

# Effect of age on variability of parotid salivary gland flow rates over time

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## Abstract

**Background:** although several reports indicate that qualitative and quantitative assessments of parotid salivary function are age-stable in healthy adults, there have been no studies of the influence of age on the variability of repeated parotid flow rates.

**Objective:** to examine the influence of age on the variability of repeated parotid flow rates in unmedicated, healthy adults.

**Materials and methods:** we assessed unilateral unstimulated and 2% citrate-stimulated parotid flow rates and collected responses to a five-item subjective xerostomia questionnaire in 14 subjects aged 20–40 years and 14 subjects aged 60–80 years. All subjects were healthy and unmedicated. We collected saliva and asked subjects to complete the questionnaire at baseline, 1 h and 2 h.

**Results:** unstimulated and stimulated parotid flow rates were similar at each time point in young and older subjects, and remained stable over the collection period. There were no differences in the standard deviations of the three collections of unstimulated and stimulated flow rates between young and older subjects. There were no differences between questionnaire responses between the two groups, and no change in response over time.

**Conclusions:** there is no increased age-related variability in parotid salivary flow rates over repeated measures. Stimulated parotid flow rates are stable over 2 h in healthy people, and are similar in young and older individuals. These results suggest that parotid glands have a large secretory reserve.

**Keywords:** ageing, heterogeneity, parotid, saliva, variability

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## Introduction

Saliva plays a critical role in the maintenance of oral health [1]. Salivary functions include the preservation, protection and repair of oral mucosal tissues, remineralization of teeth, and the modulation of viral, fungal and bacterial populations. In addition, salivary fluids facilitate food breakdown, bolus formation and taste, and can buffer acids from the external and internal environments. Alterations in salivary gland function can have adverse effects on oral and systemic health. Individuals with reduced salivary output are prone to dental caries, oral mucositis, dysphagia, oral infections and altered taste [2].

Many older adults have salivary gland dysfunction and complain of a dry mouth (xerostomia) [3]. It was thought that salivary function declined with greater age, but it is now accepted that output from major salivary glands does not change greatly in healthy individuals. Results of cross-sectional [4–8] and longitudinal [9–11]

studies indicate that parotid salivary gland function in healthy individuals is generally age-independent. Furthermore, the constituents of parotid saliva do not change with age [6, 10]. Many medical conditions and their treatments (including medications, head and neck radiation and chemotherapy) may contribute to salivary gland dysfunction in elderly subjects [2, 12–15].

There have been attempts to explain the vulnerability of older adults to salivary dysfunction and xerostomia [16]. Medical problems and medications may adversely affect the health of older adults as well as their oral condition [17, 18], which may adversely influence salivary physiology [2]. However, elderly people show great variability in oral and systemic health status, ranging from very healthy and unmedicated to permanently incapacitated and dependent.

Heterogeneity may increase with age. Elderly people have diverse physiological and psychological characteristics [19]. Consequently, some researchers

have begun to emphasize the need to examine the diversity among similarly aged individuals in addition to normative age patterns.

While data from many studies suggest that heterogeneity increases with age [20, 21], little research has been devoted to heterogeneity in oral health and function. Indeed, no study has investigated the variability of salivary gland function among similarly aged individuals. Such information may help explain discrepancies between subjective xerostomia complaints and salivary output in healthy older adults.

We have examined the influence of age on the variability of extended parotid flow rates in unmedicated, healthy adults.

## Materials and methods

### Subjects

We evaluated 28 people aged either between 20 and 40 years or between 60 and 80 years (Table 1). All subjects completed a signed consent form approved by the University of Michigan investigational review board. All subjects were healthy, living at home and middle class. None was being treated for any systemic disease or taking any prescription or non-prescription medications. Rigorous medical, neurological and laboratory screening excluded those with underlying medical disorders.

### Parotid saliva collection

One investigator saw all participants between 0800 h and 1100 h. All subjects refrained from eating, drinking, smoking and performing oral hygiene for a minimum of 2 h before saliva collection. Saliva flow is termed 'unstimulated' when no exogenous or pharmacological stimulation is used and 'stimulated' when secretion is increased by gustatory stimuli. We asked participants wearing removable dental prostheses to remove them for the duration of the study.

We collected unstimulated and stimulated parotid salivary samples according to established criteria [4, 5] by placing a modified Carlson-Crittenden cup (Stone Machine Co., Colton, CA, USA) over the orifice of one parotid gland (Stenson's duct). Unstimulated samples were collected initially for 2 min. For any subject with

no unstimulated parotid saliva production after 5 min, a retest was performed. After two negative unstimulated test results, plus positive evidence of a stimulated secretion, we discontinued collection and recorded unstimulated parotid flow rate as zero [22]. For stimulated parotid saliva, we applied 2% citric acid to the dorsal lateral surface of the tongue for 5 s at 30-s intervals [23, 24]. After a 2-min equilibration period during which saliva was not collected, we collected stimulated secretions for 2 min while maintaining citric acid stimulation. We performed unstimulated and stimulated parotid salivary collections at baseline and each hour over a 2 h period for a total of three collections. We collected all samples in preweighed plastic graduated conical tubes. After collection, flow rates were determined gravimetrically, assuming a specific gravity of 1.0, and reported as ml/min.

The same investigator collected unstimulated and 2% citrate-stimulated parotid salivas at 1 h intervals from six healthy, unmedicated subjects for calibration. Intra-examiner correlation coefficients were 0.98 for unstimulated parotid and 0.96 for stimulated parotid flow rates.

### Subjective questionnaire

We asked participants the following five questions about oral dryness before each saliva collection period:

1. Does your mouth feel dry when eating a meal? (no/yes)
2. Are you thirsty? (no/yes)
3. Does the amount of saliva in your mouth seem to be too little (yes), too much (no), or you don't notice it (no)?
4. Do you have difficulties swallowing? (no/yes)
5. Do you sip liquids to aid in swallowing dry foods? (no/yes)

Four of these questions (1, 3, 4 and 5) have been correlated with objective findings of salivary gland dysfunction. All these questions have been previously used in investigations of dry mouth [3, 25].

### Statistical analyses

We entered data into a computer and analysed them with RS1 software (BBN Software Products, Boston, MA, USA) and Systat (SYSTAT Inc., Evanston, IL, USA).

Table 1. Subject data

	Men		Women	
	Young	Older	Young	Older
Number	7	7	7	7
Mean age, years ( $\pm$ SD)	28.6 $\pm$ 4.8	68.7 $\pm$ 3.5	27.0 $\pm$ 4.3	68.1 $\pm$ 4.3
Age range, years	23-35	64-73	20-32	64-74

Stimulated and unstimulated parotid flow rates were analysed over time and between age and gender groups using a repeated measures ANOVA with one within factor (time) and two between factors (age and gender groups). We calculated the standard deviation for stimulated and unstimulated flow rates from the three collection periods for each person. To estimate variability between age groups, we compared the mean of the standard deviations of stimulated and unstimulated flow rates of young and older groups using Student's *t*-test.

We analysed responses to each of the five items in the subjective xerostomia questionnaire over time with McNemar's test. For each question, consistency was evaluated by examining if any responses differed over the three time points. We then assessed differences in consistency between young and older subjects using  $\chi^2$  tests. A criterion of  $P < 0.05$  was accepted for significance in all statistical tests.

## Results

### Parotid salivary gland flow rates

Overall, stimulated and unstimulated parotid flow rates did not change throughout the 2 h of the study, and there were no differences over time between young and older groups (Figure 1) or between men and women. Mean and standard deviation values are summarized in Table 2. Using a repeated measures ANOVA for unstimulated and stimulated flow rates separately, none of the main effects (age, gender, time) or the interactions (age  $\times$  time, age  $\times$  gender, gender  $\times$  time, age  $\times$  time  $\times$  gender) was statistically significant ( $P > 0.05$ ). A comparison of the means of the standard deviations of unstimulated flow rates (young = 0.034, older = 0.039;  $P > 0.05$ ) and stimulated flow rates (young = 0.195, older = 0.206;  $P > 0.05$ ) over the three collection periods between young and older age groups revealed no significant differences.

### Subjective questionnaire

Results of the five-item subjective xerostomia questionnaire revealed no statistically significant changes over time. Furthermore, responses did not show any differences at any of the three time periods between age groups, nor were there any changes over time between young and older age groups.

## Discussion

These results demonstrate that parotid salivary flow rates remain stable over 2 h in healthy, unmedicated subjects, and are similar in young and older individuals. Overall, there were no age differences in parotid flow rates or subjective complaints of xerostomia.

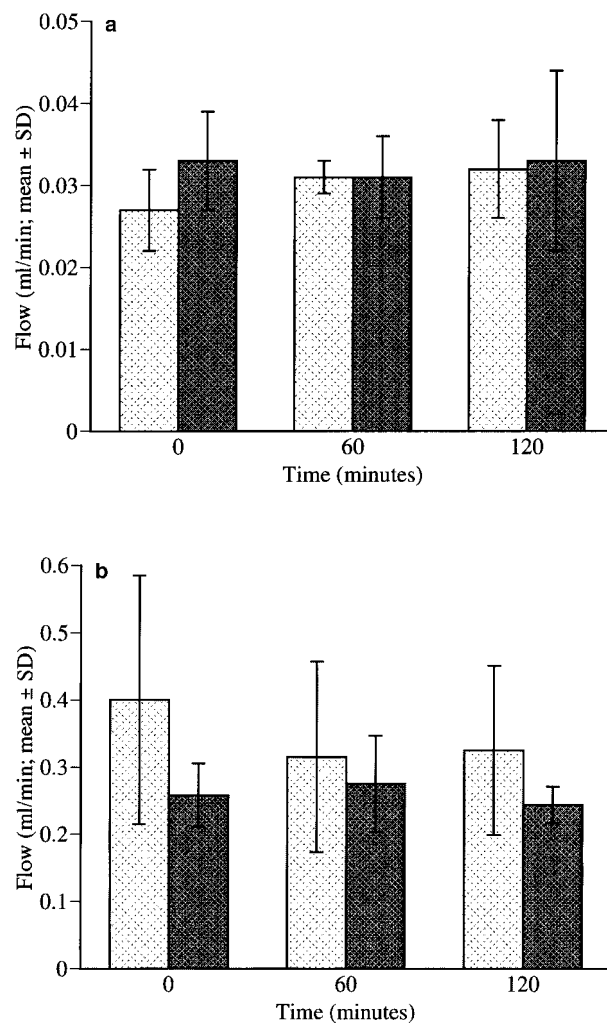


Figure 1. **a** Unstimulated and **b** 2% citrate-stimulated parotid flow rates over a 2 h period of time in 14 young (□) and 14 older (■) healthy, unmedicated adults.

Table 2. Parotid salivary flow rates

	Mean flow rate, ml/min ( $\pm$ SD)		
	Baseline	1 h	2 h
Unstimulated <sup>a</sup>			
Young	0.027 $\pm$ 0.032	0.031 $\pm$ 0.033	0.032 $\pm$ 0.038
Older	0.033 $\pm$ 0.039	0.031 $\pm$ 0.036	0.033 $\pm$ 0.044
Stimulated <sup>a</sup>			
Young	0.400 $\pm$ 0.215	0.315 $\pm$ 0.173	0.325 $\pm$ 0.199
Older	0.258 $\pm$ 0.211	0.275 $\pm$ 0.203	0.244 $\pm$ 0.217

<sup>a</sup>There were no significant differences over time between young and older subjects (repeated measures ANOVA,  $P > 0.05$ ).

Although salivary flow rates show much variability [22], we found no change in variability over the study period and no difference in variability between younger and older subjects. There were no age-related differences in responses to the xerostomia questionnaire.

Our results are consistent with cross-sectional studies of healthy adults that have shown that parotid salivary gland function is stable across the age-spectrum [4–8]. However, the large amount of variability in parotid salivary flow rates in a healthy population [22] could obscure important age-related changes in output reported in cross-sectional investigations. Importantly, however, longitudinal studies have confirmed that parotid output is age-stable [9–11], and the results from the standard deviation analyses in our investigation clearly establish that parotid function is similar in different age groups. Finally, the results of the xerostomia questionnaire are consistent with the flow rate data, and suggest that there may not be age-related differences in parotid variability over 2 h.

The similarities in flow rate and variability data between age groups suggest resilience of the oral cavity during ageing, which has been previously observed [17]. Most studies of parotid function in healthy adults across the human life span demonstrate that this physiological mechanism is robust and can maintain output despite decreases in acinar (fluid-producing) cells in elderly people [26, 27]. Although all subjects in our investigation were healthy, many elderly patients have multiple medical problems and may take several prescription and non-prescription medications. Consequently, variability may be more pronounced as people get older and have medical problems and treatment: this was not evident in our homogenous population of young and older healthy adults.

Studies examining age-related changes typically focus on mean-level differences or other measures of central tendency [21]. Little attention is devoted to dispersion within age categories. For example, some older subjects may experience no decrease in salivary flow over time while others may exhibit clinically significant decreases in salivary function. The focus on mean-level differences allows many age-based generalizations to be made. While such generalizations are often useful, focusing on mean-level differences may reinforce age norms and age stereotyping [21, 28, 29]. Such age norms misrepresent the nature of age differences and may not reflect individual differences.

Saliva plays a vital role in maintaining oral health, and decreases in quantitative or qualitative output may adversely affect oral and pharyngeal health [2]. The increased physiological heterogeneity that occurs in older individuals corresponds to a progressive deterioration of essential cells in the body. This may be consistent with a loss of salivary parenchymal acinar cells with ageing [26, 27], yet the parotid gland is able

to maintain function without observed changes in quantity, quality or variability.

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## Key points

- There is no increased age-related variability in parotid salivary flow rates over repeated measures.
  - Stimulated parotid flow rates are stable over 2 h in healthy people, and are similar in young and older individuals.
  - Parotid glands have a large secretory reserve over the human life span.
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## Acknowledgements

We acknowledge the support of the NIH (NIDR R03 DE10906-01), the University of Michigan General Clinical Research Center (M01 RR00042), and the University of Michigan School of Dentistry Student Research Program (NIDR Training Grant DE07101).

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Received 27 July 1998; accepted in revised form 21 January 1999