Olfactory Dysfunction in Anorexia and Bulimia Nervosa

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Fifty-five eating-disordered women and 16 normal controls participated in this study to determine whether olfactory function is altered in patients with food-restricting anorexia, anorexia with bulimic features, and bulimia nervosa. Olfactory function was assessed using the University of Pennsylvania Smell Identification Test and by determining phenyl ethyl alcohol odor detection thresholds. Only the very low-weight anorexics showed impairments in their identification and detection of odors. This group's olfactory function did not improve from admission to discharge despite significant weight gain. Although, overall, smoking had only a minor influence on olfactory function, the very low-weight anorexic smokers had the lowest scores of all subjects. Since higher-weight anorexics did not show such impairments, the results suggest that the severe and prolonged starvation experienced by the very low-weight anorexics caused or contributed to intractable deficits in the olfactory system and that these deficits are compounded by smoking. © 1995 by John Wiley & Sons, Inc.

The olfactory system plays an important role, along with the sense of taste, in the development of food preferences and the control of food intake (Burdach & Doty, 1987). Numerous diseases are associated with decreased or distorted olfactory function (for review, see Doty, 1991) and with loss of appetite and body weight (Deems et al., 1991).
Although it is not known whether the sense of smell is compromised in patients with eating disorders (EDs), weanling rats made anorexic by dehydration (hypertonic saline infusion) showed depressed intake of sucrose solutions which were associated with odor (Bruno & Hall, 1982). This suggests that the anorexia produced by dehydration is influenced by olfactory cues.

The purpose of the present study was to determine whether the sense of smell is altered in patients with food-restricting anorexia, anorexia with bulimic features, and bulimia nervosa (BN). Should anorexia be associated with alterations in the ability to identify or detect odorants, then the anorexic condition could serve to exacerbate or help maintain the disordered eating. This exacerbation might be further accentuated by anorexia-related alterations in the ability to taste (see for example Casper, Kirschner, Sandstead, Jacob, & Davis, 1980). If this is, indeed, a vicious cycle, then elucidation of its elements may lead to novel approaches for the treatment of anorexia and related disorders.

**METHOD**

**Subjects**

Fifty-five hospitalized female patients participated in the study: 15 with bulimia nervosa (BN); 14 with anorexia nervosa, restricting subtype, weighing between 70 and 85% of ideal body weight (ANR ≥ 70% IBW); 11 with anorexia nervosa, restricting subtype weighing less than 70% of IBW (ANR < 70% IBW); and 15 with anorexia nervosa, bulimic subtype (ANB). In the ANB group, there were 7 subjects with admission percents of IBW below 70%, but this was not a sufficient number to define a separate, very-low-weight group, as was the case for the ANR group. All ED subjects were recruited from the Johns Hopkins Eating Disorders Unit following informed consent procedures approved by the Joint Committee for Clinical Investigation. Diagnoses were based on DSM-III-R criteria. A demographic questionnaire was administered to match controls to the patients according to age, ethnicity, socioeconomic status, education, and smoking behavior.

Treatment consisted of a comprehensive integration of nutritional rehabilitation, normalization of eating behavior, psychotherapy, and behavioral relearning (Andersen, 1985). Smoking was allowed when patients were not on constant observation at specific, restricted times through the program.

The control group (CTL) consisted of 16 normal weight females who were screened through a preliminary interview and additional questionnaires, including the Eating Attitudes Test (EAT; Garner & Garfinkel, 1979), to detect symptomatology of an ED; the Eating Inventory (EI; Stunkard & Messick, 1985), to measure cognitive restraint; and the Zung Self-Rating Scale (ZUNG; Zung, 1970), to detect symptomatology of depression. Only those individuals scoring <15 on the EAT, <10 on the EI, and <40 on the ZUNG were asked to participate.

Patients ranged in age from 12 to 46 years with a mean age (±SEM) of 24.1 ± 1.1, and controls ranged in age from 12 to 46 years with a mean age of 25.8 ± 1.2. Mean percent IBW (±SEM) for the groups are as follows: ANB: 71 ± 2, BN: 96 ± 3, ANR < 70% IBW: 57 ± 3, ANR ≥ 70% IBW: 78 ± 1, and CTL: 93 ± 2.

**Test Procedure**

Subjects were tested twice. Patients were tested within 2 days of admission to the inpatient ward and then again at discharge. Controls were tested on intervals matched
to those of patients, with a mean interval of 42.3 days. The tests were conducted at 11:00 a.m. and took approximately 45 min to complete.

The University of Pennsylvania Smell Identification Test (UPSIT), a 40-item, multiple-choice standardized test which incorporates microencapsulated (“scratch and sniff”) odors, was administered (Doty, Shaman, & Dann, 1984). This test is highly reliable (Doty, Frye, & Agrawal, 1989) and sensitive to subtle alterations in olfactory function.

Odor detection thresholds (ODTs) were measured using a single stair case forced-choice detection threshold paradigm incorporating the rose-like stimulus phenyl ethyl alcohol (PEA; Aldrich Chemical Company) in a half-log step (volume/volume) dilution series extending from $-13.0$ to $-1.0$ log concentrations. In brief, the subject’s task was to report which of the pair of randomly presented stimuli evoked the stronger sensation (see Doty et al., 1978).

RESULTS

Analyses were performed using SPSS/PC+ statistical software (SPSS, Inc., Chicago). Multiple analyses of variance (MANOVA) were followed by pairwise comparisons (Tukey-HSD). Means are cited as ±SEM.

UPSIT Scores

The mean UPSIT scores for each of the five study groups are presented in Table 1. A MANOVA computed with the between-subject factors of group and smoking status (including those who had quit smoking) and the within-subject factor of time (treatment: admission vs. discharge) revealed a significant main effect of group [$F(4,58) = 4.33$, $p = .004$]. Although there was a tendency for smokers to have lower UPSIT scores than nonsmokers, this trend did not reach the .05 level of significance [$F(2,58) = 2.57$, $p = .085$; Table 2]. No significant interactions among group, smoking, and time were found.

A second MANOVA identical to the one above, but excluding those subjects who had quit smoking, was computed to eliminate the confounding effects that smoking cessation may have had on olfactory function. This MANOVA revealed a weaker yet significant effect of group [$F(4,57) = 2.61$, $p = .045$] and a significant effect of smoking [$F(1,57)$...]

Table 1. Mean (±SEM) threshold and UPSIT scores at admission and discharge for each subject group

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Admission</th>
<th></th>
<th>Discharge</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Threshold</td>
<td>UPSIT</td>
<td>Threshold</td>
<td>UPSIT</td>
</tr>
<tr>
<td>ANB</td>
<td>15</td>
<td>$-8.8 ± 0.6$</td>
<td>$37.6 ± 0.4$</td>
<td>$-8.8 ± 0.5$</td>
<td>$37.9 ± 0.4$</td>
</tr>
<tr>
<td>BN</td>
<td>15</td>
<td>$-9.6 ± 0.6$</td>
<td>$38.3 ± 0.5$</td>
<td>$-9.5 ± 0.7$</td>
<td>$38.2 ± 0.4$</td>
</tr>
<tr>
<td>ANR ≥70% IBW</td>
<td>14</td>
<td>$-7.8 ± 0.6$</td>
<td>$38.4 ± 0.6$</td>
<td>$-8.3 ± 0.6$</td>
<td>$38.1 ± 0.4$</td>
</tr>
<tr>
<td>ANR &lt;70% IBW</td>
<td>11</td>
<td>$-7.3 ± 0.6$</td>
<td>$35.3 ± 2.0$</td>
<td>$-8.0 ± 0.9$</td>
<td>$35.1 ± 2.5$</td>
</tr>
<tr>
<td>Control group</td>
<td>16</td>
<td>$-8.2 ± 0.6$</td>
<td>$38.4 ± 0.3$</td>
<td>$-9.4 ± 0.6$</td>
<td>$38.6 ± 0.4$</td>
</tr>
</tbody>
</table>

Note. UPSIT = University of Pennsylvania Smell Identification Test; ANB = anorexia nervosa, bulimic subtype; BN = bulimia nervosa; ANR = anorexia nervosa, restricting subtype; IBW = ideal body weight.
Table 2. Mean (±SEM) threshold and UPSIT scores at admission and discharge for current smokers and nonsmokers (excluding those who had quit smoking) in each subject group

<table>
<thead>
<tr>
<th>Smoking</th>
<th>N</th>
<th>Admission</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Threshold</td>
<td>UPSIT</td>
<td>Threshold</td>
</tr>
<tr>
<td>ANB</td>
<td>Yes</td>
<td>4</td>
<td>-9.1 ± 1.0</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>9</td>
<td>-8.6 ± 0.9</td>
</tr>
<tr>
<td>BN</td>
<td>Yes</td>
<td>8</td>
<td>-8.7 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>7</td>
<td>-10.5 ± 0.8</td>
</tr>
<tr>
<td>ANR ≥70% IBW</td>
<td>Yes</td>
<td>4</td>
<td>-8.9 ± 0.9</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>9</td>
<td>-7.5 ± 0.8</td>
</tr>
<tr>
<td>ANR &lt;70% IBW</td>
<td>Yes</td>
<td>5</td>
<td>-6.3 ± 0.8</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>6</td>
<td>-8.2 ± 0.9</td>
</tr>
<tr>
<td>Control group</td>
<td>Yes</td>
<td>5</td>
<td>-8.4 ± 1.2</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>10</td>
<td>-8.3 ± 0.7</td>
</tr>
</tbody>
</table>

Note. UPSIT = University of Pennsylvania Smell Identification Test; ANB = anorexia nervosa, bulimic subtype; BN = bulimia nervosa; ANR = anorexia nervosa, restricting subtype; IBW = ideal body weight.

= 4.44, p = .040]. There were no significant interactions. Thus, by comparing only concurrent smokers to those who had never smoked, smoking emerged as a significant factor.

An additional MANOVA was calculated to determine if the effect of weight status on the UPSIT scores was consistent across groups, including the ANB group. When weight status (less than 70% IBW vs. 70% IBW or above), smoking status, and time were entered as factors, there were significant effects of weight status \(F(1,66) = 8.67, p = .004\) and smoking status \(F(2,66) = 3.0, p = .025\) on the UPSIT scores, such that low-weight anorexics (<70% IBW), including ANR and ANB, had lower UPSIT scores than the other subjects (admission: 36.1 ± 1.2 vs. 38.3 ± 0.2; discharge: 36.4 ± 1.6 vs. 38.2 ± 0.2), and smokers had lower UPSIT scores than nonsmokers. There was also a significant Weight Status × Smoking Status × Time interaction \(F(1,66) = 4.51, p = .037\); low-weight smokers did not show improved UPSIT scores at discharge whereas other smokers did. The Weight Status × Smoking Status interaction was also statistically significant \(F(1,66) = 3.97, p = .05\); low-weight smokers tended to have greater deficits, relative to non-smokers of comparable weight, than did other smokers.

In stepwise regression analyses of data from all groups, a significant proportion of variance in admission UPSIT scores was accounted for by percent of IBW at admission \(R^2 = .14, p = .0017\) and by age \(R^2 = .21, p = .0005\). Subjects whose body weights at admission were closer to ideal had higher UPSIT scores \(r = .37, p < .001\), while older subjects had lower UPSIT scores at admission \(r = -.31, p < .01\).

When Pearson correlations between subject characteristics and measures of olfactory function were calculated for each diagnostic group, it was found that the correlations were significant for only the ANR group (including subjects above, at, and below 70% IBW at admission). The admission UPSIT scores were negatively correlated with length of illness \(r = -.62, p < .001\) and age \(r = -.52, p < .01\), and positively correlated with percent of IBW at admission \(r = .50, p < .01\). When correlations were computed for the pooled patient groups (excluding the control group) in order to consider length of illness, length of illness was negatively correlated with admission UPSIT scores \(r = -.32, p < .01\).

A simple regression analysis performed on the data from the 11 ANR subjects who had lengths of illness greater than or equal to 36 months revealed that length of illness
accounted for a significant proportion of the variance in admission UPSIT scores ($R^2 = .47$, $p = .02$). Thus, in those subjects with lengths of illness of at least 36 months, length of illness was more strongly negatively correlated with UPSIT scores.

Planned comparisons did not reveal any significant differences between admission and discharge UPSIT scores within groups (without regard to smoking status).

**ODT Scores**

When a MANOVA was computed for ODT scores with group, smoking status, and time entered as factors, no significant effects or interactions were found, including or excluding those subjects who had quit smoking. An additional MANOVA was calculated for ODT scores to examine the effects of weight status across subject groups. A significant effect of weight status was found [$F(1,66) = 5.01, p = .03$] such that low-weight subjects (below 70% IBW at admission) had higher ODTs (i.e., lower odor detection ability) than other subjects (admission: $7.9 \pm 0.5$ vs. $8.6 \pm 0.3$; discharge: $8.1 \pm 0.6$ vs. $9.1 \pm 0.3$). There was also a significant effect of time [$F(1,66) = 5.39, p = .02$], such that ODTs were slightly lower at discharge than at admission, but there was no effect of smoking status (Table 2). Thus, like the UPSIT scores, ODT scores were affected by weight status. Unlike the UPSIT scores however, ODT scores were not affected by smoking, but lowered over time. Therefore, starvation and smoking had a relatively intractable, additive effect on the smell identification ability of these subjects, but starvation alone affected smell detection.

In stepwise regression analyses of data from all groups, smoking, age, admission percent IBW, and length of illness failed to account for the variance in admission ODT scores. There were no significant Pearson correlations between admission ODT scores and the above subject characteristics.

A simple regression analysis performed on the data from the 11 ANR subjects who had lengths of illness greater than or equal to 36 months revealed that length of illness accounted for a significant proportion of the variance in admission ODT scores ($R^2 = .61$, $p = .004$).

**DISCUSSION**

In this investigation of olfactory function in patients with EDs only the very low-weight anorexics showed impairments in their ability to identify (UPSIT) and detect (threshold) odors. This group's olfactory function did not improve appreciably from admission to discharge despite significant weight gain (average percent of IBW at discharge = 78). Since anorexic patients in the higher-weight category did not show impairments, the diagnosis of anorexia per se does not predispose to olfactory impairment. It is possible that the severe and prolonged starvation experienced by the low-weight anorexics caused permanent or intractable changes to the olfactory system. This conclusion should be drawn with caution, however, since the very low-weight anorexics had not achieved IBW at discharge. Future studies should determine whether anorexics who have experienced severe and prolonged starvation continue to have impairments in olfactory function once IBW has been achieved.

Starvation and protein deprivation have been reported to decrease cell renewal in the small-bowel epithelium (Hopper, Rose, & Wannemacher, 1972) and it has been suggested that starvation and general malnutrition may have similar effects on the turnover
of the receptors in the tongue and olfactory epithelium (Schiffman, 1983a, 1983b). It may be that malnutrition retards the regeneration of epithelial cells affecting taste and olfaction. Conversely, olfactory dysfunction may predispose patients to more severe cases of anorexia, once initiated by socioculturally prominent dieting.

Other variables besides body weight at the start of treatment emerged as factors associated with diminished olfactory function including age and length of illness. Since age and length of illness were not correlated in the patients in this study, these two factors independently influence olfactory function. Several studies have observed decreased olfactory acuity to accompany increasing age (Schiffman, Moss, & Erickson, 1976; Doty, Shaman, Applebaum, et al., 1984; Deems & Doty, 1987; Rolls & McDermott, 1991). Although the sample of ED patients in this study did not span a large age range, the correlation does suggest a similar linear relationship. It may be that starvation exacerbates sensory dysfunction or deterioration, and this is compounded for older subjects.

Length of illness was negatively correlated with UPSIT scores at admission and discharge for the anorexics (including those above and below 70% IBW). This may be related to weight status because admission percent of IBW was negatively correlated with length of illness in the restricting anorexics. In those individuals, it may be the case that the effects of starvation have been acting on the body longer and, thus, have eroded certain functions like smell identification ability over a period of time.

In the present study smoking had only a minor influence on the olfactory test scores (in accord with other studies; see Frye, Schwartz, & Doty, 1990). Indeed, no statistically significant effects of smoking were found except when smoking was coupled with other risk factors such as very low weight. Very-low-weight anorexics who smoked had the lowest UPSIT scores, although the differences did not reach significance. The very-low-weight anorexic smokers smoked the same number of cigarettes per day as the other subjects, but they had smoked for a significantly longer period of time than the bulimics, and this may have contributed to their relative olfactory dysfunction. It is possible that once individuals go below a certain percent of IBW, olfactory function may be more vulnerable to other detracting influences like age and smoking. Smoking cessation may help improve olfactory function in very-low-weight patients. This is important because olfactory dysfunction may perpetuate anorexia by adversely affecting taste function and impeding weight gain. These results suggest an interactive and perhaps potentiating role for olfactory dysfunction and other contributing factors.

Impairments of olfactory function have implications for the recovery process. If very-low-weight anorexics are unable to appreciate the hedonic value of food they may be less likely to gain the necessary weight for physical health. Patients with olfactory dysfunction have reported a change in their eating habits, a decreased enjoyment of food, and decreased food intake (Schechter & Henken, 1974; Ferris & Duffy, 1989). In a case report of an ED patient with anosmia and loss of taste sensitivity (due to head trauma), binge eating was unaffected, with high levels of seasoning added to foods to stimulate taste (Fahy, DeSilva, Silverstone, & Russell, 1989). Following behavioral treatment, binge eating stopped, but the anorexia remained, suggesting the impact of chemosensory dysfunction in maintaining anorexia. Chemosensory function may play a role in maintaining anorexia by reducing the sensory stimulation from food thereby decreasing the likelihood of food ingestion.

This study shows impairment in olfactory function in very-low-weight anorexics, but not in the other ED groups tested. More studies are required to determine the prevalence
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of such olfactory changes and to test directly whether they impact on food intake and selection.

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