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Olfactory dysfunction: properties of the Sniffin' Sticks Screening 12 test and associations with quality of life

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Abstract

Purpose The Sniffin' Sticks Screening 12 test is a test of olfactory performance based on pen-like odor dispensing devices. The aims of this study were to analyze the performance of this test in a general population sample and to explore associations between olfactory dysfunction and quality of life.

Methods A large community sample ($n = 7267$) completed the Sniffin' Sticks Screening 12 test and several questionnaires measuring quality of life, anxiety, dispositional optimism, social support, and satisfaction with life.

Results According to the criteria recommended by the test manufacturer, 5.1% of the participants were anosmic (score ≤ 6), 52.4% were dysosmic ($7 \leq$ score ≤ 10), and 42.5% were normosmic (score ≥ 11). While frequencies of correct identification differed between the 12 sticks, all sticks contributed positively to the test results. The associations between olfactory functioning and quality of life variables were negligible. In the multivariate analyses, none of the associations reached the 1% significance level.

Conclusions While studies with patients in otorhinolaryngological clinics often report substantial detriments to their quality of life in relation to olfactory dysfunction, the present epidemiological study cannot confirm this association for the general population.

Keywords Olfactory dysfunction · Anosmia · Sniffin' Sticks test · General population study · Quality of life

Introduction

Olfactory dysfunction is a frequent consequence of several diseases such as chronic inflammation of the nasal mucosa, obstructions of the olfactory cleft, or viral infections. Several instruments have been developed to test olfactory functioning. The Sniffin' Sticks test is one of the most frequently used instruments. It consists of three components: the determination of odor threshold, odor discrimination, and odor identification [1, 2].

The Sniffin' Sticks Screening 12 test (SST) is a 12-odor identification test which can be used for rapid screening of olfactory dysfunction in clinical practice. There are also more elaborated forms of the test with 16 and with 32 odors [3]. Normative studies for the 12-odor test have been performed in several countries [1, 4–6]. Some odors are relatively difficult to identify. Therefore, Danish researchers [7] replaced some of the answer alternatives and reached higher identification rates after doing so. However, a high identification rate of an odor item (i.e., a high percentage of

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correct responses) does not necessarily mean that the item can reliably discriminate well between poor and good olfactory performers. One aim of this study was to assess the contribution of each of the 12 items to the total score and to test the reliability of the SST.

Patients with olfactory problems often complain about detriments to their quality of life (QoL) and about mental health problems. According to a systematic review [8], depressed patients had lower olfactory threshold, discrimination, and identification scores compared to non-depressed patients, and a German study found higher rates of odor identification impairment (OR = 1.7) among depressed people than in non-depressed controls [9]. An Austrian study with 22 anosmic patients and 25 healthy controls detected lower levels of self-esteem in the anosmic group [10]. Patients suffering from olfactory dysfunction also report impairments in the areas of food enjoyment, personal hygiene, and sexual life [11, 12]. The most often reported problem is the lack of experienced taste of food [13, 14]. Based on a sample of patients with olfactory disorders, a German study [15] found lower levels of QoL in all eight dimensions of the QoL questionnaire SF-36 as compared to controls. However, there was no correlation within the group of patients between the objectively measured olfactory dysfunction and the SF-36 domains except for the bodily pain dimension. Another study compared people with a complete inability to smell with a normal control group concerning the SF-36 dimensions [16]. The anosmic group reported significantly worse QoL on four of the SF-36 scales.

Most of these results concerning the relationship between olfactory dysfunction and QoL have been obtained comparing groups of patients with controls, some of the studies were based on small sample sizes. From a public health perspective, it is also relevant to investigate the relationship between olfactory dysfunction and QoL in the general population, including people with and without olfactory dysfunction, since the patients who have most commonly been examined thus far might also suffer from detriments other than pure olfactory dysfunction, making it difficult to separate the effect of olfactory dysfunction from other effects, e.g., treatment effects.

The aims of this study were (a) to investigate the reliability of the SST on item level, and (b) to test the impact of olfactory dysfunction on QoL, based on a large community sample.

Methods

Sample

Data were gathered in the LIFE-Adult-Study of the Leipzig Center for Civilization Diseases (LIFE). This population-based study comprises a representative sample of people living in Leipzig, Germany, a city with about 550,000 inhabitants. An age- and gender-stratified random sample of 10,000 adult inhabitants was selected for participation in the study. The addresses were obtained from the resident's registration office. The participation rate was 33%. Since, according to the study protocol, the focus was on people between 40 and 80 years old, the age group 18–39 was included but underrepresented. The main aim of the LIFE study was to examine the development of civilization diseases. The study included the collection of sociodemographic data, medical history, lifestyle factors, and several medical examinations. Details of the study design have been published elsewhere [17]. Informed consent was obtained from all participants. The study was approved by the Ethics Committee of the University of Leipzig.

Instruments

SST

The SST (Burghart Messtechnik GmbH, Wedel, Germany) is a test of olfactory performance based on identification of odors using pen-like odor dispensing devices. For each of the 12 sticks, the participants have to choose the correct answer from a list of four words indicating odors (e. g., peach, apple, lemon, grapefruit). The test performance is the sum of the correctly identified odors, whereby scores range from 0 to 12. Scores from 0 to 6 indicate anosmia, 7–10 hyposmia, and 11–12 normosmia [18].

Questionnaires

QoL was measured with the Short Form Health Survey-8 SF-8 [19]. This questionnaire comprises eight one-item dimensions: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. Two factors of second order can be calculated: the Physical Component Score (PCS) and the Mental Component Score (MCS). In addition, we used the Generalized Anxiety Disorder screener GAD-7 [20], the Life Orientation test LOT-R, for measuring dispositional optimism [21], the ENRICHD Social Support Scale ESSI [22], and the Satisfaction with Life scale SWLS [23]. Socioeconomic status (SES) was calculated according to the German National Health Survey (Bundesgesundheitssurvey) [24].

Statistical analyses

Item analyses were performed using the correlations between each single test item and the scale when the item was removed. Reliability was measured with Cronbach's alpha coefficient [25]. This coefficient is often used for

statistical analyses of psychological questionnaires. It can be interpreted as an estimation of the correlation between the test result and the "true" score of a person. While it is impossible to infer this true score, it is possible to estimate the correlation of that true score with the test score. Coefficients of 0.80 and above indicate good reliability, and coefficients of 0.60 and above at least acceptable reliability. The impact of the socioeconomic status on olfactory function was measured with a three-way ANOVA (SES, gender, age group), since SES is confounded with age and gender. The association between odor performance and QoL data was examined using logistic regression analyses, the dependent variable was the presence or absence of normosmia. For each of the independent variables (QoL and mental health variables), we calculated separate univariate analyses and multivariate analyses, including the "covariates' age, gender", and SES. The statistical analyses were performed with SPSS version 20 (IBM Corp, Armonk, NY, USA).

Results

Of the 10,000 persons included in the study, 7413 underwent olfactory testing, at least in part. Complete data sets were available from 7267 of the respondents and incomplete sets from 146 respondents. Only the 7267 people with complete SST data were included in the analyses. Table 1 presents sociodemographic properties of the sample.

Frequency of correctly identified odors

Table 2 presents the results of the SST for the 12 odors. The sequence of the odor alternatives in the rows of Table 2 (odors 2 to 4) is not identical with the sequence of presentation in the test, since the correct odors were distributed among the four places in the test, while in Table 2, the correct answers are presented in the left column. The frequency of correct answers (see left column of Table 2) varied between the 12 sticks. Peppermint was correctly identified by 94.9% of the participants, while the identification rate of lemon (59.3%) was much lower. 3 of the 12 odors were difficult to identify, i.e., they were difficult to distinguish from the distractor odors, with rates of false responses above 30%: cinnamon, lemon, and pineapple. The incorrect answers were not evenly distributed for some of the odors. For lemon, the distractor grapefruit was chosen considerably more often (32.0%) than peach (5.2%) or apple (3.6%).

The right-hand side of Table 2 presents the (part-whole-corrected) correlations between the items and the test result (r_{it}). All items were positively associated with the total test result. The reliability of the test (Cronbach's alpha) was 0.544. The last column of Table 2 shows that three items could be removed without reducing test reliability: shoe leather, cinnamon, and lemon. Removing other items would diminish the reliability.

Table 3 shows the distribution of the overall test result. A proportion of 5.1% of the sample were anosmic (score ≤ 6), 52.4% were dysosmic ($7 \leq$ score ≤ 10), and 42.5% were normosmic (score ≥ 11; 100% − 57.5%). The mean number of correctly identified odors was 9.9 ± 1.78.

In an additional analysis, we studied the olfactory function of the 146 participants with incomplete SST data. For these participants, we calculated the proportion of correct identifications of those odors for which individual data were available, and multiplied the proportion by 12 to

Table 1 Sociodemographic characteristics of the sample

	Males ($n = 3{,}478$)		Females ($n = 3{,}789$)		Total sample ($n = 7{,}267$)	
	n	(%)	*n*	(%)	*n*	(%)
Age						
Mean	56.9		56.3		56.6	
(SD)	(12.8)		(12.4)		(12.6)	
Age group						
≤ 39 years	202	(5.8)	184	(4.9)	386	(5.3)
40–49 years	952	(27.4)	1103	(29.1)	2055	(28.3)
50–59 years	748	(21.5)	895	(23.6)	1643	(22.6)
60–69 years	849	(24.4)	909	(24.0)	1758	(24.2)
≥ 70 years	727	(20.9)	698	(18.4)	1425	(19.6)
Socioeconomic status						
Low	663	(19.1)	765	(20.2)	1428	(19.7)
Medium	2012	(57.8)	2345	(61.9)	4357	(60.0)
High	798	(22.9)	671	(17.7)	1469	(20.2)
Missing	5	(0.1)	8	(0.2)	13	(0.2)

Table 2 Percentages of item responses and item analyses

No.	Correct odor	%	Odor 2	%	Odor 3	%	Odor 4	%	r_{it}	Alpha del.
1	Orange	92.8	Blackberry	3.1	Strawberry	1.6	Pineapple	2.5	0.207	0.527
2	Shoe leather	79.1	Smoke	6.9	Glue	9.7	Grass	4.3	0.146	0.542
3	Cinnamon	**63.6**	Honey	22.2	Vanilla	11.1	Chocolate	3.2	0.154	0.546
4	Peppermint	94.9	Chives	0.6	Spruce	4.1	Onion	0.4	0.299	0.515
5	Banana	87.4	Coconut	3.6	Walnut	2.0	Cherry	6.9	0.273	0.511
6	Lemon	**59.3**	Peach	5.2	Apple	3.6	Grapefruit	32.0	0.165	0.544
7	Liquorice	83.6	Gummy bear	7.9	Chewing gum	6.3	Cookies	2.1	0.294	0.503
8	Coffee	92.1	Cigarette	4.2	Wine	0.5	Smoke	3.2	0.254	0.518
9	Clove	90.8	Pepper	3.2	Cinnamon	4.8	Mustard	1.3	0.245	0.519
10	Pineapple	**69.7**	Pear	10.3	Plum	6.8	Peach	13.2	0.247	0.516
11	Rose	91.7	Chamomile	3.9	Raspberry	2.8	Cherry	1.5	0.294	0.510
12	Fish	83.0	Bread	3.2	Cheese	8.8	Ham	4.9	0.225	0.521

r_{it}: part-whole-corrected test–item correlation; alpha del.: alpha if item deleted

Bold: rates of correct identification below 70%

Table 3 Percentages of SST scores

No. of correct answers	*n*	% correct	Cumulative % correct
1	9	0.1	0.1
2	16	0.2	0.3
3	45	0.6	1.0
4	57	0.8	1.7
5	89	1.2	3.0
6	155	2.1	5.1
7	284	3.9	9.0
8	565	7.8	16.8
9	1149	15.8	32.6
10	1810	24.9	57.5
11	1983	27.3	84.8
12	1105	15.2	100.0

arrive at an estimation of the SST score. The mean SST score of these 146 participants was 10.2 ± 2.1.

Relationship between olfactory dysfunction and socioeconomic status

The mean scores of correctly identified odors were: $M = 9.5 \pm 1.9$ (low SES), 9.9 ± 1.7 (medium SES), and 10.1 ± 1.7 (high SES), the corresponding prevalence scores of normosmia were 31.9%, 44.6%, and 46.6%, respectively. In the three-way ANOVA (SES, gender, age group), the impact of SES was statistically significant with $F = 20.8$, $df = 2$, and $p < 0.001$.

Relationship between olfactory dysfunction and psychological and QoL variables

Table 4 presents results of the logistic regression analyses. In the univariate analyses more than half of the predictors showed significant odds ratios. Adjusting for age, gender, and SES in the multivariate analyses resulted in non-significant relationships except in a single instance (Physical functioning).

Discussion

The first question was whether all items contribute to a reliable assessment of olfactory function or dysfunction. We confirmed the findings of other studies that three odors are difficult to distinguish from the distractors: cinnamon, lemon, and pineapple. However, removing these items would not improve the test results. Even if the identification rate of an odor is low, the contribution of the item to a reliable test result may be positive. The total reliability of the test (Cronbach alpha = 0.54) is low; a coefficient of 0.60 is assumed to be necessary for an acceptable reliability. This means that adding further items would probably increase the precision of assessment. Under the assumption that the additional items of the 16-item test have the same discriminative power as the average of the 12 items, the Cronbach alpha coefficient would increase to 0.61, which is somewhat higher than 0.54 of the 12-item test.

The threshold of at least 11 correct answers was used to identify normosmia according to the recommendation of the test authors [18]. In our sample, about 50% of the participants scored either immediately above or below this threshold (25% scored 10 and 27% scored 11). This means that there is some unreliability in the distinction between

Table 4 Odds ratios for the relationship between questionnaire scores and olfactory dysfunction

	Univariate analyses			Multivariate analyses, adjusted for age, sex, and SES		
	B	OR	Sig.	B	OR	Sig.
SF-8						
Physical functioning	0.029	1.029	< 0.001	0.009	1.009	0.014
Role-physical	0.020	1.020	< 0.001	0.006	1.006	0.081
Bodily pain	0.005	1.005	0.079	− 0.001	0.999	0.674
General health	0.024	1.024	< 0.001	0.005	1.005	0.271
Vitality	0.003	1.003	0.464	0.000	1.000	0.902
Social functioning	0.006	1.006	0.080	0.004	1.004	0.270
Role-emotional	0.006	1.006	0.130	0.005	1.005	0.191
Mental health	− 0.009	0.991	0.005	− 0.004	0.996	0.238
PCS: physical comp. score	0.019	1.019	< 0.001	0.005	1.005	0.080
MCS: mental comp. score	− 0.009	0.991	0.002	− 0.002	0.998	0.425
GAD-7: anxiety						
GAD-7 score	0.008	1.008	0.233	0.003	1.003	0.677
LOT-R: optimism						
LOT-R total score	0.038	1.038	< 0.001	0.012	1.012	0.094
ENRICHD: social support						
ENRICHD score	0.018	1.018	0.007	0.009	1.009	0.193
SWLS: satisfaction with life						
SWLS score	− 0.002	0.998	0.593	− 0.002	0.998	0.668

normosmia and dysosmia. A further indicator of limited reliability is the relatively low test–retest correlation ($r = 0.60$) of the SST [3]. These are arguments for the use of the version with 16 items, at least if a valid identification of the olfactory performance of a patient is needed. A recent study [3] enlarged the Sniffin' Sticks identification test to 32 items and proved better validity and reliability than the 16-item test. An Arabic version of the Sniffin' test adapted the 16-item version [26]. While the 12-item test is of limited validity for individual assessments of olfactory functioning, it is nevertheless suitable as a screening instrument and as an instrument in epidemiological analyses with large sample sizes. Since self-rated olfactory sensitivity is only weakly related to the objectively measured olfactory function [5], the SST should not be replaced with subjective assessments.

SES was associated with the SST performance; participants with a low SES showed reduced ability to identify odors. One of the three components of SES is the occupational situation. However, we did not have sufficiently precise data to calculate SST mean scores for special professional groups.

QoL was not associated with olfactory function, at least when age, gender, and SES are taken into account. There is a univariate relationship between physical functioning and olfactory dysfunction, however, this relationship is mainly mediated by age: older people report less physical functioning and less olfactory functioning. In addition to such effects mediated by age, sex, and SES, olfactory dysfunction did not influence QoL in a significant way. In our large sample, one OR of 1.009 (physical functioning and olfactory dysfunction) was statistically significant with $p = 0.014$, the effect is however negligible. While physicians hear from their patients that detriments in smelling and tasting abilities reduce their well-being and happiness, and while studies with olfactory-specific quality of life questionnaires (e. g., [27]) confirm these observations [28], this is not reflected in the large-scale analyses with the instruments typically used in such epidemiological reports. It is also possible that a recent loss of olfactory function due to a disease or medical treatment actually results in a short-term reduction of QoL, but people adapt to this situation and report normalized QoL after some time. Therefore, we cannot safely speculate that olfactory function was irrelevant for individual patients' QoL.

Some studies on olfactory dysfunction compared patients with healthy controls. The sample sizes were often relatively small, e. g, the control group of the study on the relationship between anosmia and self-esteem [10] included 25 healthy controls. The normative table presented here for the adult general population provides more profound reference scores.

Some limitations of the study should be mentioned. The participation rate of the study was not high (33%), which might cause a bias. Due to the dichotomous character of the items (correct/incorrect), the Cronbach alpha reliability coefficient (which was designed for metric items) is not totally comparable with other tests that use metric

item formats. The questionnaires used to measure lack of psychosocial well-being and QoL were not tailored to the domain of sniffing. It would be interesting to compare the subjectively assessed ability to identify odors with the objective measurement; such a subjective assessment was however not included in this study. It is possible that dysosmic or anosmic people were overrepresented among the participants who did not complete all 12 odors. However, the mean olfactory capacity of the participants with incomplete data ($M = 10.2$) was not lower than the capacity of the full responders ($M = 9.9$). Therefore, we do not believe that there is a strong bias due to missing data. Finally, it is difficult to assess the generalizability of the odor identification performance to other regions of Europe [7, 29] or other continents [26, 30].

In summary, the SST proved to be well-applicable in a large epidemiological study. The relationship between olfactory dysfunction and QoL observed in clinical studies should not be generalized to public health associations in the general population.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study was approved by the Ethics Committee of the University of Leipzig, Germany, and has been performed in accordance with the ethical standards as laid down in the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Hummel T, Kobal G, Gudziol H et al (2007) Normative data for the "Sniffin' Sticks" including tests of odor identification, odor discrimination, and olfactory thresholds: An upgrade based on a group of more than 3000 subjects. Eur Arch Otorhinolaryngol 264(3):237–243. https://doi.org/10.1007/s00405-006-0173-0
2. Rumeau C, Nguyen DT, Jankowski R (2016) How to assess olfactory performance with the Sniffin' Sticks test(®). Eur Ann Otorhinolaryngol Head Neck Dis 133(3):203–206. https://doi.org/10.1016/j.anorl.2015.08.004
3. Sorokowska A, Albrecht E, Haehner A et al (2015) Extended version of the "Sniffin' Sticks" identification test: test-retest reliability and validity. J Neurosci Methods 243:111–114. https://doi.org/10.1016/j.jneumeth.2015.01.034
4. Lin S-H, Chu S-T, Yuan B-C et al (2009) Survey of the frequency of olfactory dysfunction in Taiwan. J Chin Med Assoc 72(2):68–71. https://doi.org/10.1016/S1726-4901(09)70025-5
5. Sorokowska A, Schriever VA, Gudziol V et al (2015) Changes of olfactory abilities in relation to age: Odor identification in more than 1400 people aged 4 to 80 years. Eur Arch Otorhinolaryngol 272(8):1937–1944. https://doi.org/10.1007/s00405-014-3263-4
6. Katotomichelakis M, Balatsouras D, Tripsianis G et al (2007) Normative values of olfactory function testing using the 'sniffin' sticks'. Laryngoscope 117(1):114–120. https://doi.org/10.1097/01.mlg.0000246518.79894.7e
7. Fjaeldstad A, Kjaergaard T, van Hartevelt TJ et al (2015) Olfactory screening: validation of Sniffin' Sticks in Denmark. Clin Otolaryngol 40(6):545–550. https://doi.org/10.1111/coa.12405
8. Kohli P, Soler ZM, Nguyen SA et al (2016) The association between olfaction and depression: a systematic review. Chem Senses 41(6):479–486. https://doi.org/10.1093/chemse/bjw061
9. Khil L, Rahe C, Wellmann J et al (2016) Association between major depressive disorder and odor identification impairment. J Affect Disord 203:332–338. https://doi.org/10.1016/j.jad.2016.06.022
10. Kollndorfer K, Reichert JL, Brückler B et al (2017) Self-esteem as an important factor in quality of life and depressive symptoms in anosmia: a pilot study. Clin Otolaryngol 42(6):1229–1234. https://doi.org/10.1111/coa.12855
11. Hummel T, Nordin S (2009) Olfactory disorders and their consequences for quality of life. Acta Oto-Laryngol 125(2):116–121. https://doi.org/10.1080/00016480410022787
12. Croy I, Nordin S, Hummel T (2014) Olfactory disorders and quality of life—an updated review. Chem Senses 39(3):185–194. https://doi.org/10.1093/chemse/bjt072
13. Temmel AFP, Quint C, Schickinger-Fischer B et al (2002) Characteristics of olfactory disorders in relation to major causes of olfactory loss. Arch Otolaryngol Head Neck Surg 128(6):635. https://doi.org/10.1001/archotol.128.6.635
14. Tafalla M (2013) A world without the olfactory dimension. Anat Rec 296(9):1287–1296. https://doi.org/10.1002/ar.22734
15. Neuland C, Bitter T, Marschner H et al (2011) Health-related and specific olfaction-related quality of life in patients with chronic functional anosmia or severe hyposmia. Laryngoscope 121(4):867–872. https://doi.org/10.1002/lary.21387
16. Smeets MAM, Veldhuizen MG, Galle S et al (2009) Sense of smell disorder and health-related quality of life. Rehabil Psychol 54(4):404–412. https://doi.org/10.1037/a0017502
17. Loeffler M, Engel C, Ahnert P et al (2015) The LIFE-Adult-Study: objectives and design of a population-based cohort study with 10,000 deeply phenotyped adults in Germany. BMC Public Health 15(1):691. https://doi.org/10.1186/s12889-015-1983-z
18. Hummel T, Konnerth CG, Rosenheim K et al (2001) Screening of olfactory function with a 4-min odor identification test: reliability, normative data, and investigations in patients with olfactory loss. Ann Otol Rhinol Laryngol 110(10):976–981. https://doi.org/10.1177/000348940111001015
19. Ware JE, Kosinski M, Dewey JE et al (2001) How to score and interpret single-item health status measures: A manual for users of the SF-8™ Health Survey. QualityMetric Incorporated, Lincoln (RI)
20. Spitzer RL, Kroenke K, Williams JBW et al (2006) A brief measure for assessing generalized anxiety disorder - The GAD-7. Arch Int Med 166(10):1092–1097
21. Scheier MF, Carver CS, Bridges MW (1994) Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem)—a reevaluation of the life orientation test. J Pers Soc Psychol 67(6):1063–1078. https://doi.org/10.1037/0022-3514.67.6.1063

22. Berkman LF, Blumenthal J, Burg M et al (2003) Effects of treating depression and low perceived social support on clinical events after myocardial infarction: the enhancing recovery in coronary heart disease patients (ENRICHD) randomized trial. JAMA 289(23):3106–3116. https://doi.org/10.1001/jama.289.23.3106
23. Diener E, Emmons RA, Larsen RJ et al (1985) The Satisfaction with life scale. J Personal Assess 49(1):71–75
24. Lampert T, Kroll L, Mueters S et al (2013) Measurement of the socioeconomic status within the German Health Update 2009 (GEDA). Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz 56(1):131–143
25. Cronbach LJ (1951) Coefficient alpha and the internal structure of tests. Psychometrika 16:297–334
26. Oleszkiewicz A, Taut M, Sorokowska A et al (2016) Development of the Arabic version of the "Sniffin' Sticks" odor identification test. Eur Arch Otorhinolaryngol 273(5):1179–1184. https://doi.org/10.1007/s00405-015-3718-2
27. Croy I, Buschhüter D, Seo H-S et al (2010) Individual significance of olfaction: development of a questionnaire. Eur Arch Otorhinolarygol 267(1):67–71. https://doi.org/10.1007/s00405-009-1054-0
28. Simopoulos E, Katotomichelakis M, Gouveris H et al (2012) Olfaction-associated quality of life in chronic rhinosinusitis: adaptation and validation of an olfaction-specific questionnaire. Laryngoscope 122(7):1450–1454. https://doi.org/10.1002/lary.23349
29. Masala C, Saba L, Cecchini MP et al (2018) Olfactory function and age: A Sniffin' Sticks Extended Test study performed in Sardinia. Chem Percept 11(1):19–26. https://doi.org/10.1007/s12078-017-9233-7
30. Yuan BC, Lee PL, Lee YL et al (2010) Investigation of the Sniffin' Sticks Olfactory Test in Taiwan and comparison with different continents. J Chin Med Assoc 73(9):483–486. https://doi.org/10.1016/S1726-4901(10)70103-9