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Clinical study

Residual olfactory dysfunction in coronavirus disease 2019 patients after long term recovery

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ABSTRACT

Introduction: Hyposmia is among the most common symptoms of COVID-19 patients. Previous research has mainly described this issue at the disease's early stages. Because olfactory impairment can indicate neurological degeneration, we investigated the possibility of permanent olfactory damage by assessing hyposmia during the late recovery stage of COVID-19 patients.
Methods: Ninety-five patients were assessed with the Brief Smell Identification Test for Chinese (B-SITC) and Hyposmia Rating Scale (HRS) after 16 weeks from disease onset. Five weeks later, 41 patients were retested with B-SITC.
Results: At the first visit, hyposmia was identified in 26/82 (31.7%) and 22/95 (23.2%) of participants by HRS (HRS score $\leq$22) and B-SITC (B-SITC score <8), respectively. The rates of hyposmia in patients who performed B-SITC after 14–15 weeks, 16–17 weeks, and $\geq$18 weeks from disease onset were 7/25 (28%), 8/35 (23%) and 7/35 (20%), respectively, which demonstrated a trend of olfaction improvement as recovery time prolonging. Hyposmia percentages decreased from the first visit (34.1%) to the second visit (24.4%) for the 41 patients who completed 2 visits. B-SITC scores of the first-visit hyposmia participants increased significantly at the second visit (5.29 ± 2.02 to 8.29 ± 2.40; n = 14, P = 0.001). Severe cases tended to recover less than common cases.
Conclusions: Hyposmia was present in up to one-third of COVID-19 patients after about 3 months from disease onset. Notable recovery of olfactory function was observed at a next 5-weeks follow-up. Clinical severity had little influence on olfactory impairment and recovery.
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1. Introduction

As of 2 July 2021, Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), which causes the well-known coronavirus disease 2019 (COVID-19) [1] has infected 182,319,261 people around the world and has caused 3,954,324, deaths, and these numbers are still increasing [2]. The most common symptoms of COVID-19 include fever, cough, fatigue, dyspnea, muscle soreness, headache and diarrhea [3]. As the disease spreads worldwide, olfactory alterations have been identified as a frequent symptom [4]. Importantly, some patients with COVID-19 have reported hyposmia or anosmia as their first or even only symptom [5–7].

A number of studies have reported that at the acute phase of the disease, 5%–98% of COVID-19 patients have hyposmia [8]. Most studies have assessed olfaction with questionnaires or consultation [4,9–10], and only a few have used quantitative olfaction tests. A retrospective study reported a hyposmia incidence of 5.1% in a Chinese population [9]. Recently, a study found that as many as 11% of COVID-19 patients had dysosmia, as identified with Toyota-Takagi (T&T) olfactometer test, 95 days after disease onset [11]. As hyposmia impacts quality of life [12], and olfactory disorders may mark the onset of some neurodegenerative diseases, such as Alzheimer's disease [13] and Parkinson's disease [14], it is critical to estimate the prognosis of hyposmia in recovered COVID-19 patients. Our study aimed to identify residual hyposmia with validated and objective olfaction tests after 16 weeks or even longer from disease onset.

2. Material and methods

2.1. Population

A total of 207 discharged patients clinically diagnosed with COVID-19 who were admitted to the Puai Hospital of Tongji

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Medical college, Huazhong University of Science and Technology (The Fourth Hospital of Wuhan) during 25 January 2020 to 11 March 2020 were recruited for the study. Of those, 95 patients without olfactory impairment before infection according to self-report history completed the Hyposmia Rating Scale (HRS) and the Brief Smell Identification Test for Chinese (B-SITC) at their first visit during 28 April 2020 to 23 June 2020. Of the 95 first-visit participants, 41 completed B-SITC for the second time at a follow-up visit during 26 June 2020 to 6 July 2020.

We obtained demographic information, disease history, clinical diagnosis, disease severity and laboratory indexes from the electronic medical record system of the Fourth Hospital of Wuhan.

2.2. Olfactory tests

2.2.1. Hyposmia Rating Scale (HRS)

The HRS is a validated self-administered test originally developed for Parkinson's disease patients. It consists of seven questions, beginning with: "Are you experiencing problems with your sense of smell?" The next six questions are designed to assess to what degree a person has difficulty with recognizing specific kinds of odors (flowers, unburned gas, garbage, perfume, body odor, home cooking). When the cut-off score is set at 22, the HRS yields a sensitivity and specificity of 70% and 85%, respectively [15].

2.2.2. Brief smell Identification test for Chinese (B-SITC)

We performed the recently developed B-SITC olfactory test [16], which was modified from B-SIT. The odors selected for B-SITC are more familiar for the Chinese population than those used with B-SIT. B-SITC has been used in many studies of Parkinson's disease, and the sensitivity and specificity have been shown to be better than those of B-SIT. Participants with a B-SITC score <8 were considered to have hyposmia.

2.3. Statistical analysis

We analyzed all data using IBM SPSS 25 software. Continuous variables were compared by independent t-test or paired sample t-test. Continuous data were presented as mean ± Standard deviation (SD). Categorical variables were compared by Chi-square test. Age, sex, and smoking status were adjusted for with logistic regression analysis when comparing variables between the hyposmia and normal olfaction groups.

2.4. Ethics statementt

All participants were informed of the study benefits and risks, and signed the informed consent. This study was approved by the ethics committee of the Fourth Hospital of Wuhan, and was registered on Medical Research Registration Information System of China.

3. Results

3.1. The first visit

At the first visit, Patients performed B-SITC and HRS. 22/95 (23.2%) patients were identified with hyposmia according to their inadequate performance with B-SITC (B-SITC score <8; Table 1).

We compared the epidemiological and clinical information between normal olfaction group (B-SITC ≥8, refered to as "normal group" in the rest part of this article) and hyposmia group (B-SITC <8). The interval between disease onset and our first visit was similar between groups. The normal group was significantly younger than hyposmia group (46.62 ± 13.76 y vs 57.86 ± 14.90 y, P = 0.001). The proportion of hyposmia patients increased as the patients' age increased (≤30 y: 0 (0%); 31–50 y: 7 (38.1%); >50 y: 15 (68.2%), P = 0.018). The percentage of patients with hypertension was significantly higher in the hyposmia group than in normal group (8.2% vs 31.8%, P = 0.010). However, the difference in hypertension between groups disappeared after adjusting for sex, age, and smoking history with logistic regression analysis (hypertension, P = 0.081; smoking, P = 0.416; sex, P = 0.145; age, P = 0.006). There were no significant differences between groups for clinical severity, comorbidity, RT-PCR result, maximum body temperature, hospitalization time or laboratory index (Table 1).

There was a declining trend for rates of hyposmia as the duration between disease onset and B-SITC test increased (Fig. 1), although this trend was not statistically significant (Fig. 1).

3.2. Changes of olfactory function between two visits

Forty-one participants with baseline B-SITC results at the first visit participated in a follow-up olfactory evaluation with B-SITC a few weeks later, the durations between visits for the 27 first-visit olfactory normal patients and the 14 first-visit hyposmia patients were 5.63 ± 1.15 weeks and 6.14 ± 1.10 weeks respectively (P = 0.177). The hyposmia percentages of two visits were presented in Fig. 2. The B-SITC scores changes between our first and second visit were presented in Fig. 3. 27 first-visit olfaction normal participants showed a slightly smell change at the second visit (9.52 ± 1.12 to 9.00 ± 1.19; P = 0.017). In contrast, olfactory function of the 14 first-visit hyposmia participants improved drastically at the second visit (5.29 ± 2.02 to 8.29 ± 2.40, P = 0.001). All 41 participants together demonstrated an improvement between visits (first: 8.07 ± 2.50, second: 8.76 ± 2.07, P = 0.001).

We found no significant differences were observed in B-SITC changes between common and severe cases. However, there was a trend that B-SITC scores in common cases increased slightly more than that in severe cases, for all 41 patients finished 2 visit (common cases: 0.70 ± 2.47, n = 30 vs severe cases: 0.64 ± 2.06, n = 11, P = 0.064).

4. Discussion

In the present study, we evaluated the olfactory function of COVID-19 patients 16 weeks or even longer after disease onset. At the first evaluation, hyposmia was identified in about 23% (B-SITC) or 32% (HRS) of participants. This proportion is much higher than those reported in similar studies also investigating the Chinese COVID-19 population either after 95 days from disease onset (11%) [11], or even at the early stage of the disease (5%) [9]. The hyposmia rate reported in other ethnicities at the acute stage has differed greatly, ranging from 25% to more than 90% [10,17–19]. Previous studies have reported that 60% to 90% of patients with hyposmia recover within the first 2 weeks following disease resolution [10,17]. The relatively high hyposmia proportion may attribute to the objective and validated olfactory tests [15,16]. We used in the present study for assessing hyposmia symptoms, whereas previous studies have relied primarily on questionnaires or interviews [10,19] and the unawareness of olfactory dysfunction often occur in self assessments [20].

Our second olfaction test conducted around 5 weeks later demonstrated a considerable improvement. This indicates a favorable prognosis for olfactory dysfunction in COVID-19 patients. A study in mice has shown that the obligatory SARS-CoV-2 entry receptor proteins ACE2 and TMPRSS2 are mainly expressed in sustentacular cells of the olfactory epithelium, and not in olfactory neurons [21]. The olfactory epithelium has been shown to be able to regenerate when horizontal basal cells remain intact [22], which

Table 1
Demographic Information.

	Normal (73) B-SITC score ≥8	Hyposmia (22) B-SITC score <8	All participants	P value
Male n(%)	36(49.3)	13(59.1)	49(51.6)	0.472
Age mean ± SD(n)	46.62 ± 13.76(73)	57.86 ± 14.90(22)	49.22 ± 14.74(95)	**0.001**[#]
Age group				**0.018**[#]
≤30, n(%)	6(8.2)	0(0.0)	6(6.3)	
31–50, n(%)	42(57.5)	7(31.8)	49(51.6)	
51–64, n(%)	14(19.2)	7(31.8)	21(22.1)	
≥65, n(%)	11(15.1)	8(36.4)	19(20.0)	
Smoke n(%)	8(11.0)	2(9.1)	10(10.5)	1.000
Alcoholism n(%)	4(5.5)	3(13.6)	7(7.4)	0.347
Coronary disease n(%)	3(4.1)	2(9.1)	5(5.3)	0.327
Hypertension n(%)	6(8.2)	7(31.8)	13(13.7)	**0.010**[#]
Diabetes n(%)	4(5.5)	1(4.5)	5(5.3)	1.000
Positive RT-PCR n(%)	45(61.6)	15(68.2)	60(63.2)	0.577
Severe cases n(%)	15(20.5)	6(27.3)	21(22.1)	0.561
Maximum temperature (℃) mean ± SD (n)	38.10 ± 1.08(70)	38.30 ± 0.84(20)	38.14(1.03)	0.450
Hospitalization time (day) mean ± SD (n)	13.56 ± 8.57(71)	16.50 ± 10.82(20)	24.21 ± 9.13(91)	0.206
Laboratory indexes				
CRP (mg/dl) mean ± SD (n)	21.57 ± 28.60(67)	26.95 ± 33.64(18)	22.71 ± 29.60(85)	0.497
Lymphocyte (*10^9/L) mean ± SD (n)	1.38 ± 0.67(71)	1.67 ± 2.16(18)	1.44 ± 1.13(89)	0.332
WBC (*10^9) mean ± SD (n)	5.01 ± 1.81(71)	5.54 ± 2.27(19)	5.12 ± 1.91(90)	0.281
Eosnophils (*10^9) mean ± SD (n)	0.08 ± 0.15(71)	0.10 ± 0.28(18)	0.08 ± 0.18(89)	0.703
Interval between 1st visit and disease onset (week), mean ± SD (n)	17.04 ± 1.85(73)	16.64 ± 1.87(22)	16.95 ± 1.85(95)	0.372
B-SITC n, %	73, 77%	22, 23%	95, 100%	
HRS score mean ± SD (n)	22.43 ± 3.52(63)	20.58 ± 4.99(19)	22.00 ± 3.95(82)	0.074

B-SITC: Brief Smell Identification Test for Chinese; HRS: Hyposmia Rating Scale.[#]: P<0.05

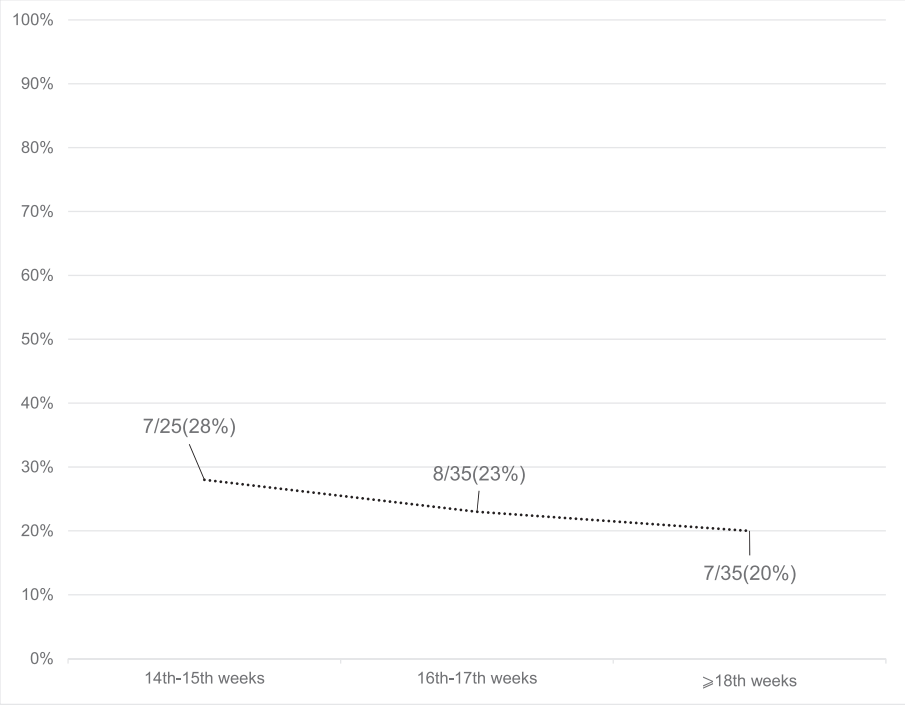

Fig. 1. Hyposmia percentages at the first visit Participants were divided into three groups based on the durations from disease onset to the first visit. The rate of hyposmia demonstrated a declined trend, but without significance (chi-squared test value = 0.527, P = 0.768).

suggests a potential mechanism to be explored for the improvement of olfaction in COVID-19 patients.

At the first visit, we observed a nonsignificant trend that the hyposmia group comprised more severe cases than mild cases (27.3% vs 20.5%, P = 0.563) (Table 1). Additionally, comparison of inter-visits B-SITC score changes between severe and non-severe patients showed that higher disease severity tended to be associated with a slower olfaction improvement (common cases: 0.70 ± 2.47, n = 30 vs severe cases: 0.64 ± 2.06, n = 11, P = 0.064). The lack of statistical significance of the findings above may be attribute to the relatively small simple size used in our study and the prolonged follow-up period after disease onset. Nevertheless, to the best of our knowledge, a relationship between olfactory function and disease severity has not been reported previously, even at the time near disease onset [9,23], and should be investigated further.

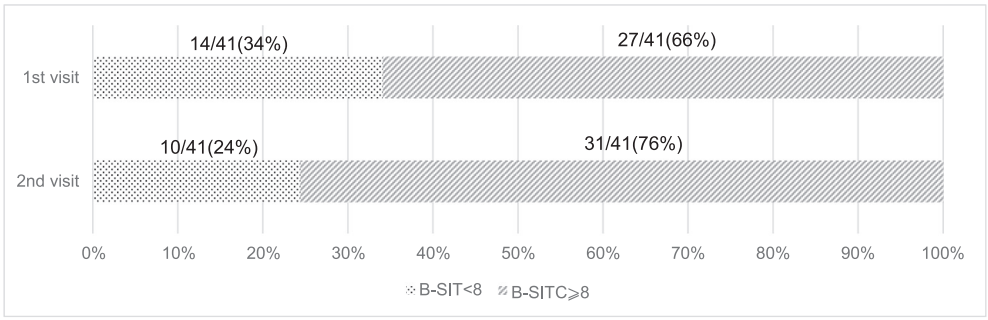

Fig. 2. Hyposmia percentages of two visits.

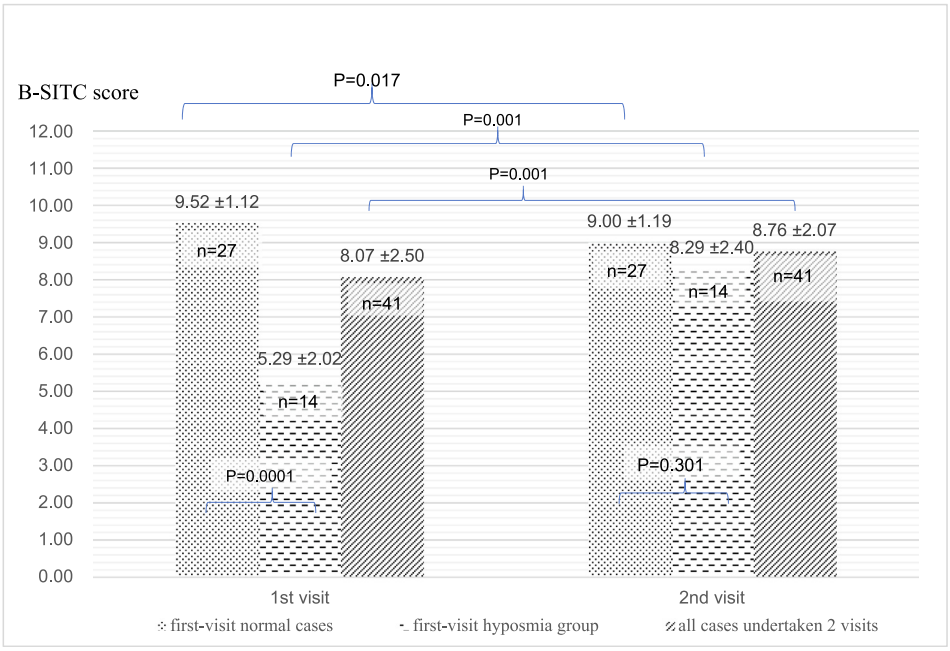

Fig. 3. Changes of B-SITC scores between 2 visits First-visit normal cases: patients' olfactory function were identified normal with B-SITC (B-SITC score ≥8) at our first visit; First-visit hyposmia group: patients' olfactory function were identified hyposmia with B-SITC (B-SITC score <8) at our first visit.

Residual olfactory symptoms lasting 16 weeks or longer should be monitored carefully, as smell loss is closely associated with neurodegenerative diseases such as Parkinson's disease [14] and Alzheimer's disease [24]. Additionally, a case report found a magnetic resonance imaging signal alteration located in the posterior gyrus rectus and olfactory bulbs in a single COVID-19 case with severe anosmia [25], which heightens our concern about the potential long term neurological influence of olfactory dysfunction in COVID-19 patients. To investigate this relationship further, studies in large cohorts using brain imaging and extended follow-up time are needed.

Results from the first visit in the present study suggest that aging may exacerbate olfactory impairment (Table 1), as none of the six participants younger than 30 years showed any olfactory dysfunction. A relationship between age and hyposmia has been demonstrated in a previous study of recovered COVID-19 patients [11]. But aging cannot be the only explanation for olfactory decline in the present study, because of the 22 patients with B-SITC <8 at the first visit, those with age ranging from 31–50 years and 51–64 years each accounted for 7/22 (32%), and those older than 65 years accounted for 8/22 (36%). Whereas, a previous study has shown that the best smell performance usually exists in the general population aging 20–50 years, and that olfactory function decreases unremarkably until 64 years of age [26]. We did not find any influence of age on the extent of olfactory change between the two visits (≤30 y [n = 1], 1.00 ± 0.00; 31–50 y [n = 14], −0.43 ± 1.40; 51–64 y [n = 14], 1.21 ± 2.29; ≥65 y [n = 12], 1.33 ± 2.99; P = 0.057).

Patients with various comorbidities were distributed evenly in B-SITC normal group and hyposmia group except for patients with hypertension (normal olfaction group: 8.25% vs hyposmia group: 31.8%, P = 0.010) (Table 1). However, the higher proportion of hypertension in the hyposmia group compared with that in the normal olfaction group may be due to the higher proportion of patients older than 50 years in the hyposmia group compared with the normal group (normal olfaction group: 34.3% vs hyposmia group:68.2%) (Table 1), as people older than 50 years are more likely to be diagnosed with hypertension before infection [27]. As expected, the difference in hypertension frequency between groups was no longer significant after adjusting for sex, age, and smoking status.

Several studies have reported that in COVID-19 patients, women are more susceptible than men to suffer from olfactory dysfunction [10,17], and the association has been attributed to gender-related inflammatory processes. However, the opposite

relationship between gender and olfactory function has been reported in Parkinson's disease [28] and Alzheimer's disease [24]. Other studies, as well as the present study, have not found a correlation between sex and olfactory function either in COVID-19 [8,23] neither in other virus-induced infections [29]. Smoking, which is a protective factor for olfaction in Parkinson's disease [30], was not linked with smell performance in the present study or a previous study in COVID-19 [23]. RT-PCR result, maximum body temperature and laboratory outcomes were also not linked with long term olfactory changes in the present study. A previous study of olfactory alteration in COVID-19 reported a lower recovery rate in RT-PCR-positive cases than in RT-PCR-negative cases at an one-month follow-up [18], which suggests that RT-PCR results may offer short term predictive value for olfactory recovery.

5. Conclusions

In the present study, hyposmia was present in nearly one-third of COVID-19 patients after 16 weeks or even longer from disease onset and this proportion decreased after a 5-weeks follow-up. It is reasonable to expect a favorable prognosis of olfactory impairment in COVID-19 patients because of the regenerative ability of the olfactory epithelium, but the symptom of hyposmia remaining at this rather late stage after disease onset suggests that the potential of permanent olfactory damage in COVID-19 patients warrants further study. Ideally, monitoring these patients' neurological status for several decades in the future should be conducted to determine whether olfactory dysfunction can induce long term neurological complications in COVID-19 patients.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Conflict of interest

Center of Research and Development of Jiangsu Parkinsense Biotech Co. Ltd. provided the smell test tool (B-SITC) for this study.

References

[1] Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A novel coronavirus from patients with pneumonia in china, 2019. N Engl J Med 2020;382(8):727–33.
[2] Organization WH, World Health Data Platform. https://covid19.who.int, 2021. Accessed 5 July 2021.
[3] Li L-Q, Huang T, Wang Y-Q, Wang Z-P, Liang Y, Huang T-b, et al. COVID-19 patients' clinical characteristics, discharge rate, and fatality rate of meta-analysis. J Med Virol 2020;92(6):577–83.
[4] Bénézit F, Le Turnier P, Declerck C, Paillé C, Revest M, Dubée V, et al. Utility of hyposmia and hypogeusia for the diagnosis of COVID-19. Lancet Infect Dis 2020;20(9):1014–5.
[5] Gane SB, Kelly C, Hopkins C. Isolated sudden onset anosmia in COVID-19 infection. A novel syndrome? Rhinology 2020;58(3):299–301.
[6] Kaye R, Chang CWD, Kazahaya K, et al., COVID-19 Anosmia Reporting Tool: Initial Findings. (1097-6817 (Electronic)).
[7] Wi YM, Lim SJ, Kim SH, et al. Response system for and epidemiological features of COVID-19 in gyeongsangnam-do province in South Korea.. Clin Infect Dis 2020.
[8] Chung TW, Sridhar S, Zhang AJ, et al., Olfactory Dysfunction in Coronavirus Disease 2019 Patients: Observational Cohort Study and Systematic Review. (2328-8957 (Print)).
[9] Mao L, Jin H, Wang M, et al., Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. JAMA Neurol, 2020.
[10] Lechien JR, Chiesa-Estomba CM, De Siati DR, Horoi M, Le Bon SD, Rodriguez A, et al. Olfactory and gustatory dysfunctions as a clinical presentation of mild-to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study. Eur Arch Otorhinolaryngol 2020;277(8):2251–61.
[11] Li J, Long X, Zhu C, et al. Olfactory dysfunction in recovered coronavirus disease 2019 (COVID-19) patients. Mov Disord 2020;35(7):1100–1.
[12] Boesveldt S, Postma EM, Boak D, et al. Anosmia-A clinical review. Chem Senses 2017;42(7):513–23.
[13] Reid LD, Avens FE, Walf AA. Cognitive behavioral therapy (CBT) for preventing Alzheimer's disease. Behav Brain Res 2017;334:163–77.
[14] Tarakad A, Jankovic J. Anosmia and Ageusia in Parkinson's disease. Int Rev Neurobiol 2017;133:541–56.
[15] Millar Vernetti P, Perez Lloret S, Rossi M, Cerquetti D, Merello M. Validation of a new scale to assess olfactory dysfunction in patients with Parkinson's disease. Parkinsonism Relat Disord 2012;18(4):358–61.
[16] Cao M, Wang N, Zheng P, Gu Z, Chan P. Validation of a new olfactory test for Chinese Parkinson's disease patients. J Clin Neurosci 2020;76:31–5.
[17] Chary E, Carsuzaa F, Trijolet J-P, et al. Prevalence and recovery from olfactory and gustatory dysfunctions in Covid-19 infection: a prospective multicenter study. Am J Rhinol Allergy 2020;34(5):686–93.
[18] Kosugi EM, Lavinsky J, Romano FR, et al. Incomplete and late recovery of sudden olfactory dysfunction in COVID-19. Braz J Otorhinolaryngol 2020;86(4):490–6.
[19] Passali GC, Bentivoglio AR. Comment to the article "Olfactory and gustatory dysfunctions as a clinical presentation of mild-to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study". Eur Arch Otorhinolaryngol 2020;277(8):2391–2.
[20] Wehling E, Nordin S, Espeseth T, Reinvang I, Lundervold AJ. Unawareness of olfactory dysfunction and its association with cognitive functioning in middle aged and old adults. Arch Clin Neuropsychol 2011;26(3):260–9.
[21] Bilinska K, Jakubowska P, Von Bartheld CS, Butowt R. Expression of the SARS-CoV-2 entry proteins, ACE2 and TMPRSS2, in cells of the olfactory epithelium: identification of cell types and trends with age. ACS Chem Neurosci 2020;11(11):1555–62.
[22] Joiner AM, Green WW, McIntyre JC, Allen BL, Schwob JE, Martens JR. Primary cilia on horizontal basal cells regulate regeneration of the olfactory epithelium. J Neurosci 2015;35(40):13761–72.
[23] Moein ST, Hashemian SM, Mansourafshar B, Khorram-Tousi A, Tabarsi P, Doty RL. Smell dysfunction: a biomarker for COVID-19. Int Forum Allergy Rhinol 2020;10(8):944–50.
[24] Doty RL, Reyes PF, Gregor T. Presence of both odor identification and detection deficits in Alzheimer's disease. Brain Res Bull 1987;18(5):597–600.
[25] Politi LS, Salsano E, Grimaldi M. Magnetic resonance imaging alteration of the brain in a patient with Coronavirus Disease 2019 (COVID-19) and Anosmia. JAMA Neurol 2020;77(8):1028. https://doi.org/10.1001/jamaneurol.2020.2125.
[26] Doty R, Shaman P, Applebaum S, Giberson R, Siksorski L, Rosenberg L. Smell identification ability: changes with age. Science 1984;226(4681):1441–3.
[27] Wu X, Wang Z. Role of socioeconomic status in hypertension among chinese middle-aged and elderly individuals. Int J Hypertens 2019;2019:6956023.
[28] Solla P, Masala C, Liscia A, Piras R, Ercoli T, Fadda L, et al. Sex-related differences in olfactory function and evaluation of possible confounding factors among patients with Parkinson's disease. J Neurol 2020;267(1):57–63.
[29] Tian J, Wei YX, Li L, et al. Analysis of clinical characteristics of 141 patients with postviral olfactory dysfunction. Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi 2017;31(10):749–52.
[30] Sharer JD, Leon-Sarmiento FE, Morley JF, Weintraub D, Doty RL. Olfactory dysfunction in Parkinson's disease: Positive effect of cigarette smoking. Mov Disord 2015;30(6):859–62.