of 4 or 5 min was allowed between each successive food. The order of presentation of the foods was randomized for all participants. The dry weights of the food-saliva mixture for rice, apple and cookie were subsequently obtained by freeze-drying (Freeze dryer VD-15, Taitec, Japan). The percentage dry weights of the same batches of those foods (unchewed) were also obtained, which allowed calculation of the percentage of food either inadvertently swallowed or retained in the mouth and expectorated, by the formula described by Watanabe and Dawes (1988).

There were no significant differences due to gender in salivary flow rate and times spent awake and eating and thus the results for boys and girls were pooled. Table 1 shows the mean times spent eating (breakfast, lunch, dinner and snacks), awake but not eating, and sleeping. There is surprisingly little information about the length of time spent eating each day, particularly when food is self-selected. From a study of 10 obese and 10 non-obese persons consuming two set diets, Duncan, Bacon and Weinsier (1983) reported that total eating time per day was independent of the

Table 1. Mean times ( $\pm$ SD) per day for total time spent eating (breakfast, lunch, dinner, and snacks), awake but not eating, and sleeping

Questionnaire item	Time (min)
Total time spent eating	80.8 $\pm$ 27.3
Breakfast	17.1 $\pm$ 7.9
Lunch	27.5 $\pm$ 10.0
Dinner	24.4 $\pm$ 10.9
Snacks	11.8 $\pm$ 7.4
Awake but not eating	802 $\pm$ 59
Sleeping	558 $\pm$ 77

degree of obesity and averaged 69  $\pm$  14 min and 52  $\pm$  11 min on low- and high-energy diets, respectively. Watanabe and Dawes (1988) found a total mean eating time of 54.5 min per day for 31 dental students consuming self-selected diets. In this study, on 5-year-old children, the mean eating time was longer than the above values for adults.

Table 2 shows the mean weights of foods, the mean chewing times for those weights of food, the weights of the food saliva mixtures, and the salivary flow rates. The mean salivary flow rate with the six different foods was calculated to be 3.6  $\pm$  0.8 ml/min and the mean unstimulated salivary flow rate was 0.26  $\pm$  0.16 ml/min. The percentage of food that was either inadvertently swallowed or remained stuck to the teeth or oral mucosa was calculated to be 12.1  $\pm$  4.6 for rice, 10.3  $\pm$  6.2 for apple, and 9.4  $\pm$  2.8 for cookie, and the mean value was 10.6  $\pm$  4.5. We did not adjust the computed flow rates for this in Table 2, so presumably they are a slight underestimation of the actual flow rates. Watanabe and Dawes (1988) studied the effects of chewing seven commonly consumed foods on the flow rate of whole saliva. The mean flow rates were highest with rhubarb pie (4.94  $\pm$  1.51 ml/min) and lowest with rice (3.15  $\pm$  1.48 ml/min), and the mean flow rate during consumption of seven different foods was 4.0 ml/min. The percentage of food loss was calculated to be 5.7  $\pm$  3.1 for rice, and 6.1  $\pm$  2.7 for apple.

The flow rate of unstimulated whole saliva in persons awake but not eating has been found, in studies of several hundred people (Becks and Wainwright, 1943; Heintze, Birkhed and Björn, 1983), to average about 0.32 ml/min. Our value of 0.26 ml/min in 5-year-old children was lower than that of adults.

Dawes and Watanabe (1987) have shown that the half-time for adaptation of salivary flow to a constant taste stimulus is about 11 s but in those studies the tongue was kept completely motionless. When a taste stimulus is moved around the mouth, there is little, if any, adaptation.

If we assume that 80 min per day is spent eating, at a mean flow rate of 3.6 ml/min, the total volume of saliva per day during eating will be about 288 ml. The unstimulated saliva volume while awake but not eating would total about 208 ml over 13.5 h if the average unstimulated flow rate was 0.26 ml/min. As the flow rate is virtually zero during sleep (Lichter

Table 2. Mean weights ( $\pm$ SD) of foods, the mean chewing times for those weights of food, the weight of the food-saliva mixtures, and the salivary flow rates

Food	Food wt (g)	Chewing time (s)	Wt of food-saliva mixture (g)	Salivary flow rate (ml/min)
Cookie	6.3 $\pm$ 3.4	61.3 $\pm$ 29.4	11.1 $\pm$ 4.3	4.7 $\pm$ 2.5
Pickled radish	22.8 $\pm$ 12.7	92.2 $\pm$ 49.5	29.0 $\pm$ 13.5	4.0 $\pm$ 2.2
Sausage	22.4 $\pm$ 12.7	85.6 $\pm$ 49.1	28.0 $\pm$ 13.8	3.9 $\pm$ 2.3
Mashed potato	22.7 $\pm$ 9.9	61.9 $\pm$ 32.1	26.3 $\pm$ 11.4	3.5 $\pm$ 2.3
Apple	26.2 $\pm$ 14.3	77.9 $\pm$ 45.1	31.0 $\pm$ 15.6	3.4 $\pm$ 1.6
Rice	38.2 $\pm$ 26.5	93.7 $\pm$ 37.9	41.9 $\pm$ 28.2	2.4 $\pm$ 1.2

Unstimulated salivary flow rate 0.26  $\pm$  0.16.

and Muir, 1975), the estimated total salivary volume produced per day in 5-year-old children is calculated to be about 500 ml. Although children appear to eat far longer than adults, they have lower unstimulated and stimulated salivary flow rates and a longer sleeping time so that the total volume of saliva secreted per day is very similar to that reported for adults by Watanabe and Dawes (1988).

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