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ORIGINAL ARTICLE

# Comparison of oral mucosal pH values in bulimia nervosa, GERD, BMS patients and healthy population

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**OBJECTIVES: The aim of this study was to compare the oral mucosal pH in healthy individuals to patients with gastroesophageal reflux disease (GERD), Bulimia nervosa (BN) and burning mouth syndrome (BMS).**
**SUBJECTS AND METHODS: Using a flat pH meter sensor, pH levels were established in eight mucosal sites in 26 healthy individuals, 26 GERD patients, 22 BN patients and 29 BMS patients.**
**RESULTS: A significantly lower pH was found in the BN and GERD groups (6.38 ± 00.45, 6.51 ± 0.32 respectively, $P < 0.05$) and a higher, but non-significant, pH level in the BMS group (7.01 ± 0.34, $P > 0.05$) compared with the control (C) group (6.82 ± 0.33).**
**CONCLUSIONS: BMS patients showed no pH differences from C group. The mucosa of BN and GERD patients was significantly acidic relative with controls; thus this simple technique may serve as a diagnostic tool for identifying gastro-esophageal conditions.**
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**Keywords:** pH; oral mucosa; bulimia nervosa; gastro-esophageal reflux disease; burning mouth syndrome

## Introduction

A drop in saliva, pH below 5.5 is potentially destructive to the hard (enam and dentin) and soft tissue structures (Aframian *et al*, 1995; Robb *et al*, 1995; Aframian, 2005). To maintain a non-harmful pH level in the oral cavity, the salivary system utilizes three buffer systems; phosphate, bicarbonate, and protein (Lazarchik and Filler, 1997; Bardow *et al*, 2004).

Several conditions can cause impairment in the oral buffer systems' capacity including vomiting related disorders such as bulimia nervosa (BN) as well as gastrointestinal disorders involving acid reflux into the oral cavity.

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The incidence of BN has increased significantly in the second half of the twentieth century, and currently lifetime prevalence of BN in adult women is estimated at 1.1–2.8% (Hudson *et al*, 2007). Oral manifestations of BN include tooth erosion and caries accompanied by thermal sensitivity, xerostomia, poor oral hygiene, recurrent or persistent parotid gland enlargement (Little, 2002).

Gastroesophageal reflux disease (GERD) is a condition which develops when the reflux of gastric contents into the esophagus causes troublesome symptoms and/or complications (Vakil *et al,* 2006). Approximately 40% of the population will report having intermittent episodes of heat burn of which 20% will report having heartburn once a week, and 7% once a day.

Burning mouth syndrome (BMS) is a painful condition defined as an oral mucosal burning sensation with no dental or medical cause for such symptoms (Zakrzewska *et al*, 2005; Carbone *et al*, 2009). BMS is characterized by constant and bilateral, burning sensation mainly involving the tongue and lips (Grushka, 1987; Rhodus *et al*, 2003). Epidemiological studies estimate its prevalence at between 1% and 3% of the general adult population (Ship *et al*, 1995; Bergdahl and Bergdahl, 1999).

We expected that the repeated presence of gastric contents in the mouth of BN and GERD patients may lead to a persistently acidic oral environment. No data are available on BMS patients but we hypothesized that extreme deviations from normal may contribute to the symptomatology associated with this syndrome. To our knowledge, no pH measurements of the oral mucosal lining have previously been performed in these three groups of patients.

## Subject and methods

*Subjects*

The study included 26 healthy volunteers (C group) and 77 patients (BN, GERD and BMS) (Table 1). The GERD, BMS and C groups were age-matched; however, due to the nature of the disorder, the BN group age–range was younger and all participants were females (Table 1). Primary BMS is a chronic, idiopathic intraoral mucosal pain condition that is not accompanied by clinical lesions or systemic disease (Patton *et al*, 2007). BN was classified according to the diagnostic criteria for eating disorders established by the fourth

edition of the Diagnostic and Statistical Manual of Mental Disorders (DMS IV). GERD patients were referred by the family doctor or gastroenterologist. Patients from the GERD and BN groups who also suffered from oral burning sensation, glossodynia and or dysgeusia were excluded from the study.

All of the individuals refrained from eating, drinking or brushing and washing their teeth for 1 h prior to the trial. Measurements were performed between 8 AM and 12 AM. Approval for the study was obtained from the institution's ethics committee.

Preferred sample size was calculated using the equation: Samplesize = {(Critical[z]valuefor5\confidence-limits/2XStandarddeviation)/Differencetobedetected}$^2$. The standard deviation used was 0.3 and based on our previous article (Aframian *et al*, 2006) and approximates that observed in the floor of the mouth, palate and buccal mucosa, the critical (z) value is 1.96 and the difference we wished to detect was 0.15. This results in a minimum sample size of 15, while we recruited a larger sample of 26 patients.

*Measurements*

Oral surface pH was measured with a flat, glass electrode pH meter (HANNA instruments HI 8424, Padova, Italy). Measurements were obtained from eight locations in the following order; the hard and soft palate, anterior, middle, and posterior tongue, right and left buccal mucosa and the floor of mouth. Anatomical references to assure equivalent measurement in each mucosal site were established; three sites adjacent to the orifices of the major salivary glands i.e. buccal mucosa near the orifices of Stenson's duct and one in the floor of the mouth between the sublingual caruncules. The other five locations were adjacent to minor salivary glands on the palate or to von Ebner's glands on the tongue. Each set of measurements took approximately 40 s. As the loss of carbon dioxide to the atmosphere tends to increase the pH levels with time, the first measurements in the oral cavity were established in the palate areas (hard and soft) where the saliva film coverage was the thinnest and the last measurements (35–40 s) were performed in the floor of the mouth where the mucosa was protected by the anterior portion of the tongue.

*Statistical analysis*

Data were tabulated and analyzed with PASW 18 (Mac-OS; SPSS, Chicago, IL, USA) with alpha for significance set at 0.05.

The differences in pH values between collapsed sites were examined with a repeated measures analysis of variance (R-ANOVA) followed by Fischer tests.

Data are presented in the text as mean ± s.d. and in the graphs as mean ± s.e.m. for clarity.

## Results

*Mucosal pH in each site*

Table 1 summarizes all pH in the eight locations and Figure 1 the statistical differences between groups in each site (*P* values). The highest pH levels and mean pH

**Table 1** pH distribution according to mucosal sites

| | *N (M/F)* | *Age (Years) Mean ± s.d. Median* | *Mean pH ± s.d. All sites* | *Mean pH ± s.d. Individual sites* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *HP* | *SP* | *LB* | *RB* | *AT* | *MT* | *PT* | *FM* |
| Control | 26(11/25) | 52.1 ± 9.152 | 6.82 ± 0.33 | 7.71 ± 0.51 | 7.70 ± 0.52 | 6.29 ± 0.38 | 6.30 ± 0.38 | 6.72 ± 0.37 | 6.78 ± 0.48 | 6.76 ± 0.47 | 6.41 ± 0.33 |
| GERD | 26(12/14) | 56.3 ± 12.854 | 6.51 ± 0.32 | 7.12 ± 0.68 | 6.83 ± 0.55 | 6.31 ± 0.28 | 6.20 ± 0.36 | 6.50 ± 0.38 | 6.44 ± 0.46 | 6.38 ± 0.49 | 6.33 ± 0.34 |
| BMS | 29(7/22) | 55.4 ± 13.455 | 7.01 ± 0.35 | 7.71 ± 0.7 | 7.35 ± 0.59 | 6.70 ± 0.42 | 6.67 ± 0.43 | 6.95 ± 0.35 | 6.94 ± 0.38 | 6.83 ± 0.38 | 6.62 ± 0.38 |
| BN | 22(0/22) | 27.7 ± 10.623 | 6.38 ± 0.45 | 6.78 ± 0.94 | 6.56 ± 0.83 | 6.31 ± 0.41 | 6.24 ± 0.43 | 6.13 ± 0.37 | 6.31 ± 0.48 | 6.34 ± 0.67 | 6.29 ± 0.30 |

M, male; F, female; GERD, gastroesophageal reflux disease; BMS, burning mouth syndrome; BN, bulimia nervosa; HP, hard palate; SP, soft palate; LB, left buccal; RP, right buccal; AT, anterior tongue; MT, middle tongue; PT, posterior tongue; FM, floor of mouth.

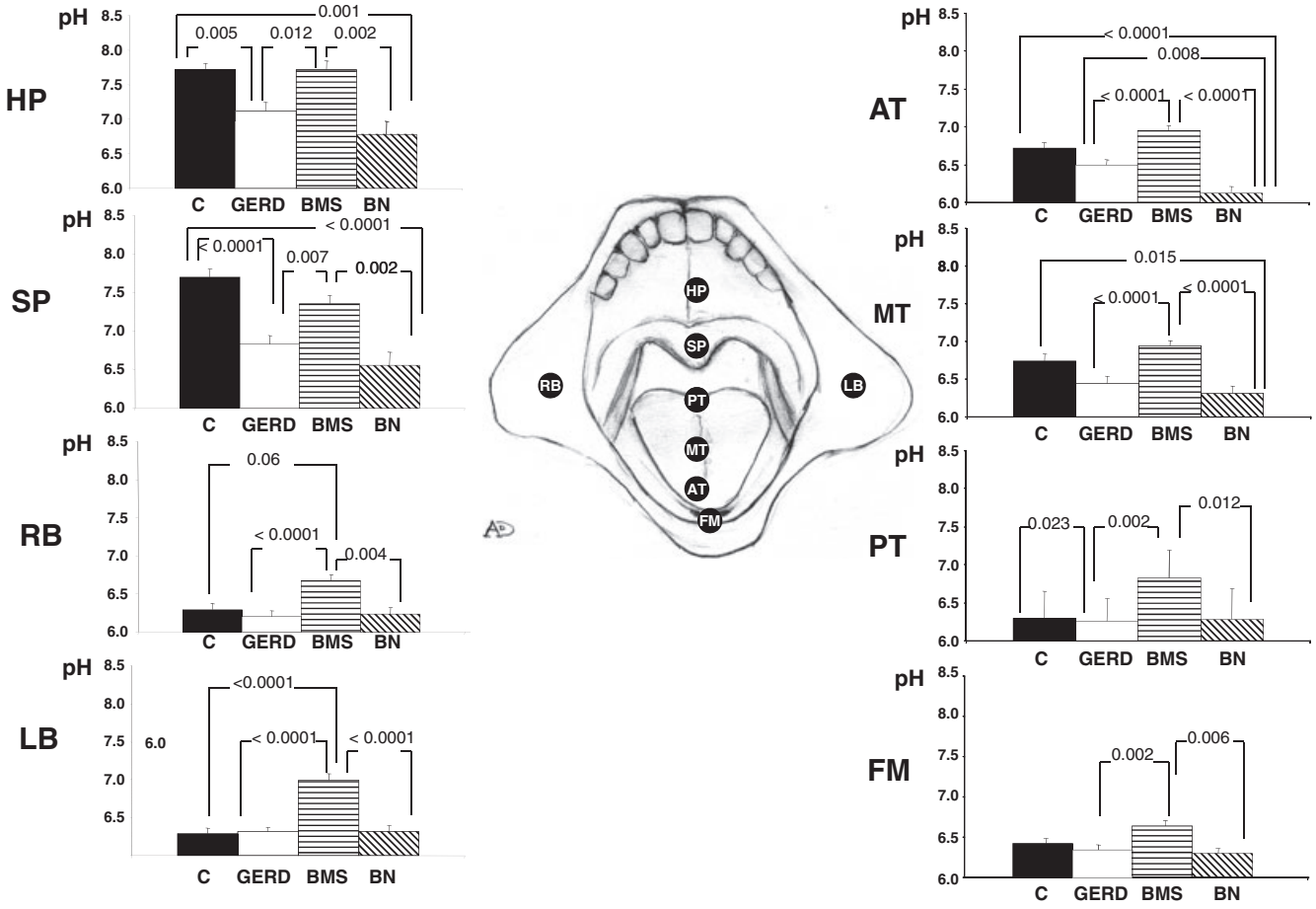


**Figure 1** Comparison of mucosal surface pH (±s.e.m.) of eight sites examined between the C, GERD, BMS and BN groups in each site. Significant differences are noted between bars. HP = hard palate, SP = soft palate, LB = left buccal, RP = right buccal, AT = anterior tongue, MT = middle tongue, PT = posterior tongue, FM = floor of mouth

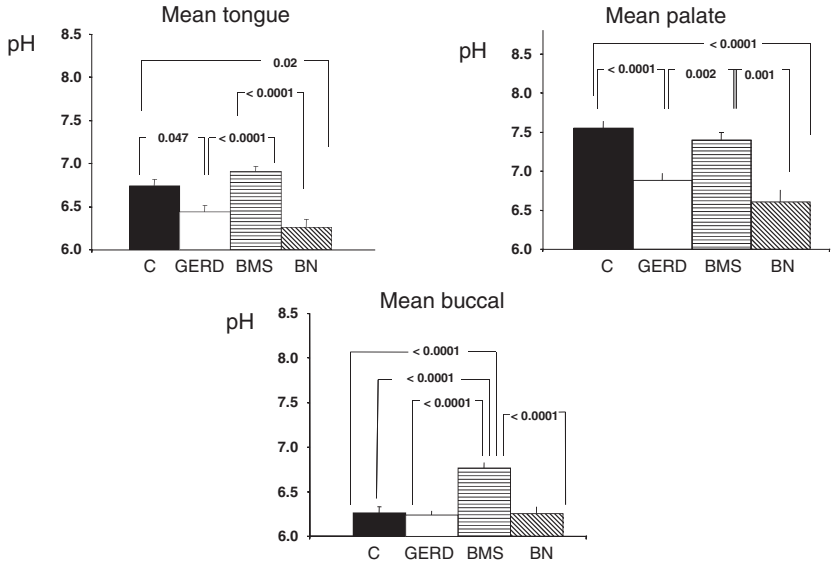


**Figure 2** Comparison of mean mucosal surface pH (±s.e.m.) of the palate (anterior and posterior), the buccal mucosa (right and left), and the tongue sites (anterior, middle, posterior) examined between the groups. GERD = gastroesophageal reflux disease, BMS = burning mouth syndrome, BN = bulimia nervosa. Significant differences are noted between bars

in all groups were measured at both hard and soft palate sites (Figures 1 and 2, C group 7.7 ± 0.47, GERD group 6.97 ± 0.51, BMS group 7.53 ± 0.57, BN 6.67 ± 0.84). In the majority of sites BN and the GERD groups showed a significant reduction of pH levels. No significant changes were noticed between GERD and BN groups compared with C group in the floor of mouth site (Figure 1). In all sites, mucosal pH

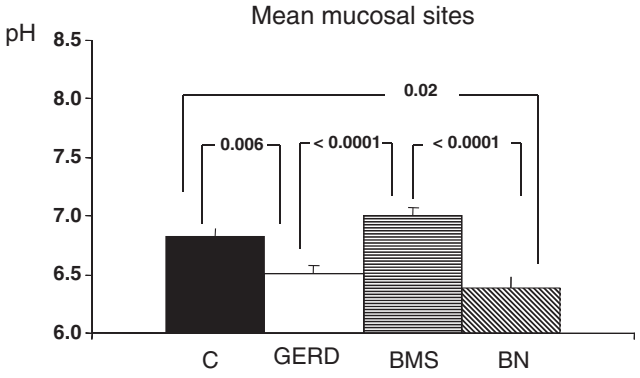


**Figure 3** Comparison of mean mucosal surface pH (±s.e.m.) in all sites between groups. GERD = gastroesophageal reflux disease, BMS = burning mouth syndrome, BN = bulimia nervosa. Significant differences are noted between bars

levels were the lowest in the BN group except the posterior tongue location (Figure 1). However, when collapsing the measured locations on the dorsum of the tongue e.g. anterior, middle and posterior sites, the pH levels in the BN group were the lowest compared with the other groups (Figure 2; C group 6.74 ± 0.4, GERD group 6.43 ± 0.41, BMS group 6.91 ± 0.41, BN 6.26 ± 0.45).

The mean of right and left buccal sites exhibited the lowest pH in all groups (Figure 2; C group 6.29 ± 0.35, GERD group 6.25 ± 0.3, BMS group 6.83 ± 0.367, BN 6.28 ± 0.4) compared with the mean pH in the palate (soft and hard; Figure 2; C group 7.7 ± 0.48, GERD group 6.97 ± 0.51, BMS group 7.53 ± 0.57, BN group 6.66 ± 0.84) and the mean tongue (anterior, middle and posterior, Figure 2; C group 6.74 ± 0.4, GERD group 6.43 ± 0.41, BMS group 6.91 ± 0.33, BN group 6.26 ± 0.45).

*Mean mucosal pH all sites*

The mean mucosal pH of all sites in group C was 6.82 ± 0.33. Both BN and GERD groups showed a significant reduction in pH measurements (6.38 ± 0.45; $P = 0.02$, 6.51 ± 0.32; $P = 0.006$ respectively, Table 1, Figure 3). The mean pH level in the BMS group for all sites (7.01 ± 0.35) was not significantly different from that in the C group, but was significantly different from that in both the BN and GERD groups ($P < 0.0001$, Table 1, Figure 3).

## Discussion

In the present study, we found that the lowest mucosal pH levels were measured in the BN group followed by the GERD group, both significantly compared with that in the control group. Significantly higher pH levels were found in buccal mucosal sites of the BMS group compared with that in the C group.

The oral cavity allows for the easy collection of health related information such as salivary biomarkers and electrolytes (Davidovich *et al*, 2009; Fleissig *et al*, 2009). Furthermore, pH level assessment is relatively easy to perform, and may serve as a diagnostic and monitoring tool for underlying systemic diseases (Aframian *et al*, 1995, 2006; Davidovich *et al*, 2009).

The mean mucosal pH of all sites in the control group was 6.82 ± 0.33, in accordance with that of our previous study on healthy volunteers (6.78 ± 0.04, Aframian *et al*, 2006).

Bulimia nervosa occurs most commonly in female adolescents and carries significant psychological and physical morbidity. The cause of BN is unknown, however, cultural and psychiatric and genetic factors are most probably involved (Devlin, 1999). Bulimic patients is a risk group for tooth wear mainly because of a low pH resulting from gastric acids as well as from highly acidic carbonated beverages or fruit juice consumption. In these patients, extensive erosion of the palatal aspects and to a lesser extent the buccal surfaces of the upper anterior teeth is observed. The finding of a significant oral mucosal lower pH in our study emphasizes the potential harm of the disorder on the oral soft tissues. Erythematous mucosal lesions, especially on the soft palate in purging type behavior, may be related to the direct action of acid during vomiting (epithelial erosion), and sometimes to repetitive frictional trauma caused by the object used to induce vomiting (Mueller, 2001); a synergistic damaging effect between chemical and mechanical factors is also a possibility. The previous observations suggest a correlation between the pathogenesis of an entity termed necrotizing sialometaplasia and vomiters (Aframian *et al*, 1995; Aframian, 2005). This lesion is manifested by a deep ulcer located mostly in the border between the hard and soft palate mimicking minor salivary gland tumors. Indeed, we found a significantly lower pH levels in both of these sites (Table 1, Figure 2), suggesting that low mucosal pH may be involved in vomiting induced sialometaplasia.

Moreover, pH measuring system can serve to confirm diagnosis in suspected BN cases as these patients have the tendency to conceal their vomiting episodes.

A previous study found that the average pH of the thawed vomitus from vomiters was 3.8 (Milosevic *et al*, 1997). In a more recent study, salivary pH in BN group was 6.58 compared with 6.88 in healthy volunteers (Blazer *et al*, 2008); we found a slightly lower pH of 6.38. This observation can be explained since in the study by Blazer *et al*, pH levels were obtained from extra orally collected saliva. We feel that our method more reliably represents the intra orally mucosal pH.

The GERD group showed higher pH levels compared to the BN group (significantly lower than in the control group, Figure 3). As the oral cavity serves as the portal entry to the gastrointestinal tract, a lower pH is not surprising. Dental erosion caused by chronic exposure of the oral cavity to gastric acid has been documented previously (for review Lazarchik and Filler, 1997). Nevertheless, the impact on the soft tissue was not well explored.

Gastroesophageal reflux disease encompasses a large variety of clinical presentations including non-erosive reflux disease, esophagitis of different grades of severity, and severe complications such as strictures, deep ulcers or Barrett's esophagitis, as well as extra-esophageal

manifestations. Moreover, Barrett's esophagitis may lead into carcinoma (Belhocine and Galmiche, 2009). A future study testing oral pH in these subgroups of GERD patients may have an impact on assessing the severity as well as the respond to anti-acid treatments.

Burning mouth syndrome is a chronic disease characterized by burning of the oral mucosa (primarily the tip of tongue) and is more frequent among postmenopausal women. As a burning sensation is associated with acidity one may hypothesize that lower pH levels in the oral mucosa, especially in affected areas such as the tongue, are involved. However, pH levels in the BMS group showed no significant difference in most sites including the tongue compared with the C group. Moreover, in the buccal sites, pH levels in the BN group was found more basic compared with the C group.

The pathophysiology of BMS is still unknown, and evidence is conflicting. Some studies suggest a central origin, others point to a peripheral neuropathic origin (Albuquerque *et al*, 2006; Eliav *et al*, 2007; Carbone *et al*, 2009) The absence of lower pH levels in our study reinforce theories of a more central rather than local pathological process in BMS.

In conclusion, further research regarding the high mucosal pH levels in BN and GERD patients may expand the usage of such a relatively non-invasive tool for monitoring the systemic complications in these patient groups and their relationship to clinical manifestation such as tooth erosion, salivary secretion and saliva composition.

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