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Original Article

Dentistry Section

Comparative Evaluation of the Effect of Menstruation, Pregnancy and Menopause on Salivary Flow Rate, pH and Gustatory Function

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ABSTRACT

Objective: There are five situations in a women's life during which hormone fluctuations make them more susceptible to oral health problems – during puberty, at certain points in the monthly menstrual cycle, when using birth control pills, during pregnancy, and at menopause. The present study aimed at evaluating the effect of menstruation, pregnancy and menopause on salivary flow rate, pH and gustatory function.

Materials and Methods: The study was carried out on 120 patients including 30 controls (with normal menstrual cycle of 28 to 30 d) and 90 cases (30 patients within three days of menstruation, 30 pregnant and 30 postmenopausal). Paraffin-stimulated saliva samples were obtained by expectoration to calculate salivary flow rate, pH was measured electrometically and patients were prospectively evaluated for gustatory function. Then, whole mouth taste test was performed in which the quality identification and intensity ratings of taste solutions were measured.

Results: No statistically significant difference was found between the groups with respect to salivary flow rate but pH values were significantly lower in post menopausal women ($p<0.05$). Regarding correct quality identification the results were non-significant. Intensity for taste perception for sucrose was significantly lower in postmenopausal women than intensity of taste perception for other tastes ($p<0.05$). Also, postmenopausal women reported change in their dietary habits as all of them expressed liking for sweeter food.

Conclusion: Reduced salivary flow rate and pH in postmenopausal women may make them more prone to the occurrence of oral health problems. Also, pregnant and postmenopausal women appeared to have a reduced perception of sucrose, which can alter eating habits, such as intake of more sweet foods whereas no significant difference is observed in taste perception of NaCl, citric acid and quinine hydrochloride between the subjects.

Keywords: Gustatory function, Menstruation, Menopause, pH, Pregnancy, Salivary flow rate

INTRODUCTION

Saliva, the most available and non-invasive biofluid of the human body, permanently "bathes" the oral cavity and is trying to cope with an ever-changing milieu. Saliva includes a large number of organic and inorganic compounds, which act as a "mirror of the body's health." Thus, it forms a diagnostic window to the body, both in health and disease [1]. The ability to use saliva to monitor a patient's health and disease states a highly desirable goal for health promotion and health care research. Taking this into account, quantitative and/or qualitative alterations in salivary secretion may lead to local or extra oral adverse effects. These are compelling reasons to use saliva as a diagnostic fluid to monitor health and disease [2].

Health needs of women are different mainly because of the distinct changes that occur over their lifetime. This is because hormonal fluctuations occur throughout the woman's life affecting the pHysiology of the entire body including the oral cavity. Thus, the different pHases like pregnancy, menstruation, and menopause may either directly affect metabolism of periodontal tissues or might induce changes in salivary flow rates, buffering capacity, and taste perception [3].

As there is a mutual relationship between saliva flow and diet, food does not only influence salivary flow, but saliva can also affect sensory perception. The sense of taste is one of the most important human senses and plays a critical role in an individual's food preferences, which ultimately guide the dietary behaviour and thus the nutritional status of humans. Thus, with changes in salivary flow rate and pH; pregnancy, menstruation and menopause might also change the ability to perceive taste [4].

Most of the studies have focussed on the significance of salivary flow rate and pH of saliva in the development of caries and sex-dependent differences in flow rate, pH and taste perception. A number of articles have been published using the terms "saliva", "pregnancy" and "menopause" but salivary flow rate, pH and taste perception in menstruating, pregnant and menopausal women have been rarely evaluated in a single article. The present case control study aimed to investigate the effect of menstruation, pregnancy

[Table/Fig-1]: Caliberated tube for the collection of saliva B,C,D. Collection of saliva for the different study groups

		N	Mean	Std. Deviation
Salivary Flow Rate in ml/min	Control group	30	1.2980	.60944
	Menstruating group	30	1.0920	.39846
	Pregnant group	30	1.2900	.53177
	Post menopausal group	30	.9300	.19488
	Total	120	1.1525	.46934
pH	Control group	30	6.6320	.84481
	Menstruating group	30	6.5570	.63363
	Pregnant group	30	6.4170	.78943
	Post menopausal group	30	5.9840	.52311
	Total	120	6.3975	.72724

[Table/Fig-2]: Descriptive statistics of salivary flow rate and pH value in different study groups

			Mean difference	Std. error	p-value
pH	Control group	Menstruating group	.07500	.31718	.814
		Pregnant group	.21500	.31718	.502
		Postmenopausal group	.64800	.31718	.048
	Menstruating group	Control group	-.07500	.31718	.814
		Pregnant group	.14000	.31718	.662
		Postmenopausal group	.57300	.31718	.079
	Pregnant group	Control group	-.21500	.31718	.502
		Menstruating group	-.14000	.31718	.662
		Postmenopausal group	.43300	.31718	.181
	Postmenopausal group	Control group	-.64800*	.31718	.048
		Menstruating group	-.57300	.31718	.079
		Pregnant group	-.43300	.31718	.181

[Table/Fig-3]: Comparative analysis of pH in different groups
p-value <0.05 (Significant)

Concentration levels of taste solutions	Control group		Menstruating		Pregnant		Post menopausal		p-value x^2 Value
	Number	%	Number	%	Number	%	Number	%	
1	0	0	0	0	0	0	0	0	1.97 NS p>.05
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	12	40	
4	15	50	12	40	21	70	18	60	
5	15	50	18	60	09	30	0	0	

[Table/Fig-4]: Percentage of intensity of salty (NaCl) taste perception identification

and menopause on saliva by evaluating the salivary flow rate, pH and gustatory function in different groups of women and to evaluate the mutual relationship between saliva and gustatory function.

MATERIAL AND METHODS

A convenience sample was composed of 120 subjects selected from those reporting to the Department of Oral and Maxillofacial Pathology and the Department of Obstetrics and Gynecology SGT Dental and Medical College, Gurgaon, India. Of these total 120 subjects, the control group included 30 female patients who had regular menstrual cycles of 28-30 d in the age range of 20-30 y. The study group included 90 patients between 15-55 y of age. The patients included in the study group were 30 menstruating women with in first three days of menstruation (with normal cycle of 28-30 d) [5], 30 pregnant women between sixth and ninth month of pregnancy and 30 post menopausal women with history of menopause more than one year. All of the subjects were healthy individuals attending the clinics for regular examination. A questionnaire covering information on age, sex, systemic disease, daily medication and various oral symptoms was filled out for each individual. Dietary regimen and oral hygiene habits were also noted along with any associated

Concentration levels of Taste solutions	Control group		Menstruating		Pregnant		Post menopausal		p- value x^2 Value
	Number	%	Number	%	Number	%	Number	%	
1	0	0	0	0	0	0	0	0	13.667 significant p<.05
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	12	40	
4	12	40	12	40	27	90	18	60	
5	18	60	18	60	03	10	0	0	

[Table/Fig-5]: Percentage of intensity of sweet (sucrose) taste perception identification

Concentration levels of Taste solutions	Control group		Menstruating		Pregnant		Post menopausal		p-value x^2 Value
	Number	%	Number	%	Number	%	Number	%	
1	0	0	0	0	0	0	0	0	0 NS p>.05
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	4	40	
4	0	0	0	0	0	0	0	0	
5	30	100	30	100	30	100	30	100	

[Table/Fig-6]: Percentage of intensity of sour (citric acid) taste perception identification

Concentration levels of Taste solutions	Control group		Menstruating		Pregnant		Post menopausal		p-value x^2 Value
	Number	%	Number	%	Number	%	Number	%	
1	0	0	0	0	0	0	0	0	0 NS p>.05
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	
5	30	100	30	100	30	100	30	100	

[Table/Fig-7]: Percentage of intensity of bitter(quinine hydrochloride) taste perception identification

Taste solutions	Control group	Menstruating group	Pregnant	Post Menopausal	P value
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Sweet	2.92 ± 2.15	2.92±1.12	2.78±1.58	2.64±1.64	p<.05 S
Sour	3 ± 1.58	3±1.58	3±1.58	3±1.58	p>.05 NS
Salty	2.9 ± 2.2	2.92±1.12	2.86±1.35	2.88±1.22	p>.05 NS
Bitter	3 ± 1.58	3±1.58	3±1.58	3±1.58	p>.05 NS

[Table/Fig-8]: Mean total taste intensity ratings from whole mouth-taste test

symptom of xerostomia. All subjects signed an informed consent form before the study procedures. Before the commencement of the study, Ethical clearance was taken from Research review board of SGT Dental College, Gurgaon, India.

Inclusion criteria were the patients free from systemic or local diseases which affect salivary secretions, normal chewing ability, with no evidence of dry mouth or salivary gland disorders and having good oral hygiene. Exclusion criteria were patients having any oral diseases (like oral submucous fibrosis and candidiasis), systemic diseases (such as Diabetes, nutritional deficiency, and endocrinal disorders), patients on medication, history that could affect gustatory function (history of radiotherapy), patients with the habit of smoking, with high risk pregnancy and those having unwillingness to participate in the study.

Salivary analysis

Considering close correlation of intensity of taste perception with diurnal quantitative salivary secretions, all measurements were recorded in the late morning; at least one hour after each patient

Groups	n	Mean Rank	Mann-Whitney U -value	p value
Control group	30	10.5	50	1, NS p>.05
vs				
Menstruating group		10.5		
Control group		13		
vs	30		25	.022, NS p>.05
Pregnant group		8		
Control group		13.5		
vs	30		20	.004, S , p <.05
Post Menopausal group		7.5		

[Table/Fig-9]: Comparison between different groups for sucrose perception

had finished eating (Between 11:00 a.m. and 2:00 p.m.) in a comfortable room free from noise and distraction. Salivary samples of the menstruating group were collected within the first three days of menstruation [6].

Estimation of flow rate of saliva

The subject was asked to clear the mouth by swallowing the residual saliva, and was instructed to chew the piece of paraffin wax for 30 sec to stimulate the salivary flow. After 30 sec the subject was made to expectorate in to the spittoon. Further continuation of chewing for 5 min was done and the stimulated saliva was collected at regular intervals in the calibrated tube provided by the manufacturer [Table/Fig-1]. The quantity of the saliva was measured by checking the ml markings on the side of the tube and noted down at 5 min [7].

Estimation of salivary pH

Salivary pH was measured electrometrically using Slope pH meter, Model No 152-R [6].

Estimation of gustatory function

To test gustatory function; a whole mouth threshold taste test was carried out. A concentration series of sucrose, sodium chloride, citric acid and quinine hydrochloride solutions were used for sweet, salty, sour and bitter types of taste respectively. This test was used to detect, identify and evaluate the intensity of different concentrations of taste solutions [8].

In this test, five concentration levels (in ½ log steps) of sodium chloride (0.01–1.0 mM), citric acid (0.32-0.032 mol/L), quinine hydrochloride (0.01-1mM) and sucrose (0.01-1mM) were prepared in 5 ml samples which the subjects were asked to sip and rinse for 10 sec and then expectorate. All the solutions were made with distilled water. Then, they were asked to identify the taste (sweet, salty, sour and bitter or tasteless) and intensity of the taste was noted. If the subject was unable to identify the taste, another row with the next higher concentration of the taste solution was given. This procedure was carried out in the same way for all the four taste tastant in an individual, followed by distilled water rinse which preceded each different taste solutions.

The intensity threshold of taste perception of each solution was determined by scoring the lowest concentration as '5' and the highest concentration as '1' [8]. Quality judgements for each solution were coded as correct, incorrect or tasteless as per subject's interpretation [8].

The Statistical Package for Social Sciences (SPSS) was used for the statistical analysis. To evaluate the significance of the parameters used between the four investigated groups Kruskal Wallis test, Mann Whitney test and Post hoc tests were used. p-values lower than 0.05 were regarded as statistically significant.

RESULTS

Salivary flow rate, pH and gustatory function were evaluated in total 120 candidates including 30 controls and 90 cases (30 menstruating, 30 pregnant and 30 post menopausal) and the comparison of the results was made between all the groups.

No statistically significant difference was found between the groups with respect to salivary flow rate but pH values were significantly lower in post menopausal women (p<0.05) [Table/Fig-2&3].

Regarding correct quality identification, the results were statistically non significant. Almost all the groups detected salt, sour and bitter tastes correctly. Only two postmenopausal and one amongst pregnant group were unable to identify the sweet taste correctly. They stated this quality as tasteless.

As far as the judgements of intensity of taste perception are concerned, intensity of taste perception for sweet was significantly lower in postmenopausal women than judgements of intensity of taste perception for other tastes (p<0.05) [Table/Fig-4-7].

There was a significant difference in mean total taste intensity ratings for sucrose between post menopausal group and control group (p<0.05) but was non significant when compared between menstruating, pregnant and control group (p>0.05) [Table/Fig-8&9]. When mean total intensity ratings for citric acid, sodium chloride, quinine hydrochloride were considered no significant difference was observed between the groups (p>0.05)

Duration of complete amenorrhoea varied from 3 to 10 y. No significant relation was found in the taste alteration on the basis of duration of amenorrhoea. There were a few postmenopausal subjects who failed in tasting all basic taste substances as strongly as before menopause. Also they reported change in their dietary habits as all of them expressed liking for sweeter food. Gustatory and food habit changes during the menstrual cycle were studied in 30 women. It was revealed that although the taste function may change through the menstrual cycle, changes in gustatory thresholds were minimal and remained within the normal range. Changes in gustatory sense when investigated in pregnant women reported that they had experienced some type of change in taste, usually a change in sour taste. Also pregnant women had higher gustatory thresholds than non-pregnant women.

DISCUSSION

Oral digestion per se is only of marginal importance in humans, but saliva is important in preparing food for mastication, for swallowing, and for normal taste perception. Without saliva, mealtimes are difficult, uncomfortable, and embarrassing [9]. Women may be more susceptible to salivary changes because of the unique hormonal changes they experience. There are five situations in a women's life during which hormone fluctuations make them more susceptible to oral health problems – during puberty, at certain points in the monthly menstrual cycle, when using birth control pills, during pregnancy, and at menopause. Many studies have shown that oral mucosa is sensitive to the effect of sex hormones (estrogen and progesterone). They affect the oral cavity as their level changes, likewise when hormonal changes (particularly the increase in progesterone) occur during the menstrual cycle, some women experience oral changes that can include bright red swollen gums, swollen salivary glands, development of canker sores, or bleeding gums. Menstruation gingivitis usually occurs a day or two before the start of the period and clears up shortly after the period has started. Hormone levels change considerably during pregnancy and an increased level of progesterone, in particular, can cause gum disease any time during the second to eighth month of pregnancy – a condition called pregnancy gingivitis. Oral changes do occur as a consequence of hormonal changes due to menopause including altered taste, burning sensations in the mouth, greater sensitivity to hot and cold foods and beverages, and decreased salivary flow that can result in dry mouth. The decline in estrogen that occurs with menopause also puts women at greater risk for loss of bone density. Loss of bone, specifically in the jaw, can lead to tooth loss. Thus there could be a direct link between changing hormonal status and oral health among females [5,10,11].

Salivary function depends on its flow rate and composition. A healthy flow rate is critical for the maintenance of the whole body health. In our study, we chose to measure stimulated saliva as it is useful for the study of functional reserve which helps us to determine the role of whole saliva in oral mucosal defence. The salivary flow rate is also a modulator of salivary pH. At low flow rates, less bicarbonate is released, and pH decreases. Salivary flow rates vary widely between subjects. However, it remains quite constant during the different stages of life for a given individual. On average, women tend to have lower flow rates than men. In addition, at the individual level, women seem to have more variation in their salivary pH as well. It has been suggested that hormonal fluctuations during events like puberty, menstruation, pregnancy and menopause could explain those differences. Moreover, there is a noticeable decrease of unstimulated saliva after menopause. The salivary flow rate is also affected by various cardiometabolic risk components. Degenerative alterations in the acinar cells, which cause a decrease of the saliva flow rate and a diminution of salivary pH, are frequently observed among diabetic and dyslipidemic patients. Hyposalivation has also been linked to obesity, aging and hypertension [12].

The present study has demonstrated that salivary flow rate decrease during pregnancy and after menopause, although the rate of decrease was not found to be statistically significant. Previous studies on the topic of the effect of menopause and pregnancy on salivary flow rate have revealed diverse results. Some studies have reported no change in salivary flow rate after menopause [13,14], while other studies have shown lower flow rates in pregnant and postmenopausal women [2,3,15]. It has also been suggested that ageing may lead to a decrease in salivary flow rate as a consequence of parenchymal atropHy [16]. Alternatively, some authors showed that healthy old people had a normal salivary flow rate with a great functional reserve, mainly in the parotid glands [13]. Since all subjects included in the present study were completely free from systemic or local disease and they took no medication which affect salivary secretion, the statistically non-significant difference between salivary flow rate in the different groups in our study therefore can be justifiable. However, patients suffering from low salivary flow rate should be encouraged to take an active role in management using artificial saliva or saliva substitutes to replace moisture and lubricate the mouth. They can be also given saliva stimulants or sialagogues to increase secretions. In severe cases, cholinergic parasympathomimetic agents are administered to relieve the symptoms [17].

In relation to pH the outcome of the present study showed that salivary pH of the postmenopausal group is significantly lower than the control group, this result is similar to the results of Dural S et al., [6]. It has been well documented that the dissolution of enamel occurs when the pH falls below critical pH i.e. 5.5 [18] and the values obtained in the post menopausal group in our study were very near to critical pH value suggesting the probability for more enamel demineralization in this group. It has also been suggested that salivary pH is a significant correlate of plasma adiponectin levels in women. Plasma adiponectin is an indicator of the pro-inflammatory cardiometabolic risk profile associated with obesity and type 2 diabetes. Salivary pH is influenced by several cardiometabolic risk components such as inflammation, oxidation and numerous oral and systemic health modulators, including the menopausal status. Thus, salivary pH could be used as a potential marker for the cardiometabolic risk profile assessment [12].

Ageing bring changes in various sense organs including taste organ. Although the direct relationship between taste alteration, menstruation, pregnancy and menopause is not established, the increase in incidence of oral discomfort among women during these situations is probably because of hormone modifications [8]. Wardrop et al., found significantly higher prevalence of oral discomfort in perimenopausal and postmenopausal women [19].

A large number of studies have been carried out to find possible causes of dysguesia in pregnant and postmenopausal women. Increased level of water retention along with increased level of estrogens and progesterone are thought to play a role in these changes during pregnancy. According to Delibasi et al., oral discomfort reported in postmenopausal women may have a number of different causes and may not be related to hormonal changes that occur. Psychological symptoms in menopausal women as a cause of their oral discomfort have also been reported in a previous study. Oral discomfort in postmenopausal women could be also caused by local irritants [20]. Reasons for dysguesia in women appears to be many and whatever may be the reason, correct evaluation and its management is the main consideration for the dentist.

The principal findings of this study were significantly reduced intensity of taste perception for sweet and reduced mean total intensity rating for sucrose in post menopausal women and are consistent with the findings of Delilbasi et al., [20]. The total intensity rating for sucrose was also reduced in the pregnant women but the results were non-significant. On the other hand, the mean total taste intensity ratings of sodium chloride, citric acid and quinine hydrochloride amongst four groups are not enough to conclude that there is decline in sensitivity to salty, sour, and bitter taste respectively.

Decline in sucrose sensitivity in post menopausal women can be linked with altered diet [18]. Higher body mass index (BMI) is associated with lower perception of sweetness and lower perceived sweetness is associated with increased difference between liking for fat foods and liking for sweet foods [21]. Decrease in taste perception is not only of importance in terms of enjoyment of food but it also directly affects the food intake and thus nutritional status. Deterioration of gustatory perception and the tendency towards a higher salt and sugar intake in diet can lead to health hazardous conditions in the life of the elderly people [22]. In the present study, postmenopausal group reported their liking for sweeter food which could lead to adverse effects on their health due to excessive use of sugar.

Postmenopausal women rated sweet to be the most pleasant taste in the present study and thus preferred to eat more sweet food. Such fondness for particular taste during the developmental journey of a woman from birth to menopause has also been reported in previous studies. Verma et al., observed cyclic variation in salt preference in females during different pHases of menstrual cycle [23], whereas Kuga et al., in their study stated preference for sour taste in women during pregnancy [24]. The pregnancy is accompanied by decreased gustatory sensitivity to consume adequate electrolytes and to support their child with all nutrients. One-third of a woman's remaining life stays ahead after her last menses and thus protecting and maintaining her oral and general health should be major considerations [8].

The present study is suitable, easy to perform, inexpensive, requires minimal time and least discomfort to patient. However, the study was conducted among relatively small groups, so further studies could be undertaken among larger population groups.

CONCLUSION

Evaluation of salivary flow rate, pH and gustatory function could be a good attempt to assess risks associated with pregnancy, menopause and monthly menstrual cycle. Furthermore, the measurement of salivary pH, flow rate and gustatory function does not need substantial professional and material resources, can be performed in any clinical setting and is inexpensive. It therefore opens the door to the development of an accessible screening tool for both developed and developing countries. With the emerging worldwide epidemic of age related disorders, new technologies should be developed to more easily monitor health status, disease onset and progression. In this context, we think that salivary pH and flow rate could be very promising avenues.

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