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Predictability of the self-administered odour questionnaire for patients with olfactory dysfunction

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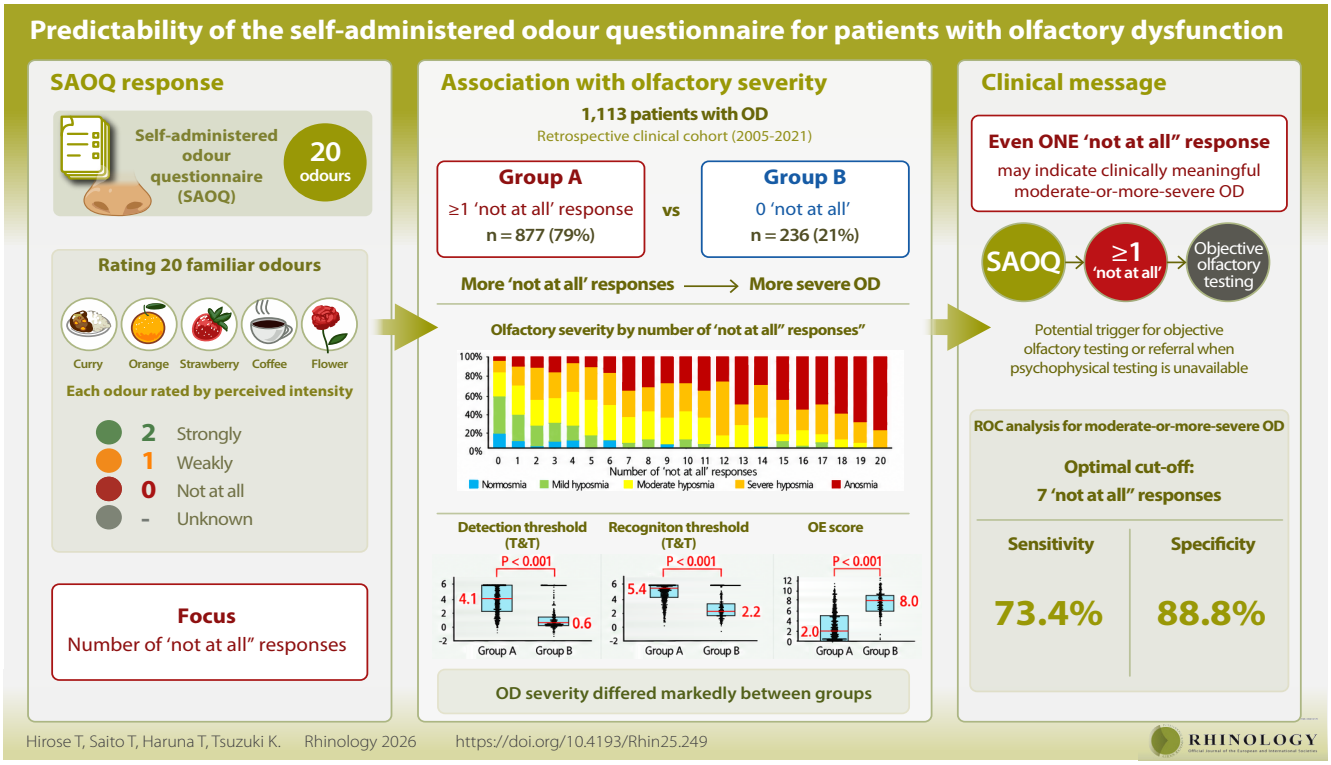

Abstract

Background: The self-administered odour questionnaire (SAOQ) is a scoring system for evaluating olfactory perception based on 20 odours familiar to the Japanese, which each odour is rated on a four-point scale: 'strongly', 'weakly', 'not at all', and 'unknown'. The purpose of this study was to analyse how the selection pattern of 'not at all' in the SAOQ relates to the results of the standard olfactory test and Open Essence (OE), and to explore the predictive value of the SAOQ in assessing olfactory dysfunction (OD).

Methodology: Data from 1113 patients who underwent treatment for OD and completed the SAOQ, standard olfactory test and OE between 2005 and 2021 were retrospectively analysed to identify patients with psychophysical smell dysfunction. According to whether they selected 'not at all' on the SAOQ, patients were divided into two groups: (A) patients with at least one unperceived odour (one or more 'not at all' responses) and (B) patients without unperceived odour (no 'not at all' responses).

Results: Group A consisted of 877 patients (79%), whereas group B consisted of 236 patients (21%). Significant differences were observed in detection and recognition thresholds on the standard olfactory test and the OE results between groups A and B. A higher number of 'not at all' answers showed a more severe OD on actual olfactory tests.

Conclusions: These data suggest that a careful interview focusing on the presence or absence of items with no odour at all contributes to the detection of potential quantitative OD. Predictability of severe OD using the SAOQ is suggested in patients with OD.

Key words: odour, olfaction, questionnaire, score, smell

Introduction

Olfactory dysfunction (OD) is a clinically significant condition that impacts various aspects of life, including the ability to detect hazards [1], mental health, social interactions [2-4], physical well-being [5], and overall quality of life (QOL) [2-4]. OD has also been recognized as a prodromal symptom of neurodegenerative diseases such as Alzheimer's disease [6-8] and Parkinson's disease [9-11]. The prevalence of OD is not negligible [12]; globally, anosmia affects approximately 5% of the general population [2], emphasizing the importance of assessing olfactory function. In Japan, OD is primarily evaluated using the standard olfactory test and intravenous olfactometry, which are covered by insurance [3]. However, these tests require special equipment, manpower, and financial resources, making their widespread use difficult.

In clinical practice, subjective assessment of OD is often conducted through interviews or questionnaires. A detailed clinical interview plays an important role in OD management, as it helps clinicians understand the underlying pathology, severity, and potential causes of OD [13].

The relationship between self-reported OD and results of actual olfaction and psychophysical tests remains an open issue. Some patients may be unaware of their smell loss, especially in progressive cases, while others may present their smell loss despite normal objective results. Previous studies have suggested that self-perception of smell does not always correspond closely with results of tests, and that self-perception of smell may be influenced by cognitive, psychological, and experiential factors [14,15].

Among available self-assessment tools, the Questionnaire of Olfactory Disorders (QOD) and its brief version (brief QOD) are widely used to evaluate the psychological and QOL impact of OD [16]. However, these tools don't directly quantify odour perception in detail. In contrast, the self-administered odour questionnaire (SAOQ), proposed by the Japanese Rhinologic Society in 2003, is unique in that it assesses odour perception itself through 20 odours familiar to Japanese. In the SAOQ, respondents assess their olfactory perception using a four-point scale: 'strongly', 'weakly', 'not at all', and 'unknown', allowing a perception-based score to be derived. This scoring system is considered as a threshold-based approach rather than identification or QOL evaluation.

Previous studies have demonstrated a significant correlation between results of SAOQ and olfactory tests, indicating its clinical utility [17,18]. The SAOQ is particularly advantageous as it is simple, cost-free, and can be fully answered in minimal time, making it a practical option for large-scale olfactory screening [18].

Among the SAOQ answer options, selecting 'not at all' for any odour may indicate the presence of latent or severe OD. Even though the SAOQ is a subjective self-report on olfaction, SAOQ respondents who selected 'not at all' for one or more of the items may have significantly more severe OD than those who did not select 'not at all'. However, the relationship between the number of 'not at all' answers in the SAOQ and actual olfactory test outcomes still remains an open issue.

The purpose of this study was to analyse how the selection pattern of 'not at all' in the SAOQ relates to the results of the standard olfactory test and Open Essence (OE), and to explore the predictive value of the SAOQ in assessing OD.

Materials and methods

Patients

Between June 2005 and September 2021, 1113 patients (479 men and 634 women; median age, 59 years; age range 5-89 years) with OD who were treated at our department and completed the SAOQ, standard olfactory test and OE before treatment were enrolled in this study. Patients were divided into two groups A and B, based on presence or absence of 'not at all' answers in the SAOQ. Group A consisted of patients with at least one unperceived odour (one or more 'not at all' responses), and group B consisted of patients without unperceived odour (no 'not at all' responses).

This study used a retrospective case series design and was approved by the ethics committee of Hyogo Medical University (approval number 1512 and 5462). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Olfactory evaluation

Self-administered odour questionnaire (SAOQ)

We have applied the SAOQ for patients with OD at the first visit since January 2005. The questionnaire consists of questions about the following 20 odours: 'steamed rice, miso, seaweed, soy sauce, baked bread, butter, curry, garlic, orange, strawberry, green tea, coffee, chocolate, household gas, garbage, timber, sweat, stool, flower, and perfume' [17,18]. These 20 odours were carefully selected based on previous studies on olfaction [19]. To answer the SAOQ, patients marked each odour at one of four levels based on their recent experience and memories: two (2) points when they could strongly smell the odour; one (1) point when they could weakly smell the odour; zero (0) points when they could not smell it at all; and 'no odour experience' (without any points). 'No odour experience' odour item was excluded from the scoring, so that 2 points by one 'no odour experience' item were subtracted from denominator. The proportion (%) of the total score for each odour compared with the full score was calculated as the SAOQ score. A higher SAOQ score indicated a better subjective sense of smell. The cutoff value of the SAOQ was statistically calculated as 66.7% with a sensitivity of 99.0% and a specificity of 90.1%, based on a conventional receiver-operating characteristic (ROC) curve and the area under the curve (AUC) analysis in the previous study [17]. Considering the clarity and practicality of clinical application, we decided on the cutoff

Table 1. Olfactory severity in groups A and B.

	group A n = 877	group B n = 236
normosmia	10 (1%)	30 (13%)
mild hyposmia	56 (6%)	101 (43%)
moderate hyposmia	138 (16%)	67 (28%)
severe hyposmia	242 (28%)	23 (10%)
anosmia	431 (49%)	15 (6%)

Group A had the highest prevalence of anosmia, whereas Group B had the highest prevalence of mild hyposmia. The distribution of olfactory severity between groups A and B was compared using the chi-square test. Adjusted residual analysis was performed to determine which severity categories significantly contributed to the observed group differences.

value of 70% to facilitate understanding of more accurate values suggesting OD. Patients who answered as 'no odour experience' to more than 11 odours were excluded from the analysis. In this study, 23 patients met this criterion and were therefore excluded from the analysis.

Standard olfactory test using a T&T olfactometer

The standard olfactory test using a T&T olfactometer (standing for Takagi and Toyota), which is covered by insurance in Japan, was used to evaluate olfactory acuity [3]. The T&T olfactometer consists of five odourants: (i) β-phenyl ethyl alcohol, which smells like a rose; (ii) methyl cyclopentenolone, which smells like burning; (iii) isovaleric acid, which smells like sweat; (iv) γ-undecalactone, which smells like fruit; and (v) skatole, which smells like garbage (Daiichi Yakuhin Sangyo Co., Ltd. Tokyo, Japan). The reagents have 8-staged concentration (from -2 to 5) in A, C, D, and E and 7-staged concentration (from -2 to 4) in B. The maximum concentrations of A5, B4, C5, D5, and E5 are 631, 25.1, 100, 795, and 79.5 (mg/ml), respectively. Each reagent was diluted ten times at every stage to the most diluted stage (-2). Patients were given a paper filter (width, 7 mm; length, 140 mm) dipped into an odour reagent on one side of the tip [20]. Patients sniffed the paper filter at a distance of 10-20 mm through the nostrils. This test kit was used to determine the detection and recognition thresholds for each odourant in increasing concentrations. Detection threshold was defined as the lowest concentration detectable by the patients, whereas recognition threshold was defined as the lowest concentration at which the odour could be identified. Subsequently, detection and recognition thresholds in the five odourants were averaged, and the mean values were used to evaluate the olfactory acuities. A lower value indicated better olfactory function.

The severity of OD was determined based on the values of recognition threshold and classified into five groups: (i) normosmia (≤ 1.0); (ii) mild- (1.2 - 2.4); (iii) moderate- (2.6 - 4.0); (iv) severe-hyposmia (4.2 - 5.4); and (v) anosmia (5.6 ≤) (3).

Open Essence (OE)

We also performed another smell identification test, Open Essence (OE), on the patients enrolled in this study. OE is a card-type test kit developed in Japan for assessment of olfactory identification abilities [21,22]. Microcapsulated fragrance is printed on one side of the twice-folded card, and the other side carries information on alternatives. When the subject opens the twice-folded card, the microcapsule breaks and the odour is presented. There are 12 cards with different odours: India ink, wood, perfume, menthol, Japanese orange, curry, gas for household use, rose, Hinoki cypress, sweaty socks, condensed milk, and roasted garlic. All of these odours are familiar to Japanese people [22]. The subject was asked to select the type of odour on a given card from the alternatives printed on the right side of the card and to enter the answer into the answer sheet. The 6 alternatives were composed of 'correct odour', 'odour closest to the correct one', 'odour close to the correct one', 'odour far different from the correct one', 'detectable but not recognizable', and 'no smell detected' in accordance with cluster analysis. Only correct answer, 'correct odour' was given 1 point, and the other answers were considered as wrong given 0 points. The total points for all cards were calculated. The cutoff value for OE was set at 8 points, with scores of 8 or higher considered as normal smell sensation based on the previous study [23].

Statistical analysis

The Mann-Whitney U test was used to compare the olfactory test results between groups A and B. The chi-square test was used to compare the distribution of olfactory severity categories between groups A and B, and adjusted residual analysis was performed to identify categories contributing to the group differences. The chi-square test was used to compare the olfactory test results between group B and the group that selected 'not at all' only once. Receiver-operating characteristic (ROC) curve analysis was additionally performed to determine the optimal cut-off value for the number of 'not at all' responses in predicting moderate or more severe OD. The optimal cut-off value was determined using the Youden index, and the corresponding sensitivity and specificity were calculated. All p-values were two-sided, and values of $p < 0.05$ were considered as significant. All statistical analyses were performed using the Stat Flex version 7.0 software (Osaka, Japan).

Results

Group A, comprising patients with at least one unperceived odour, consisted of 877 patients (79%), whereas group B, comprising those without unperceived odour consisted of 236 (21%)

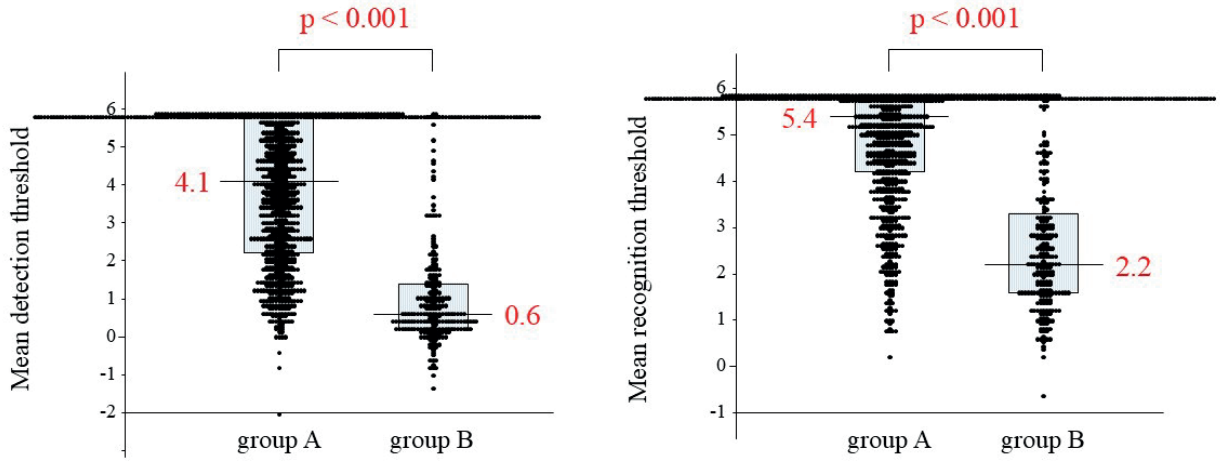

Figure 1. Comparison of olfactory detection and recognition thresholds between groups A and B. Both mean detection and recognition thresholds in group A were significantly higher than those in group B ($p < 0.001$, Mann-Whitney U test).

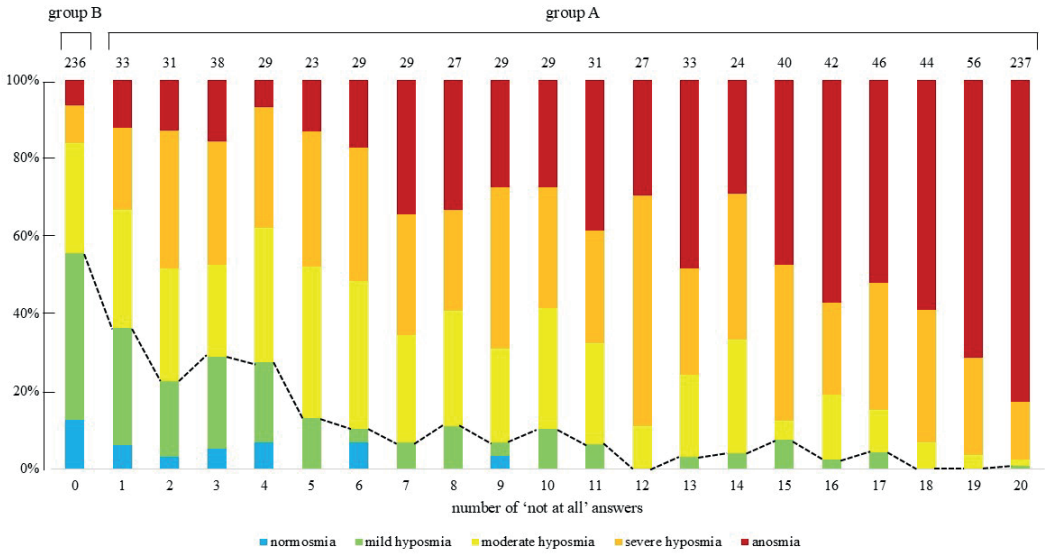

Figure 2. Olfactory severity based on the number of 'not at all' answers in the SAOQ. As the number of 'not at all' answers increased, there was a tendency for olfactory severity to worsen. Dotted line indicates distinguishment normosmia and mild hyposmia from moderate, severe hyposmia, and anosmia.

(Table 1). Patients in group A showed more severe OD compared to those in group B, with a higher prevalence of anosmia (49% in group A and 6% in group B) and severe hyposmia (28% in group A and 10% in group B), whereas normosmia and mild hyposmia were more frequent in group B (13% in group B and 1% in group A for normosmia; 43% in group B and 6% in group A for mild hyposmia). A chi-square test demonstrated a significant difference in the distribution of olfactory severity between groups A and B ($\chi^2(4) = 370.074$, $p < 0.001$, Cramer's V = 0.577). Residual analysis revealed that normosmia, mild-, and moderate-hyposmia were significantly more frequent in group B, whereas severe hyposmia and anosmia were significantly more frequent in group A. Both the mean detection and recognition thresholds in group A were significantly higher than those in group B ($p < 0.001$) (Figure 1).

As the number of 'not at all' answers increased, there was a clear tendency toward worsening olfactory severity (Figure 2). Specifically, among patients who selected 'not at all' only once, 2 had normosmia (7%), 10 had mild- (30%), 10 had moderate- (30%), 7 had severe-hyposmia (21%), and 4 had anosmia (12%). In contrast, among those who selected 'not at all' for all 20 items, none had normosmia (0%), 2 had mild- (1%), 4 had moderate- (2%), 35 had severe-hyposmia (15%), and 196 had anosmia (82%). Furthermore, the proportion of moderate or more severe OD was significantly higher in patients who selected 'not at all' only once (a part of group A) than in those who selected none (group

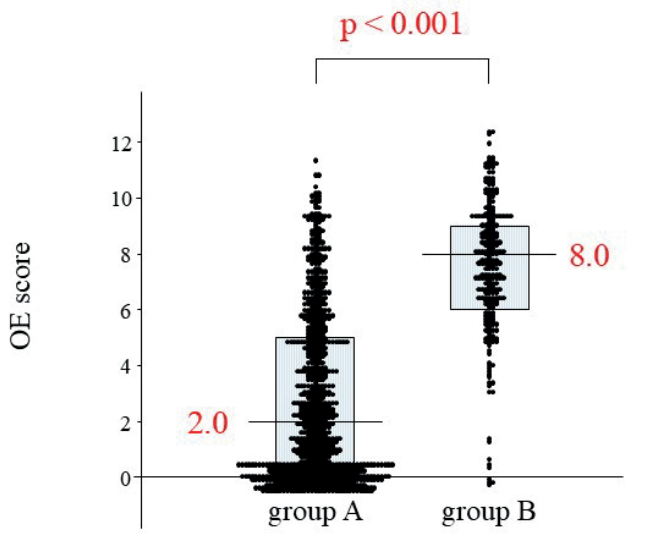

Figure 3. Comparison of smell identification between groups A and B. The OE score in group A was significantly lower than that in group B ($p < 0.001$, Mann-Whitney U test).

B). ROC curve analysis demonstrated that the optimal cut-off value for the number of 'not at all' responses in predicting moderate or more severe OD was 7, with a sensitivity of 73.4% and a specificity of 88.8%.

The OE scores in group A were significantly lower than those in group B ($p < 0.001$) (Figure 3). As the number of 'not at all' answers increased, the OE scores tended to decrease (Figure 4).

Discussion

This study demonstrated a significant association between the SAOQ answers and actual olfactory tests, suggesting that the SAOQ could serve as a useful screening tool for quantitative OD. Specifically, respondents with at least one unperceived odour (group A) showed significantly higher olfactory detection and recognition thresholds, indicating poorer olfactory function compared to those without unperceived odour (group B).

The findings revealed a clear correlation between the number of 'not at all' answers and the severity of OD. As shown in Figure 2, patients who selected 'not at all' even once had a significantly higher frequency of moderate or more severe OD compared to those who never selected 'not at all'. The more respondents selected 'not at all', the more pronounced this tendency became, with a gradual increase in the proportion of those classified as having severe hyposmia or anosmia. Importantly, these results indicate that selecting 'not at all' even once may reflect meaningful moderate or more severe OD in specialized smell and taste clinic for patients with OD. In number of unperceived odour selected, once or none is critical from a clinical perspective. Although ROC analysis identified an optimal cut-off value of 7, this value was likely influenced by the inclusion of only patients with OD. If healthy control was enrolled in this study, the optimal cut-off value would shift closer to one. These results suggest that selecting 'not at all' even once may indicate a high likelihood of moderate or more severe OD, highlighting its clinical relevance as a screening indicator of OD.

Moreover, the results emphasize the importance of classifying patients with OD based on their number of 'not at all' answers in the SAOQ. Focusing on the presence or absence of 'not at all' answers was thought to be clinically useful, given the observed tendency of worsening olfactory function with increasing 'not at all' answers. Given that self-administered reports often correlate with actual olfactory test results, our findings align with previous studies demonstrating the utility of questionnaire-based assessments in identifying OD [17,18]. By refining the interpretation of SAOQ answers, this study contributes to improving the utility of SAOQ as a reliable screening tool for detecting OD in clinical settings.

Internationally, questionnaires such as the QOD and brief QOD are widely used to evaluate the impact of OD on QOL and psychological status [16]. In contrast, the SAOQ specifically focuses on rapid and convenient screening of olfactory function using daily familiar odours, which represents its unique advantage. SAOQ-like questionnaires that enable quick olfactory function screening using familiar everyday odours are extremely rare internationally, which further highlights the distinctive advantage of the SAOQ. Although the SAOQ cannot evaluate parosmia or QOL impacts, its assessment purposes and characteristics differ from those of QOD, suggesting these tools could complement each other.

Several olfaction specific factors may account for the discrepancy between self-reported olfactory function and objective test results. (i) The sense of smell is often unnoticed in daily life. Just as with many chronic conditions in which symptoms progress subtly [24], olfactory decline typically develops gradually. Consequently, patients may fail to recognize their impairment and tend to underestimate it due to habituation. (ii) Psychological and cognitive factors, including anxiety, depression, and reduced attentional capacity, can often influence subjective olfactory ratings, leading to either overestimation or underestimation. (iii) Widely used olfactory tests are predominantly quantitative, whereas qualitative disorders such as parosmia and phantosmia rely entirely on self-report and therefore show poor concordance with psychophysical measures. (iv) Self-reported olfactory function reflects an individual's accumulated experiences and memories, while psychophysical tests (e.g., T&T olfactory test, University of Pennsylvania Smell Identification Test (UPSIT), and Sniffin' Sticks) capture olfactory performance at a single point in time, resulting in a mismatch in temporal perspective.

Although this study provides valuable insights into the relationship between SAOQ responses and objective olfactory function, some limitations should be noted. First, some patients without

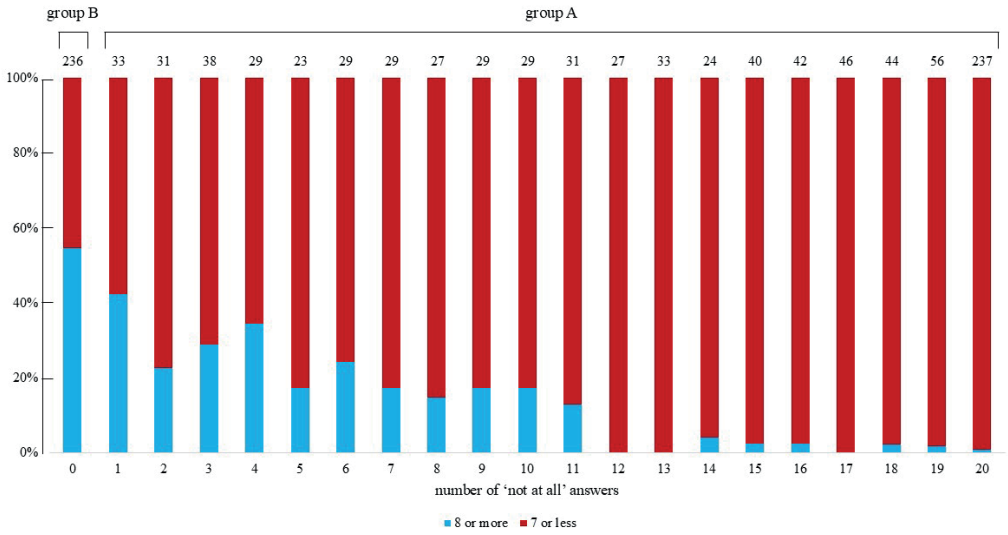

Figure 4. Smell identification based on the number of 'not at all' answers in the SAOQ. As the number of 'not at all' answers increased, the OE score tended to decrease.

unperceived odour showed abnormal results by tests, indicating that self-reported assessments may underestimate OD. This highlights the limitation of the SAOQ as a purely self-reported tool and the need for combining actual tests. Second, because this study included only patients with OD from a specialized smell and taste clinic in a single centre, the generalizability of the results may be limited. Third, only the Japanese standard olfactory test and OE were used, without comparison to widely adopted international tests such as UPSIT or Sniffin' Sticks. Fourth, the SAOQ assesses quantitative aspects of OD, but does not capture qualitative symptoms such as parosmia or phantosmia which affect patients' QOL [25].

Despite these limitations, this study highlights that even a single 'not at all' answer in the SAOQ offers clinically meaningful insight into OD severity. These findings contribute to early detection of patients with OD.

Conclusion

A careful interview focusing on the presence or absence of items with no odour at all contributes to the detection of potential quantitative OD. Furthermore, a higher number of items suggests a more severe condition. Predictability of severe OD using the SAOQ is suggested in patients with OD.

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Author contributions

TH (first and corresponding author): study design, analysis of data, interpretation of data, drafting of manuscript, and final approval of manuscript; TS: data collection, analysis of data, and final approval of manuscript; TH (third author): data collection, analysis of data, and final approval of manuscript; KT: study design, interpretation of data, drafting of manuscript, and final approval of manuscript.

Ethics approval and consent to participate

This study used a case series design and was approved by the ethics committee of Hyogo Medical University (approval number 1512 and 5462). This study was conducted in accordance with the principles of the Declaration of Helsinki.

Conflict of interest

The authors declare that they have no competing interests.

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