

# Correlation Assessment of unstimulated whole saliva flow rate with anthropometric indices

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## Abstract

**Background and Aim:** Controversy exists regarding the correlation of saliva secretion with obesity. Considering the significant role of saliva in oral and dental health and the increasing prevalence of obesity in Iran in the past three decades, this study aimed to assess the independent association of anthropometric indices including body mass index (BMI), weight gain after the age of 20 years and waist circumference (WC) with unstimulated whole saliva flow rate.

**Materials and Methods:** This comparative cross-sectional study was conducted on 313 systematically healthy subjects who referred to Guilan Dental School. Age, gender, the level of education, BMI, WC and weight gain after the age of 20 was recorded. Unstimulated whole saliva flow rate was measured and the independent association of anthropometric indices with saliva flow rate was statistically analyzed. Statistical significance was set at  $P < 0.05$ .

**Results:** 331 subjects (186 females and 145 males) were evaluated. Among them, 107 were obese ( $BMI \geq 30 \text{ kg/m}^2$ ), 114 were overweight ( $BMI = 25\text{-}29.9 \text{ kg/m}^2$ ), and 110 had normal weight ( $BMI = 18.5\text{-}24.9 \text{ kg/m}^2$ ). The mean saliva flow rate was 0.33 ml/minute. The odds ratio of reduction in saliva flow below the mean value (0.33 ml/minute) in obese compared to normal weight individuals was 1.84. The cut-off point of saliva flow reduction was 10.20 kg weight gain after the age of 20 with 62.3% sensitivity and 61.2% specificity. Weight gain after the age of 20 (odds ratio=1.06, 95% CI: 1.03-1.08) and gender (odds ratio: 1.87, 95% CI: 1.18-2.97) were found to be predictors of saliva flow reduction.

**Conclusion:** This study showed that weight gain in adults was significantly correlated with the saliva flow rate, and weight gain after the age of 20 years was the main anthropometric index related to saliva flow reduction. The mean saliva flow rate in overweight and obese females was higher than counterpart males.

**Key Words:** Weight Gain, Saliva, Body Mass Index, Obesity

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## Introduction

Saliva is secreted by the salivary glands and plays an important role in health, function, and homeostasis of the oral environment; it also regulates the intraoral ecosystem [1-3].

Quantitative and qualitative shortage of saliva adversely affects the physical and social health, self-confidence and consequently the quality of life of individuals [3]. Evidence shows that childhood obesity is correlated with a reduction in stimulated

saliva flow rate and subsequent development of dental caries and adversely affects the oral health of children [4-8]. In adulthood, obesity is correlated with tooth loss due to increased rate of caries and periodontal disease, mediated by the inflammatory factors such as the C-reactive protein, fibrinogen, adipokines and other inflammatory cytokines secreted by adipose tissue [9,10]. Evidence shows that salivary bacteria may be related to overweight and obesity [11]. Adipose tissue and its secretory products have been isolated from the salivary glands and their secretions. In many cadaver studies, increased fat accumulation in salivary glands has been noted due to advanced age [12-17].

Dental caries and obesity are both related to nutritional habits, socioeconomic status, and lifestyle. They both impose a high burden on the health system. Prevalence of caries has been reported between 17.9 to 90% [9]. However, epidemiologic studies have reported this rate to be 42-67% [18]. The prevalence of obesity varies from 9 to 35% in different parts of the world. Iran, as a fast developing country, is not an exception to this rule and obesity follows an ascending trend in different parts of Iran as well [19-22]. In Guilan, the prevalence of overweight and obesity in individuals over 25 years was reported 24.6% [23,24]. Several studies with different methodologies have been carried out to elucidate the correlation between dental caries and obesity and have reported various results. One of the important factors involving the development of caries is the reduction of saliva flow by decreasing the food debris and cariogenic microorganisms' washout, and reducing the cariostatic enzymes production, and changing the buffering capacity of the saliva which results in decreasing its ability to neutralize the critical pH. All these factors are contributed to increased rate of dental caries [25,26].

It has been postulated that there is a correlation between decreased saliva secretion and the occurrence of dental caries and periodontal diseases [8,9]. Although there might be an association between decreased saliva flow and increasing prevalence of obesity, because of insufficient evidence regarding the presence of a correlation between obesity and saliva secretion

rate in adults, this study aimed to assess the independent correlation of anthropometric indices with saliva flow in overweight and obese adults in city of Rasht, Guilan Province.

## Materials and Methods

This study was approved by the ethics committee of Guilan University of Medical Sciences (IR.GUMS.REC.1395.119) and was conducted in accordance with the Declaration of Helsinki. A total of 331 subjects were evaluated in this comparative cross-sectional study after signing written informed consent forms.

The inclusion criteria were as follows: healthy adults, males and/or females, with no history of weight loss in the past six months, no auto-immune or any systemic diseases such as diabetes mellitus, hyperlipidemia, hypertension (metabolic syndrome), Sjogren's syndrome, Parkinson's disease or Alzheimer. Subjects with hormonal disorders (hyper- or hypothyroidism, adrenal insufficiency, acromegaly), cirrhosis, renal disease, cancer, AIDS, pregnant women, professional athletes, those on a specific diet in the past six months or subjects experiencing either weight loss or gain, and patients who take neurological and/or any other drugs which may have an impact on saliva secretion were not included. Drug addicts, subjects with xerostomia and patients taking antihistaminic drugs (e.g. diphenhydramine), acetyl choline, pilocarpine, phenothiazine, and iodine or histamine containing drugs were not included either [1,2,3].

### **Data collection tools:**

#### *Sociodemographic characteristics:*

Sociodemographic information of subjects including age, gender, occupation, and weight at 20 years of age were recorded using a self-report questionnaire. The level of education was divided into two groups of high school diploma and college/university degree.

#### *Anthropometric characteristics:*

In order to calculate body mass index (BMI), patients were asked to take off their shoes and thick clothing and weight were measured using a digital scale with 0.1kg accuracy and height was measured using a stadiometer. The waist circumference (WC) was measured above the iliac crest and below the umbilicus without applying

pressure using a tape measure in centimeters. Patients were asked about their weight at age 20 and by subtracting this value from the current weight, weight gain of each subject was calculated. The WC reference was considered  $\leq 102$  cm in males and  $\leq 88$  cm in females [27]. According to the World Health Organization, patients with BMI between 18.5-24.9 kg/m<sup>2</sup> were considered normal, 25-29.9 kg/m<sup>2</sup> were considered overweight and  $>30$  kg/m<sup>2</sup> were considered obese.

**Saliva collection:** Unstimulated whole saliva was collected by the spitting method during 10 minutes between 9 a.m. to 12 p.m. [28]. Participants were asked to refrain from eating, drinking, and chewing gum or smoking for one hour prior to saliva collection. The saliva flow rate was calculated in g/minute [3,28].

#### *Statistical analysis:*

Kolmogorov-Smirnov test was used in order to examine the normal distribution of the data regarding unstimulated saliva and the P-value was set at  $<0.05$ . The Partial correlation was used to assess the presence of correlations. Multiple logistic regression was applied to assess the odds ratios and ANCOVA was used to evaluate the effect of confounders.

## Results

In the present study, a total of 331 healthy individuals were evaluated among whom were 86 (56.2%) females and 145 (43.8%) males. The mean age of participants was  $31.05 \pm 6.5$  years (ranged 20-48 years). The BMI results showed that 110 (33.2%) of contributors had normal weight, 114 (34.4%) were overweight and 107 (32.3%) were obese. The mean increase in weight after the age of 20 was  $10.22 \pm 9.6$  kg. The mean unstimulated saliva flow rate was  $0.33 \pm 0.10$  ml/min (ranged between 0.04-0.67 ml/min). Table 1 shows demographic information of subjects and anthropometric indices including weight gain after the age of 20 years, BMI and WC.

Weight gain after the age of 20 years showed a significant inverse correlation with saliva flow rate ( $P < 0.0001$ ,  $r = -0.232$ ). In other words, per each 1 kg weight gain after the age of 20 years, the odds of the reduction in saliva flow to a value less than the mean value of 0.33 ml/min increased by 1.05 times. BMI also showed a significant inverse correlation

with saliva flow rate ( $P = 0.004$ ,  $r = -0.159$ ). The odd ratio of saliva flow reduction to less than the mean value of 0.33 ml/min in the obese individuals compared to normal weight subjects was 1.84 (95% CI: 1.08-3.16). In females, the saliva flow decreased significantly ( $P = 0.02$ ) by increasing the BMI (Fig. 1).

Subjects with a higher WC had 2.04 times higher odds of saliva flow reduction (95% CI: 1.3-3.2) compared to contributors with normal WC (Fig. 2). The mean unstimulated saliva flow rate was significantly different among different age groups ( $P = 0.041$ ) and males had significantly higher flow rate than females ( $P = 0.003$ ). Aging showed a significant correlation with reduction in saliva flow rate ( $P = 0.0444$ ,  $r = -0.111$ ) (Fig 3). Gender and weight gain after the age of 20 were the predictors of reduction in saliva flow rate in the final logistic model ( $P < 0.0001$ ).

Women were 1.9 times more likely to experience a reduction in saliva flow rate compared to men (odds ratio: 1.87, 95% CI: 1.18-2.97). In other words, by every 1 kg weight gain after the age of 20, the odds ratio of reduction in saliva flow increased by 1.06 times. This rate was 1.33 per 5 kg weight gain in males (odds ratio: 1.06, 95% CI: 1.03-1.08). The mean saliva flow rate was  $0.35 \pm 0.11$  ml/min in subjects with a weight gain less than the median and  $0.3 \pm 0.09$  ml/min in subjects with a weight gain more than the median (10 kg) ( $P = 0.001$ ).

ANCOVA was used to control for the potential effect of confounders and showed that weight gain over 10 kg significantly influenced the saliva flow rate ( $P < 0.0001$ ). Weight gain by 10.20 kg after the age of 20 years was the cutoff point for decreasing the saliva flow rate below the mean value of 0.33 ml/min with 62.3% sensitivity 61.2% specificity and area under the curve of  $0.644 \pm 0.32$ , 95% AUC: 0.581-0.708,  $P < 0.0001$ ).

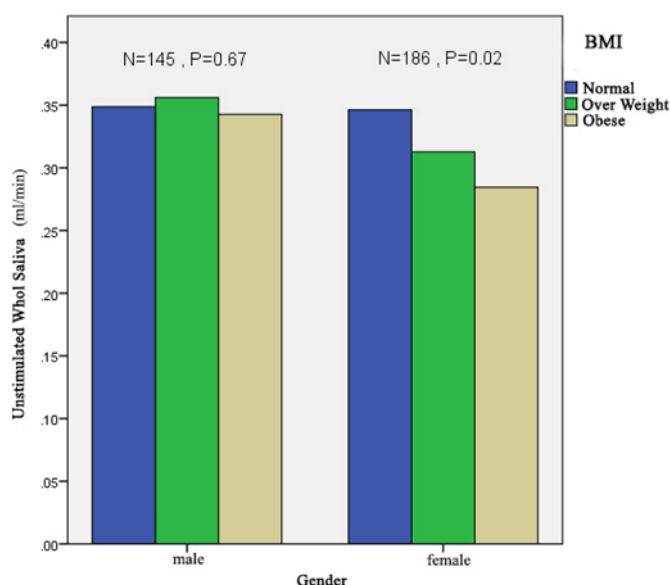
## Discussion

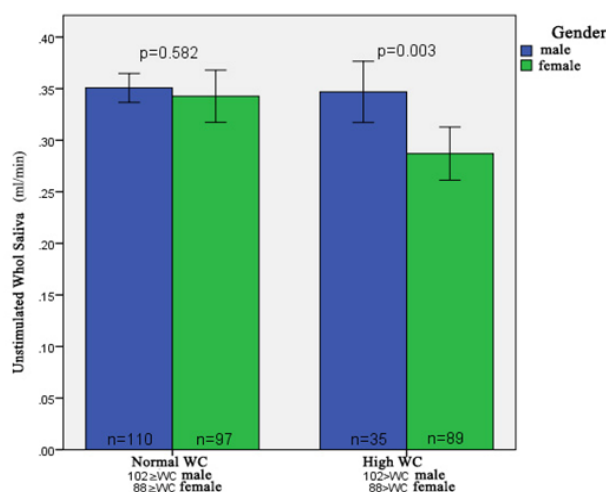
Saliva is an important factor in maintaining oral health, and change in its flow and contents affects all components of the oral cavity. Several studies have pointed to the adverse effects of obesity on dental and periodontal health [4-10]. The current study provides evidence of the correlation between saliva flow rate and

**Table 1.** The frequency distribution of demographic information and anthropometric indices as well as the unstimulated saliva flow rate in subjects (values are presented as Mean± Standard deviation)

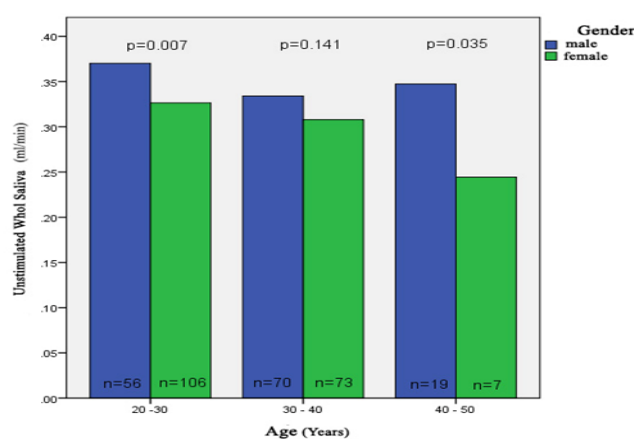
		weight gain after the age of 20	BMI	WC	unstimulated saliva flow rate
<b>Gender</b>	Males (n=145)	11.62±9.7	27.78±3.8	96.04±8.96	0.35±0.08
	Females (n=186)	9.13±9.35	27.48±4.61	88.72±10.42	0.32±0.13
	P value	0.019*	0.539	<0.0001*	0.005*
<b>Age group</b>	20-30 years (n=162)	6.51±7.24	26.45±4.44	88.20±10.26	0.34±0.11
	30-40 years (n=143)	14.07±9.85	29±3.82	95.37±9.48	0.32±0.11
	40-50 years (n=26)	12.21±12.21	27.24±3.78	96.23±8.66	0.32±0.08
	P value	<0.0001*	<0.0001*	<0.0001*	0.219
<b>BMI</b>	Normal weight (n=110)	2.57±5.85	22.81±1.68	82.89±6.85	0.35±0.12
	Overweight (n=114)	11.10±8.05	27.64±1.38	91.46±7.34	0.34±0.10
	Obese (n=107)	17.15±8.52	32.52±2.10	101.71±7.23	0.31±0.10
	P value	<0.0001*	<0.0001*	<0.0001*	0.034*

\*= significant differences

**Figure 1.** Comparison of unstimulated saliva flow (ml/min) in males and regarding the BMI



**Figure 2.** Comparison of unstimulated saliva flow in males and females regarding their WC



**Figure 3.** Difference in saliva flow rate among different age groups

anthropometric indices. The results showed that 10kg weight gain after the age of 20 years significantly decreased the saliva flow rate, irrespective of the gender. This finding also supports the theory of adverse effects of fat accumulation in the body, on salivary glands and their function [12-14]. Fat accumulation can adversely affect saliva secretion and consequently, compromise oral and dental health. It is also a risk factor for chronic oral diseases such as periodontitis and dental caries. On the other hand, reduction in saliva flow rate decreases the saliva pH (to the critical threshold) and adversely affects

dental health [25,26]. Moreover, reduction in saliva flow because of sympathetic innervations results in a decrease in the concentration of salivary compounds such as enzymes and protective agents, which increase the risk of caries and damages to oral tissues [25,26]. According to Dawes [26], reduction in saliva flow, increase the adhesion of microorganisms to epithelial cells and due to higher availability of substrates and decreased washout, bacteria proliferate at a faster rate (up to three times); therefore, tissue destruction occurs faster and to a greater extent [26].

The results of current study detected an association between BMI and secretion of unstimulated saliva, which was that obese individuals had a lower saliva flow rate compared to overweight and normal weight subjects and they are more prone to the reduction of the saliva flow rate to the less than the mean value.

Yamamoto et al. [29] stated that unstimulated saliva flow rate in both males and females was significantly correlated with BMI while unstimulated saliva in each of the two groups of males and females was not independently correlated with anthropometric indices [29]. However, in our study, the interaction effect of gender and BMI was significant [12,13,16, 30,31,32].

The results from current study indicated that in addition to BMI, gender had also a significant effect on salivary flow rate; female individuals had lower salivary flow rate ( $P=0.005$ ). Inoue et al. [13] measured the size of salivary glands using magnetic resonance imaging (MRI) and found a significant association between unstimulated saliva flow rate and the size of salivary glands with BMI and weight [13]. However, Fenoll-Palomare et al. [33] found no significant correlation between obesity and secretion of unstimulated saliva. It seems that lack of correlation in the Fenoll's study [33] might be due to small sample size and younger age of obese subjects compared to normal weight individuals in their study.

The association of WC and weight gain after 20 years and unstimulated saliva flow rate was also evaluated in the current study, however, no significant association was found in this respect between WC and unstimulated saliva flow rate ( $P=0.219$ ). This association has not been previously evaluated in any study.

In the current study, the unstimulated saliva flow rate decreased with an increase in age, which was in line with the findings of some previous studies [34,35]. Pedersen et al. [30] stated that the effect of drug intake on the reduction of unstimulated saliva flow rate was greater than that of age while Percival et al. [31] reported that decreased function of salivary glands was mainly due to advanced age. Waterhouse et al [14] and Scott [17] have suggested the theory of replacement of the acinar salivary gland tissue with adipose tissue. Our

findings support this theory since weight gain after the age of 20 years in our study decreased the saliva flow rate. In other words, reduction in saliva flow rate may occur following weight gain after the age of 20 years.

In addition to age, gender also had an association with unstimulated saliva flow rate in the current study; unstimulated saliva flow rate in women was significantly lower than that in men ( $P=0.003$ ). This finding was similar to the results of some previous studies [30,24,19,7]. Inoue et al. [13] have measured the size of salivary glands by means of MRI. They revealed that the size of salivary glands was smaller in females. They have also observed that BMI and weight were correlated with size of salivary glands and consequently unstimulated saliva flow rate [13]. Dawes [12] explained that smaller size of the oral cavity and a smaller mucosal surface area in females were probably responsible for this difference. In other words, smaller salivary glands are more affected by fat accumulation and subsequent reduction in saliva flow. Percival et al. [31] and Heintze et al. [32] stated that hormones in females are responsible for these differences. However, Tyllenda et al. [37] declared that the mean saliva flow rate in males and females was almost the same (0.16 versus 0.18ml/min). Flink et al. [9] discussed that the difference in saliva flow rate occurs between males and females in ages over 40 years. Despite all the above, Foglio-Bonda et al. [36] reported that no significant difference exists in unstimulated saliva flow rate between males and females. However, it should be noted that the study by Foglio-Bonda et al. [36] was conducted on a smaller sample size at a lower age range. However, the current study showed that saliva flow rate decreased with the age in both males and females as reported by Flink et al. [9] and demonstrated that the difference in saliva flow rate was more evident after the age of 30 years.

## Conclusion

The present study was a cross-sectional study therefore, it could not establish a cause and effect relationship between obesity and saliva flow. In general, this study showed that gender and weight gain in adulthood were independently correlated with saliva flow rate. The effect of aging on the

reduction of saliva flow after controlling for weight gain was not significant. Since the present study revealed an independent inverse correlation between weight gain in adulthood and saliva flow rate, the use of some anthropometric indices (other than BMI) may be required to describe the association of weight gain with the oral and dental diseases related to saliva secretion.

Future studies are recommended to assess the effect of weight loss on saliva flow rate in obese patients in different age groups. Also, in order to find evidence on whether a correlation between body weight and oral and dental diseases exist, further studies are required to evaluate and measure the frequency of dental caries and saliva-related oral diseases in obese and normal weight individuals. The health system authorities and dentists must be aware of the adverse effects of obesity on the reduction of saliva flow and its consequences.

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