INTRODUCTION

The control of swallowing involves a complex interaction between muscles and nerves that coordinates the safe passage of swallowed material from the mouth to the stomach. It is an ongoing process that involves the mouth, pharynx and esophagus, many oral structures, muscles and nerves.

The process of swallowing can be altered by diseases such as gastroesophageal reflux disease (GERD), which is characterized by the return of food contents present in the stomach into the esophagus, causing symptoms and impairing the quality of life of patients. GERD is the most common identifiable cause of dysphagia. In GERD, changes occur in the oropharyngeal transit of liquids and soft foods, being slower in these patients compared to the transit time in healthy subjects. Patients with GERD have impairment of esophageal chemical clearance and erosive esophagitis causes longer esophageal bolus transit. In the esophagus of healthy individuals and in patients who have suffered stroke, it was observed that a bolus with a sour taste and acidic pH has slower transit in the distal part when compared with a bolus with neutral pH. Thus, it may be that the flavor and/or pH of the swallowed liquid have influence on the swallowing of patients with GERD.

Women have less ingestion flow and volume in each swallow than men, probably due to the adaptation to anatomical differences and a lower oral volume capacity, which can be influenced by taste and pH. Our hypothesis is that the ingestion of a sour liquid with acidic pH has a different ingestion dynamic than the ingestion of a liquid with neutral taste and pH; with GERD patients, the ingestion of a sour liquid with acidic pH would take longer that in healthy subjects. Our aim in this investigation was to evaluate this ingestion in patients with GERD and individuals without the disease, and to verify the effect of gender.

METHODS

Seventy-nine individuals of both sexes were enrolled in the study. Twenty-nine subjects had a diagnosis of GERD, characterized by symptoms (heartburn and regurgitation) and diagnosed by upper GI endoscopy with esophagitis grade A or B of the
Los Angeles classification (n = 17) and/or abnormal 24-hour intraesophageal pH monitoring (n=15)²⁻¹⁸. All subjects were in treatment of the disease with proton pump inhibitors, with symptom control. There were 21 women and 8 men, aged 21-78 years (mean: 50.5 ± 12.8 years). The control group consisted of 50 subjects, 34 women and 16 men, aged 18-73 years (mean: 36.4 ± 16.2 years). To evaluate the effect of gender, two groups were formed between men (n = 24) and women (n = 55). The components of the two groups had no neurological or endocrine diseases, difficulty with swallowing or malnutrition. The control subjects had no gastrointestinal complaints. Patients were recruited from the outpatient medical and surgical clinics of the Hospital das Clínicas, Ribeirão Preto (HCRP). Control subjects were recruited from among the companions of the patients and those that work and study within the hospital of the institution. The research protocol was approved by the research Ethics Committee of both the HCRP and the Ribeirão Preto Medical School - University of São Paulo (FMERP-USP). Written informed consent was obtained from all participants.

The test was performed by ingestion, at room temperature, in duplicate, of 100 mL of water (pH 6.8) and 100 mL of lemon juice (pH 3.0) prepared with 12 g of powdered juice (Fit Diet, Ajinomoto Inter Ind. e Com Ltda, Limeira SP) diluted in 200 mL of water. Ingestion was continuous and comfortable to the individual, with simultaneous measurements of the time of ingestion, measured by stopwatch, and the number of swallows necessary for the ingestion of the entire volume. The alternating sequence of ingestion was drawn beforehand between two options: one starting with water and the other lemon.

The tests were performed with the subject sitting with the head in a neutral position, looking straight ahead. The liquids were offered in disposable plastic cups with a capacity of 100 mL. The interval between tests was a minimum time of 1 minute. Ingestion started when the liquid touched the lips of the subject and ended when the thyroid cartilage returned to resting position after the last swallow.

With the values of ingestion time and the number of swallows, we calculate: (1) interval between swallows - the total time of ingestion divided by the number of swallows; (2) ingestion flow - the total volume ingested (100 mL) divided by the time of ingestion; (3) swallowing volume - the total volume ingested (100 mL) divided by the number of swallows¹¹⁻¹³,¹⁴.

For statistical evaluation, a linear regression model was used with mixed effects (random and fixed effects). Linear mixed models are used in data analysis in which responses are grouped (more than one measure for an individual) and the assumption of independence between observations in the same group is not adequate²⁰. These models have the assumption that their waste has normal distribution with mean 0 and variance $\sigma^2$. In situations where this assumption was not observed, a logarithmic transformation was used in the response variable. This procedure was performed using the SAS® 9.0 software, using PROC MIXED. The results are presented in mean and 95% confidence interval (95% CI).

## RESULTS

In both the healthy subjects forming the control group (Table 1) and the patients with GERD (Table 2), the acidic liquid took longer to be ingested, with a greater number of swallows, slower ingestion flow and lower volume in each swallow compared with the neutral fluid ($P<0.01$). There was no difference between the control subjects and patients with GERD ($P>0.20$) in time to ingest the entire volume, the number of swallows, the interval between swallows, the ingestion flow (Figure 1) and the volume in each swallow (Figure 2).

### TABLE 1. Ingestion of 100 mL of water and 100 mL of lemon juice in normal subjects (n = 50)

<table>
<thead>
<tr>
<th>Volume (mL)</th>
<th>Mean</th>
<th>95% CI</th>
<th>Mean</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>8.1</td>
<td>7.5-8.8</td>
<td>9.9</td>
<td>8.9-11.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lemon</td>
<td>6.3</td>
<td>5.9-6.7</td>
<td>7.4</td>
<td>6.8-8.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Interval (s)</td>
<td>1.3</td>
<td>1.2-1.4</td>
<td>1.3</td>
<td>1.3-1.4</td>
<td>0.53</td>
</tr>
<tr>
<td>Flow (mL/s)</td>
<td>14.2</td>
<td>13.1</td>
<td>15.3</td>
<td>13.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Volume (mL)</td>
<td>17.6</td>
<td>16.4</td>
<td>18.8</td>
<td>16.4</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

**CI:** confidence interval

### TABLE 2. Ingestion of 100 mL of water and 100 mL of lemon juice in patients with gastroesophageal reflux disease (n = 29)

<table>
<thead>
<tr>
<th>Volume (mL)</th>
<th>Mean</th>
<th>95% CI</th>
<th>Mean</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>9.3</td>
<td>8.2-10.5</td>
<td>11.3</td>
<td>9.9-12.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lemon</td>
<td>6.7</td>
<td>6.0-7.7</td>
<td>7.7</td>
<td>7.1-8.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Interval (s)</td>
<td>1.4</td>
<td>1.3-1.5</td>
<td>1.4</td>
<td>1.3-1.5</td>
<td>0.50</td>
</tr>
<tr>
<td>Flow (mL/s)</td>
<td>12.7</td>
<td>11.4-14.0</td>
<td>10.6</td>
<td>9.6-11.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Volume (mL)</td>
<td>16.7</td>
<td>15.3-18.1</td>
<td>14.2</td>
<td>13.1-15.3</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

**CI:** confidence interval

![Figure 1](image-url)
Gomes DC, Dantas RO. Acidic and neutral liquid ingestion in patients with gastroesophageal reflux disease

6.4-7.1 - 11.5-13.2 - 15.0-18.3 - 19.7
11.6 - 1.3-1.5 - <0.01
Women - <0.01
16.0-19.4 - 17.7 - <0.01
5.7-6.9 - 1.4
Mean - Mean
7.8 - 0.02
0.11
1.2-1.3
16.6 - 15.0-18.3
19.7 - 17.8-21.7

Table 3. Ingestion of 100 mL of water and 100 mL of lemon juice in men (n = 24) and women (n = 55).

DISCUSSION

This study aimed to analyze the intake of acidic and neutral liquids in healthy subjects and patients with GERD. This was performed with the swallowing of liquid test, which is considered a reliable method for measuring the performance of swallowing\(^1\). From the data obtained, we observed that the ingestion of sour liquid with acid pH is prolonged in relation to the ingestion of no flavored liquid and neutral pH.

The longer esophageal distal clearance of the acidic bolus, seen in healthy subjects and patients with stroke\(^2\), may have influence on the pharyngeal phase of swallowing, an involuntary phase which may have adaptations to the slower esophageal transit, as is seen in Chagas’ disease\(^3\). Another possibility is that the slower swallowing is a behavior to avoid a fast alteration of intra-esophageal pH. In normal situations, the intraesophageal pH is near seven. Gastroesophageal reflux causes a fall in the intraesophageal pH, with primary or secondary contractions (volume clearance) and the acid neutralization by saliva (chemical clearance), restoring the pH to normal values.

The mixed sensory stimuli (olfactory, visual and taste) are another alternative for explanation of a longer ingestion of the acidic bolus. The sour bolus is considered by the population as an unpleasant bolus\(^4, 5\). This might cause modifications of oral and pharyngeal phases of swallowing, but there is no difference between acidic or neutral bolus in the oral and pharyngeal transit\(^6, 7\). In normal subjects the swallowing function should work at its best, without significant influence of the bolus taste\(^8, 9\).

The observed difference in ingestion may be related with the esophageal phase of swallowing. Alterations in esophagus may also cause alterations in pharyngeal function\(^10\). In proximal esophagus, the transit of an acidic bolus is faster than a neutral bolus, which should be consequence of the stronger contraction of muscles\(^11\), and in middle and in distal esophagus, the transit is slower, associated with an increase of the amount of distal esophageal residues\(^12\). Ineffective esophageal motility, present in some patients with GERD\(^13\), should have influence on the esophageal transit, but the same influence should be seen with the neutral bolus. Ineffective esophageal motility has little effect on esophageal acidic clearance in upright position\(^14\).

The results might be different if the patients were not in treatment. Control of the symptoms (heartburn and regurgitation) might cause no further response to the ingestion of the acidic liquid. We expected that the ingestion of an acidic bolus by patients with GERD would be different from normal volunteers, but there was no difference, indicating the possibility that the disease does not cause alteration of liquid ingestion.
can have influence in the anticipation of the ingestion of the bolus. With the same method used in this investigation, it has been shown that women have less ingestion flow and volume in each swallow than men\textsuperscript{(22)}, results confirmed by this study. Swallowing evaluation by videofluoroscopy found slower pharyngeal passage of a swallowed bolus in women compared to men\textsuperscript{(11)}. The observed differences in swallowing between men and women may be due to anatomical differences between genders\textsuperscript{(16)}. Men and women had the same response to the ingestion of acidic liquid, i.e., decreased ingestion flow and volume in each swallow. There are some limitations in this investigation. The number of patients included might be higher and evaluation of the oral, pharyngeal and esophageal transit was not performed. Performing the same evaluation in patients without treatment for GERD and symptomatic may reach different results.

**CONCLUSIONS**

Liquid acidic bolus has ingestion dynamics different than a neutral liquid. There was no difference between the liquid ingestion of patients with gastroesophageal reflux disease and healthy subjects. Women have lower flux of ingestion and lower volume in each swallow than men, with acidic and neutral boluses.

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**REFERENCES**


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