Association among Bad Breath, Body Mass Index, and Alcohol Intake

INTRODUCTION

Although bad breath is a common oral condition, it is not easy to assess, both for the individual and in the laboratory. Attempts to smell and estimate one’s own bad breath often reflect preconceived subjective notions and are thus unreliable (Rosenberg et al., 1995). People who are concerned about their own bad breath are often embarrassed to ask others whether they actually suffer from it. People who do suffer from bad breath are unlikely to be told by those around them (Rosenberg, 2002).

In the laboratory, odor judge measurements, despite their limitations (Rosenberg and McCulloch, 1992), are still considered the gold standard of bad breath assessment. Additional measurement often includes quantitation of volatile sulfides, either by gas chromatography or sulfide monitors (Porter and Scully, 2006). Presently, bad breath is measured by a combination of odor judge measurement and adjunct tests (e.g., enzymatic tests, measurement of volatile sulfides), or the use of colorimetric enzyme assays, such as the BANA test (Kozlovsky et al., 1994) or beta-galactosidase levels in saliva (Sterer et al., 2002). However, none of these assays can help individuals determine whether they themselves have malodor.

The purpose of the present study was to attempt to identify predictive factors for bad breath in the general adult population, by a 38-question self-administered questionnaire, along with objective odor judge and instrumental measurements.

MATERIALS & METHODS

The study design was cross-sectional and included 88 Israeli volunteer participants, ranging from 20-55 years of age (mean age, 37 ± 9 yrs; 46 males, ranging from 20 to 55 yrs), undergoing routine medical checkups at the Tel Aviv Mediton Medical Centre. Informed consent was obtained. The study protocol was reviewed and approved by the ethics committee of Tel Aviv University.

Exclusion criteria included unwillingness to participate, persons younger than 20 or older than 55, those who did not comply with the pre-examination instructions, those who had taken antibiotics in the preceding month, or those with kidney or liver disease or type 1 diabetes.

Methods and Research Outline

Measurement was performed on morning breath, following a 12-hour overnight fast, which included the participants’ refraining from drinking and smoking (but not excluding regular oral hygiene). Oral malodor was scored based on odor judge scores of whole-mouth malodor, carried out by a single odor judge as previously determined (Rosenberg et al., 1991a,b), based on a 0-5 malodor intensity level. Scoring between integers was allowed as previously reported (Sterer et al., 2002). The odor judge was trained in a malodor clinic, and his reliability was confirmed by comparison of the results.
Table 1. Dichotomous Comparison of Odor Judge vs. Self Scores

<table>
<thead>
<tr>
<th></th>
<th>Odor Judge</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(≥ 2)</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Self (y/n) +</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Self (y/n) -</td>
<td>9</td>
<td>41</td>
</tr>
<tr>
<td>Total*</td>
<td>26</td>
<td>60</td>
</tr>
</tbody>
</table>

* Two missing observations.

Table 2. Correlation Coefficients Comparing Odor Judge Scores, Volatile Sulfur Compounds, and β-galactosidase Scores

<table>
<thead>
<tr>
<th></th>
<th>Judge</th>
<th>Volatile Sulfides</th>
<th>β-galactosidase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judge</td>
<td></td>
<td>R = 0.48*</td>
<td>0.59**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Volatile sulfides</td>
<td></td>
<td></td>
<td>0.31**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p &lt; 0.01</td>
</tr>
</tbody>
</table>

* Pearson.
** Spearman.

** RESULTS**

Mean odor judge scores (± standard deviation) were 1.4 ± 1.1. Mean sulphide monitor scores were 57 ± 54 ppb sulfide equivalents; mean β-galactosidase scores were 0.6 ± 0.7. Odor judge scores and self-perception of bad breath are compared (Table 1). Based on odor judge scores, 26 persons (29.8%) suffered from oral malodor (at a cutoff of ≥ 2). The prevalence in the general population could be estimated to be between 20.2% and 39.4% (95% CI = 9.6). Seventeen persons correctly perceived that they had malodor, while 41 participants correctly perceived that they did not. Conversely, in 19 instances, participants thought that they suffered from bad breath, although this was not corroborated by the odor judge. Sensitivity, specificity, and accuracy, in comparisons of odor judge and self-perception, were 65%, 68%, and 67%, respectively.

As expected, laboratory measurements were statistically associated with one another (Table 2). Odor judge scores were significantly correlated with both Halimeter® (r = 0.48, p < 0.01; Pearson) and β-galactosidase levels (r = 0.59, p < 0.01; Spearman). A lower, but still significant, association was found between Halimeter® and β-galactosidase scores (Spearman, r = 0.31; p < 0.01).

Oodor judge measurements were also compared with β-galactosidase scores (Table 3). Cutoff for the odor judge was again ≥ 2; for the β-galactosidase test, any score above 0 was considered positive. Among the 26 individuals with bad breath, the β-galactosidase test was positive in 23 cases (sensitivity of 89%). Specificity and accuracy were 75% and 79%, respectively.

Among the 38 questions in the questionnaire, 9 provided answers that were correlated with objective odor measurements, including self-reports of alcohol intake and body mass index. Among the 9 questionnaire responses that were significantly associated with breath odor scores (unpaired t test, p < 0.05), 4 responses accounted for 35% of the predicted variability of organoleptic scores, with a multiple r = 0.59 (linear regression): (i) deduced that he/she had bad breath from facial expression or actions of others, 13%; (ii) foreign origin of mother, 10%; (iii) frequency of alcohol consumption, 6%; and (iv) weight gain (body mass index), 6%. The 5 other responses were (v) level of education, (vi) frequency of toothbrushing, (vii) snoring, (viii) having heard comments regarding bad breath from others, and (ix) self-estimation of bad breath.

A linear regression model for predicting the intensity of breath odor based on the two laboratory tests alone, i.e., the
Halimeter® and the β-galactosidase tests, achieved a prediction percentage of 48%.

Prediction of odor judge scores based on the 9 questions (linear multiple regression analysis) yielded \( R = 0.60 \). When these 9 questions were combined with the results of the objective tests (Halimeter® and salivary β-galactosidase), the multiple \( r \) rose to 0.81 (\( p < 0.0001 \)). Interestingly, sex, age, other oral hygiene habits, and dietary parameters were not significantly associated with odor judge scores.

**DISCUSSION**

In the present study, the prevalence of morning bad breath, as determined organoleptically, was found to be in the vicinity of 20-40%. This is a high prevalence, considering that oral hygiene practices were permitted on the morning of the examination. Nevertheless, this finding is in line with recent estimates (Al-Ansari *et al.*, 2006; Liu *et al.*, 2006). The results further suggest that about 20% of the population tested thought that they had significant bad breath, whereas corresponding odor judge scores were low. A recent study has reported a prevalence of unsubstantiated self-reported bad breath of 27.9% among some 400 persons (Seemann *et al.*, 2006).

To our knowledge, this is the first study showing significant associations between alcohol consumption and bad breath. Chronic alcohol drinkers have a unique type of breath that may result from oxidation of alcohol in the mouth and/or liver, to yield acetaldehyde and other odorous by-products. Alcohol may also dry out the mouth (Rosenberg, 2002).

The study also suggests that body mass index (BMI) is predictive for bad breath, independent of alcohol consumption. High body mass index has been associated with a variety of ailments, including type II diabetes, hypertension, dyslipidemia, cerebrovascular accident, myocardial infarction, cancer (e.g., prostate cancer and colon cancer), gout, arthritis, fatty liver, and sleep apnea (Haslam *et al.*, 2006) and periodontitis (Saito *et al.*, 2001). Sleep apnea problems related to obesity may cause dry mouth, which presents a risk for bad breath (Rosenberg, 1996).

As expected, odor judge scores were significantly correlated with volatile sulfur levels (\( r = 0.48; \ p < 0.01 \)), as measured by means of the Halimeter® (Rosenberg, 1996). The present study further supports the validity of a new stand-alone color test, based upon the levels of β-galactosidase in saliva (Sterer *et al.*, 2002; Sterer and Rosenberg, 2006), which showed significant correlation with the odor judge (\( r = 0.59; \ p < 0.01 \)) as well as a sensitivity, specificity, and accuracy of 89%, 75%, and 79%, respectively, with the odor judge scores as the gold standard. Both Halimeter® and β-galactosidase scores were independent factors in accounting for odor judge levels, achieving 48% prediction.

Although a convenience sample, this group contained representative ratios of males and females, with a wide representation of ages. More importantly, the population was not selected based on any complaints related to dental health or oral malodor. Whereas most malodor studies, including the present investigation, are based on a single examination, confounding factors (e.g., differences in oral hygiene habits, transient cold or post-nasal drip, menstrual cycle) might influence, to some degree, the results presented (Tonzetich, 1977). For further assessment/understanding of the prevalence of bad breath, and factors that can lead to its prediction, subject samples reflecting the general population should be similarly investigated.

**ACKNOWLEDGMENTS**

We thank Amir Shuster for critical review of the manuscript, Yardena Mazor for excellent technical assistance, and Ilana Gelernter for statistical evaluations. The financial support of Ramot Ltd., Tel Aviv University Authority for Applied Research and Development, is acknowledged. OK-to-kiss samples were provided by InnoScent Ltd., Herzliya, Israel.

**REFERENCES**


