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

ABSTRACT

Bad breath is a common condition, difficult to assess in the general population. In the present study, we tested the hypothesis that a self-administered questionnaire can help identify factors associated with greater risk of oral malodor. Persons (n = 88) undergoing routine medical check-ups completed a questionnaire including 38 questions on general and oral health, dietary habits, and their own oral malodor levels. Oral malodor assessments included odor judge scores, volatile sulfide levels (*via* a Halimeter®, Interscan Corp.), and salivary β-galactosidase. Among the questionnaire results, 9 responses were significantly associated with odor judge scores ($p < 0.05$, unpaired *t* test), including questions on alcohol intake and body mass index (BMI). Predictions of odor judge scores based on these 9 questions (linear multiple regression analysis) yielded R = 0.601; when introduced together with Halimeter® and β-galactosidase scores, the correlation rose to R = 0.843. The results suggest that alcohol intake and BMI may be factors that help predict oral malodor.

KEY WORDS: halitosis, body mass index, alcohol, β-galactosidase, Halimeter®, volatile sulfur compounds, prevalence.

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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

		Odor Judge		Total
		(≥ 2)	< 2	
Self (y/n)	+	17	19	36 (42%)
	-	9	41	50 (58%)
Total*		26	60	

* Two missing observations.

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

	Judge	Volatile Sulfides	β-galactosidase
Judge	-	R = 0.48*	0.59**
	-	p < 0.01	p < 0.01
Volatile sulfides	-	-	0.31**
			p < 0.01

* Pearson.
** Spearman.

for the first 42 persons with those of another trained odor judge, yielding a relatively high inter-examiner Kappa of 56% (Rosenberg *et al.*, 1991b). Adjunct measurements included oral volatile sulfide levels (Halimeter®, Interscan Corp., Chatsworth, CA, USA), and level of salivary β-galactosidase (OK to Kiss disk test, InnoScent Ltd., Ramat Gan, Israel). Three consecutive Halimeter® measurements were taken at 30-second intervals, and the median peak score was used for analyses. β–galactosidase measurement was carried out on whole, unstimulated saliva expectorate, as described previously (Sterer *et al.*, 2002), with the use of OK to Kiss test pallets (InnoScent Ltd.). Results were scored as either 0 (no color), 1 (very faint color), or 2 (obvious color).

Questionnaire

The questionnaire used in the study was designed specifically for this purpose and was self-administered. It included: (i) personal information (age, gender, country of origin, country of each parent's origin, level of education, weight, height, family status); (ii) medical history (past or present diabetes, renal or liver dysfunction, tonsillar infections or tonsilloliths, and medications); (iii) smoking habits (scaled for cigarettes); (iv) consumption of alcohol, coffee, tea, and light beverages (scaled); (v) dichotomous self-assessed information on oral status, *i.e.*, gum bleeding, partial or complete dentures, post-nasal drip, sputum, mouth breathing, dry mouth; (vi) scaled questions regarding oral hygiene behavior, including gum chewing, visits to dental clinic, toothbrushing, and dichotomous questions on oral hygiene, *i.e.*, tongue cleaning, mouthwash use, and dental flossing; and (vii) whether or not participants thought that they had bad breath (and if so, to what extent), whether someone had told them or otherwise indicated that they had bad breath, and at which time of the day they suffer from the problem (morning, afternoon, night, or all day).

Table 3. Dichotomous Comparison of Odor Judge and β-galactosidase Results

		Odor Judge		Total
		+ (≥ 2)	< 2	
β-galactosidase	+ (≥ 1)	23	15	38 (44%)
	-	3	45	48 (65%)
Total*		26	60	

* Two missing observations.

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 malador, 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, $r = 0.31$; $p < 0.01$).

Odor 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).

These two parameters (alcohol consumption and BMI), together with 7 other responses, were significantly related to odor judge levels. Three parameters—*i.e.*, (i) deduction of bad breath from facial expression or actions of others; (ii) having heard comments regarding bad breath from others; and (iii) self-estimation of bad breath—which are self-perceived, are usually not considered to be objective assessments (Rosenberg *et al.*, 1995), yet here were significantly associated with odor judge scores. Two other parameters—namely, (i) the foreign origin of mother and (ii) level of education (negative association)—may reflect socio-economic factors. Among many responses related to oral hygiene, including mouthwashing and tongue cleaning, it was surprising that only frequency of toothbrushing was significantly associated with oral odors. Of additional interest was the finding that snoring is associated with bad breath levels. This again may be related to mouth dryness (Tonzetich, 1977). Self-reported gum bleeding was not associated with odor scores, supporting the premise that bad breath may not be intimately related to gingivitis and periodontal diseases (Stamou *et al.*, 2005).

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.

The purpose of the present cross-sectional study was to identify predictive factors for bad breath in a group of adults presenting for a routine medical checkup, using a 38-question self-administered questionnaire, alongside objective odor judge and instrumental measurements. The results showed that: (i) 9 questions yielded responses that helped account for bad breath levels; (ii) when taken together with laboratory measurements, a strong correlation (multiple $r = 0.81$, $p < 0.0001$), was found with odor judge scores; and (iii) alcohol consumption and body mass index may constitute new predictive factors for bad breath risk.

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.

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