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# Clinical utility of and correlation between Sniffin' Sticks and TIB smell identification test (TIBSIT) among Hong Kong Chinese with or without chronic rhinosinusitis

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**Introduction:** Olfactory dysfunction (OD) is common among patients with chronic rhinosinusitis (CRS). Validated and culturally specific tests, such as the "Sniffin' Sticks" test (SST) and the TIB Smell Identification Test (TIBSIT), are crucial for the diagnosis and monitoring of OD. However, they have not been utilised in Hong Kong Chinese and their correlations are unknown.

**Methods:** Twelve CRS patients and twenty healthy volunteers were prospectively recruited from a joint allergy-otorhinolaryngology clinic in Hong Kong and performed both SST and TIBSIT. Demographics, baseline characteristics and all test results were compared and analysed.

**Results:** Patients with CRS demonstrated significantly lower test scores than healthy controls (all  $p < 0.001$ ). Significant and strong correlations were observed between all composite and subtest scores, particularly between the composite SST and TIBSIT scores ( $\rho = 0.789$ ,  $p < 0.001$ ). Multivariate analysis demonstrated that the presence of CRS and increasing age were significantly associated with OD.

**Conclusion:** Both SST and TIBSIT are useful olfactory tests and are strongly correlated among Hong Kong Chinese. We advocate that either test can be used for measuring OD among CRS patients.

## KEYWORDS

smell, olfactory dysfunction, utility, chronic rhinosinusitis, Hong Kong, Chinese

## Introduction

Olfactory dysfunction (OD), characterized by "partial or complete smell loss" (hyposmia and anosmia respectively), or "qualitative dysfunction of smell in the presence or absence of an odour object" (parosmia and phantosmia respectively), is a common symptom associated with significantly impaired quality of life and affects activities of daily living (1, 2). Patients suffering from various allergic conditions, most notably inflammatory rhinopathologies such as chronic rhinosinusitis (CRS), are especially prone to develop OD (3, 4). The prevalence of OD has been reported to be within the range of 30%–78% among CRS patients, with varying rates depending on

the tests used for measuring OD (5). In addition to genuine inter-population differences, this vast variation in prevalence rates thus far reported is likely contributed by the lack of access to testing facilities and under-reporting in many regions of the world (6–8). Therefore, more standardised and validated tests for olfactory function would be of substantial value towards both research and clinical management of patients suffering from OD.

For this sake, a number of smelling tests were developed in the past few decades to allow a more objective olfactory evaluation. For instance, respectively in 1984 and 1997, the University of Pennsylvania Smell Identification Test (UPSIT) and the “Sniffin’ Sticks” test (SST) (Burghart Messtechnik, Wedel, Germany) were developed in the United States and Germany as semi-objective, psychophysical assessment tools for olfactory function (9, 10). Since their development, UPSIT and SST have gained popularity especially among ear, nose and throat (ENT) surgeons. The commercially available UPSIT and SST have also been validated in various populations and has become one of the more widely applied tests for OD, especially in North American and European countries (11–23). However, available olfactory tests remained limited beyond Western populations. Subsequently, a Taiwanese group developed and validated a brief, office-based screening test for OD known as the TIB Smell Identification Test (TIBSIT) (Top International Biotech, Taipei, Taiwan) in 2015 (24, 25). At the time of writing, application and validation of TIBSIT has been limited to Taiwan and Malaysia (25–27). To the best of our knowledge, neither SST nor TIBSIT have been utilised among Hong Kong Chinese. Furthermore, the correlation (if any) between SST and TIBSIT is unknown. Of note, both SST and TIBSIT encompass odour identification (i.e., recognition of daily encountered odours) which is dependent on patients’ familiarization with the tested odours and is thus highly culturally specific. Therefore, it is important for both SST and TIBSIT to be applied and tested among culturally specific populations, especially in cultures for whom these tests were not initially designed. In this study, we aim to explore the clinical utility of both tests among patients with CRS and healthy volunteers in Hong Kong, as well as examine the association between SST (and its subtests) and TIBSIT.

## Methods

### Study participants

Consecutive patients attending a joint allergy-ENT clinic with newly diagnosed CRS were prospectively recruited at Queen Mary Hospital in Hong Kong between January 2022 and June 2022. For all patients, the diagnosis of CRS was confirmed with the exclusion of other conditions that may contribute to OD by joint clinical assessment by both allergists and otorhinolaryngologists with nasoendoscopy assessment. Twenty healthy individuals, who reported having a normal sense of smell and no past medical history of smelling disorders or conditions related to OD, were also recruited as controls. Only adults (individuals of at least 18 years old) were included. Individuals

with nasal tumours, history of relevant trauma, neurological disorders, recent upper respiratory tract/SARS-CoV-2 infection or concomitant nasal pathologies were excluded. Baseline demographic data was also collected to study the effect of these demographic factors on smelling function. This study was approved by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. All participants gave informed consent.

### Instruments

Under the supervision of the attending Allergist, all participants were assessed by SST and TIBSIT performed in a well-ventilated room as per product manual by trained allergy nurses, who underwent online training offered by the manufacturer. SST is a nasal chemosensory test in which pen-like, odourant-containing sticks are presented to individuals. It is composed of three subtests, namely odour threshold (T), odour discrimination (D) and odour identification (I). In the T test, patients are presented with different concentrations (16 levels) of n-butanol, and their olfactory sensitivities are assessed using a repeated staircase approach, in which multiple turning points are determined and averaged to yield an overall T score. The D test uses 16 triplets of sticks, whereof two share the same odourant, differentiating from the target stick. Individuals’ D scores are assigned based on the number of times they correctly identify the different smelling sticks. The I test uses 16 sticks containing a variety of everyday smells. In each round, four options are given to individuals, who are required to identify the presented odour from three other distractors. I scores equate to the number of correctly selected odours. Both D and I tests require the individual to be blindfolded i.e., are single-blinded tests. Throughout the entire test, individuals are also required to choose an option even if they cannot give a confident response (forced-choice). The respective scores from each of the three subtests are aggregated for a composite TDI score for interpretation. Hyposmia and functional anosmia are defined as TDI score  $\leq 30.5$  and  $\leq 16$  respectively. Supersmellers refers to those reaching the highest decile score in the 21–30 age group (TDI score  $\geq 41.5$ ) (28).

TIBSIT is a smelling test recently developed for Taiwanese (ethnically Chinese), who likely share a similar cultural background, including dietary habits, with Hong Kong Chinese. TIBSIT requires individuals to identify 8 odours common to Taiwanese Chinese and each odour is presented twice, giving rise to a total of 16 questions. Unlike SST, TIBSIT uses a “scratch-and-smell” design. Tested individuals are given a disposable test booklet, which contains a scratchable test strip with embedded fragrant microcapsules on each page. They are instructed to scratch the strip surface then identify the odour among 4 options (forced choices) and state their confidence in identification (1: not detectable; 2: detectable, but not sure; 3: detectable). Scores from all the questions are then summated and interpreted as a composite TIBSIT score.

## Statistical analysis

Continuous variables were expressed in median (lower quartile—upper quartile) and categorical variables were expressed as number (percentage). All statistical analyses were performed on IBM SPSS Statistics version 28.0 (IBM Co., Armonk, NY, USA). Continuous and categorical variables were compared between the healthy control and the patient group with Mann–Whitney *U*-Test and Chi-square test respectively. Correlations of scores of different olfactory tests (and subtests) were assessed by Spearman correlation. We defined weak, moderate, and strong correlations as  $0 < \rho \leq 0.39$ ,  $0.40 \leq \rho \leq 0.59$  and  $\rho \geq 0.60$  respectively (29, 30). We also examined the effect, if any, of age and sex on olfactory test scores. Variables with *P*-value  $< 0.1$  in univariate analysis (Spearman correlation for age and Mann–Whitney *U*-test for sex) were included in subsequent multivariate linear regression analysis. Line plots were prepared using R version 4.3.1 (R Foundation, Vienna, Austria) (31). Two-sided *P*-value  $< 0.05$  indicates statistical significance.

## Results

In total, 32 individuals were included in this study (12 CRS patients and 20 healthy volunteers). All participants

were Han Chinese, 43.8% (14/32) were males and the median age was 53.5 (interquartile range: 45.0–59.5) years. There were no significant demographic differences between patients and controls (Table 1). Olfactory test scores of all participants are shown in Table 2. Compared to healthy controls, CRS patients demonstrated significantly lower scores in all conducted tests and subtests. Overall, the median composite TDI score of CRS patients was 13.5, compared to 34.4 for healthy controls ( $p < 0.001$ ). Respectively 33.3% (4/12) and 58.3% (7/12) of CRS patients were found to have hyposmia and functional anosmia, the overall OD prevalence in this CRS cohort was thus 91.7% (11/12), contrasting the control group where only two individuals (10.0%), who aged 88 and 54, were within the range of hyposmia ( $p < 0.001$ ). A significant difference was found using TIBSIT as well (median score: 0.0 vs. 41.5,  $p < 0.001$ ).

Association analysis demonstrated that all tests and subtests were moderately or strongly correlated between each other (all  $\rho > 0.4$  and  $p < 0.001$ ). A matrix detailing all the correlation coefficients is shown in Table 3. Specifically, there was a particularly strong correlation between TDI (SST) and TIBSIT scores ( $\rho = 0.789$ ,  $p < 0.001$ ; Figure 1). Individual subtests in SST also carried strong correlations to TIBSIT.

TABLE 1 Demographic characteristics of healthy controls and chronic rhinosinusitis patients.

	Total N = 32	Healthy controls N = 20	CRS patients N = 12	<i>p</i> -value
Age (years)	53.5 (45.0–59.5)	52.5 (41.0–60.3)	57.0 (47.0–59.5)	0.239
Male sex	14 (43.8)	8 (40.0)	6 (50.0)	0.581
Ethnic Chinese	32 (100.0)	20 (100.0)	12 (100.0)	N/A

CRS, chronic rhinosinusitis.

TABLE 2 Olfactory test scores of healthy controls and chronic rhinosinusitis patients.

	Total N = 32	Healthy controls N = 20	CRS patients N = 12	<i>p</i> -value
T score (SST)	10.5 (2.2–12.0)	11.6 (10.4–12.2)	1.0 (1.0–7.1)	* $< 0.001$
D score (SST)	10.5 (7.0–12.0)	11.0 (10.0–12.0)	6.5 (4.3–7.8)	* $< 0.001$
I score (SST)	10.0 (7.0–13.0)	12.0 (9.3–13.8)	6.0 (4.3–8.5)	* $< 0.001$
TDI score (SST)	31.0 (18.4–35.9)	34.4 (31.1–36.9)	13.5 (10.3–27.2)	* $< 0.001$
Hyposmic or anosmic (SST)	13 (40.6)	2 (10.0)	11 (91.7)	* $< 0.001$
TIBSIT score	39.0 (9.5–44.0)	41.5 (39.3–47.5)	0.0 (0.0–23.5)	* $< 0.001$

Bold denotes statistical significance.

CRS, chronic rhinosinusitis; SST, "Sniffin' Sticks" test; TIBSIT, TIB smell identification test; T, threshold; D, discrimination; I, identification; TDI, composite of T, D and I scores.

TABLE 3 Correlation matrix of olfactory test scores and age.

	Age	T score (SST)	D score (SST)	I score (SST)	TDI score (SST)	TIBSIT score
Age	–	–0.338 <sup>a</sup>	–0.446*	–0.301 <sup>a</sup>	–0.428*	–0.553**
T score (SST)		–	0.459**	0.476**	0.707***	0.746***
D score (SST)			–	0.591***	0.782***	0.661***
I score (SST)				–	0.843***	0.659***
TDI score (SST)					–	0.789***
TIBSIT score						–

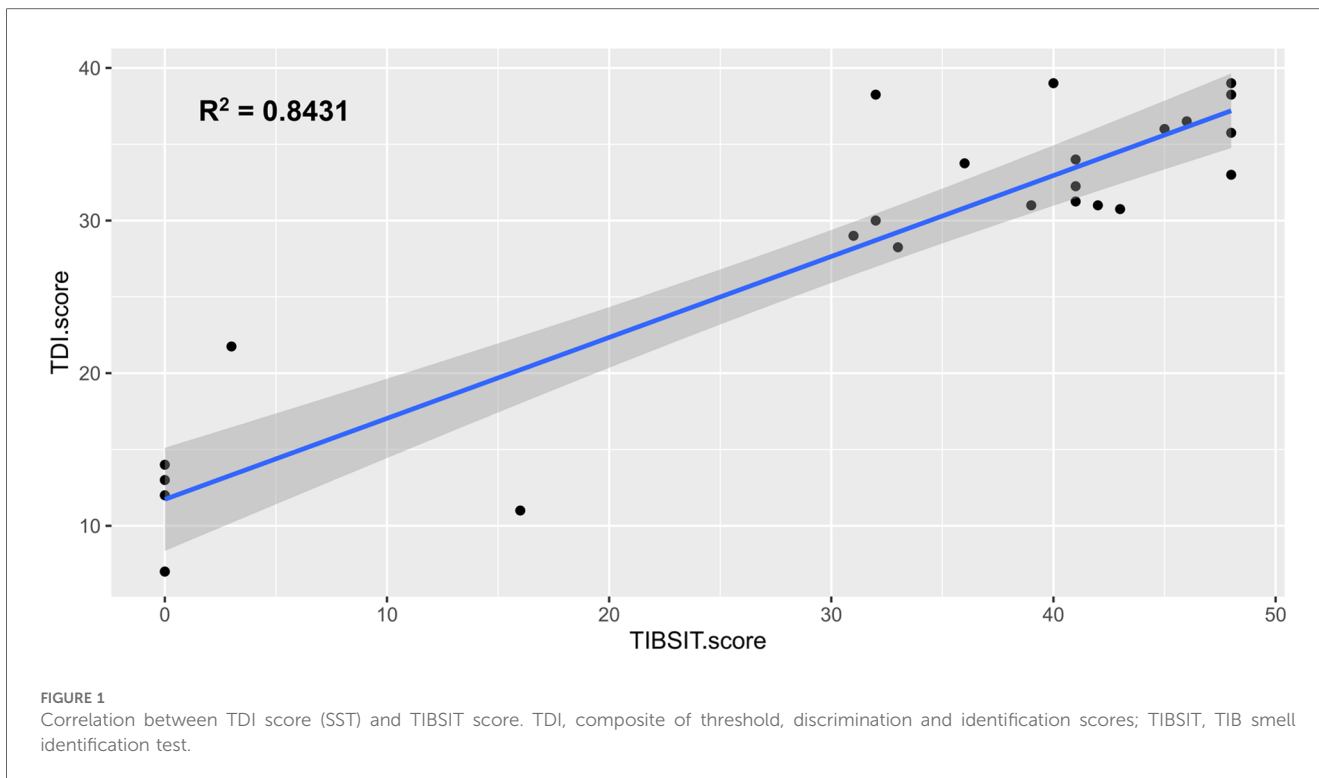
TIBSIT, TIB smell identification test; T, threshold; D, discrimination; I, identification; TDI, composite of T, D and I scores.

\* $p < 0.05$ .

\*\* $p < 0.01$ .

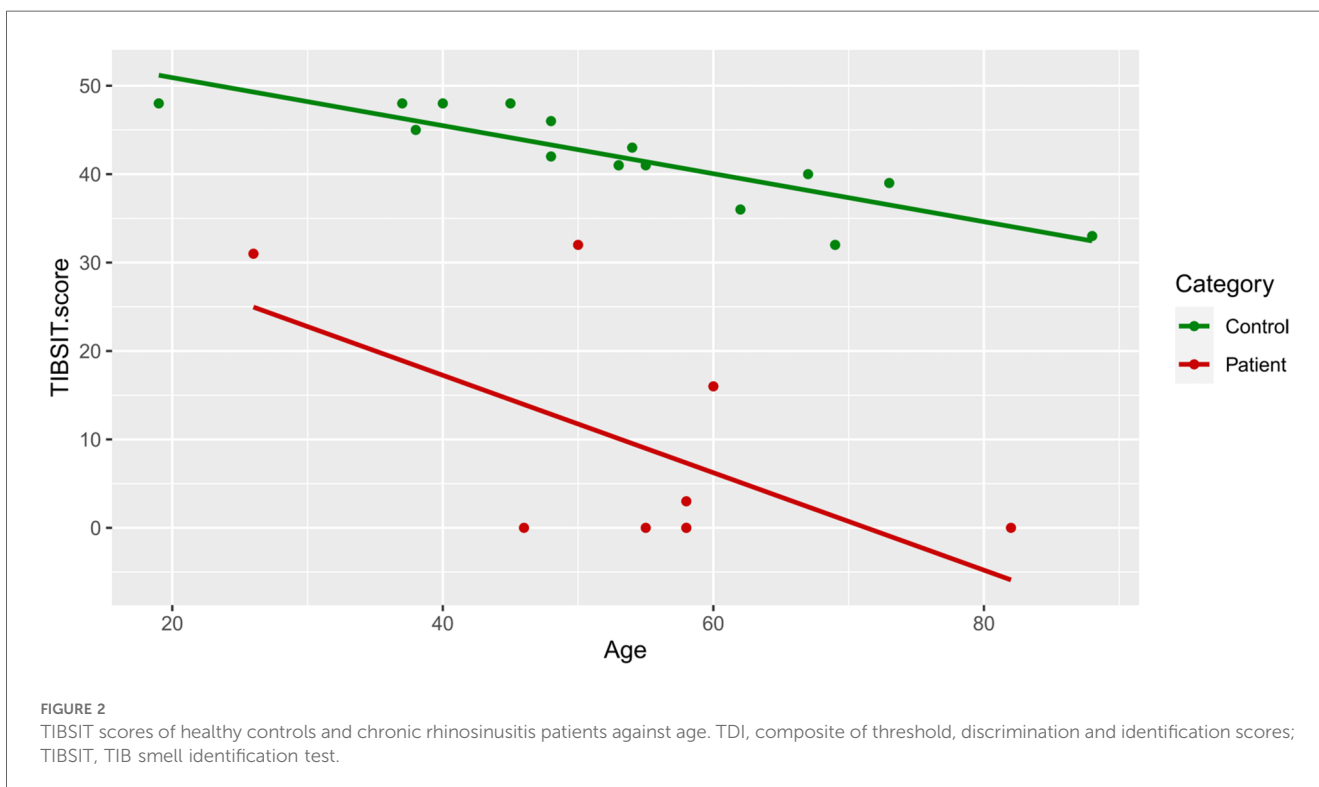
\*\*\* $p < 0.001$ .

<sup>a</sup> $p < 0.1$  but  $> 0.05$ .



In univariate analysis, older age was moderately associated with lower D, TDI and TIBSIT scores ( $r > 0.4$  and  $p < 0.05$ ), and correlations with T and I scores also reached near-significance for multivariate analysis (Table 3 and Figure 2). As shown in Supplementary Figure S1, females scored numerically higher in

TIBSIT and SST subsets, but statistical significance was only attained in the T score ( $p = 0.039$ ). In the linear regression model, when the presence of CRS, age and sex were considered, CRS remained a significant factor in all tests and subsets (all  $p < 0.001$ ; Supplementary Table S1).



## Discussion

This study applies and reports the association between two different olfactory tests, SST and TIBSIT, among Hong Kong Chinese. Using either SST or TIBSIT, our cohort of CRS patients demonstrated significant OD with the majority of our cohort found to be hyposmic or anosmic. All subtest and composite test scores were significantly inferior to healthy controls, demonstrating the clinical utility of SST and TIBSIT. This provides a basis for the clinical application of the two tests in the screening and diagnosis of OD in Hong Kong Chinese, as well as monitoring of disease progression and response to treatment. In SST, our cohort obtained a particularly low T test score (median score of 1), corroborating previous reports of T scores generally being lower than D and I scores among CRS patients (5). Further studies are required to differentiate genuine differences in impairment of detecting odour thresholds (vs. discrimination or identification), rather than inherent differences between SST subtests or reporting.

Utilisation and cross-cultural validation of olfactory tests have only been performed in selected populations, especially beyond Western cohorts (14, 32, 33). Prior to this study, results from SST and TIBSIT cannot yet be used interchangeably and results between studies using different tests cannot be readily compared. Interestingly, we found that SST and TIBSIT demonstrated strong correlations among Hong Kong Chinese despite initially being developed for vastly different populations. This may be due to Hong Kong being a culturally diverse territory, with locals previously exposed to and able to recognize a wide variety of odourants commonly found in both Eastern and Western cultures. We therefore propose either SST or TIBSIT to be used among Hong Kong Chinese, and it would be of interest to evaluate whether this phenomenon also exists in other culturally diverse populations. Such studies would be of particular interest in the Asia-Pacific region, especially given its rapidly expanding disease burden of allergic diseases (such as CRS), coupled with distinctive intra- and inter-regional variations as well as disparities in access to allergy care (34–41).

Consistent with previous studies, we also identified a decline in olfactory function with increasing age among both CRS patients and healthy individuals of our cohort (18, 25, 26). This is likely related to the natural degeneration of the olfactory system (such as the olfactory neuroepithelium and bulb) with increasing age, leading to progressive OD and inability to discriminate between odours (42, 43). Indeed, even among healthy controls, we did identify two tested subjects who were hyposmic, which we believe to be physiological. Conversely, although we also found that females tended to perform better in olfactory tests as reported by previous studies, this did not reach statistical significance (20, 28, 43, 44). Whether this non-significance was due to limitations in study design, cross-cultural or genuine inter-population differences will require future multi-ethnic studies. Overall, our results are largely reminiscent of prior studies.

There were several limitations to this study. For example, we had a relatively small sample size which may not be sufficient to

accurately reflect the normative values of our population. Future large-scale studies are needed to establish the population norms in Hong Kong. Further dedicated studies to delineate other properties of these and other smelling tests e.g., test-retest reliability are also warranted. Although all patients were screened by both allergists and ENT specialists, detailed clinical information or possible confounders such as educational background or history of pregnancy were not recorded (44). For female patients, information regarding their hormonal status, such as use of oral contraceptives or hormonal therapy, which is reported to positively influence olfactory test performance, were not available (45). There also exists possible referral bias as the joint allergy-ENT clinic primarily receives referrals for more severe CRS cases which warrant specialist care. This may lead to an overestimation of the prevalence and burden of OD among CRS patients in Hong Kong.

In summary, both SST and TIBSIT are useful instruments for OD assessments among Hong Kong Chinese. The two tests are strongly correlated and we advocate that either test can be used to evaluate OD among CRS patients. Increasing age, and possibly male sex were associated with poorer performance in smelling tests.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by the institutional review board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

HM: Data curation, Formal Analysis, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing. SH: Data curation, Investigation, Writing – review & editing. JW: Data curation, Investigation, Writing – review & editing. VC: Data curation, Investigation, Writing – review & editing. EL: Data curation, Investigation, Writing – review & editing. JY: Data curation, Investigation, Writing – review & editing. BW: Conceptualization, Data curation, Investigation, Supervision, Writing – review & editing. PL: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.



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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of *Frontiers*, at the time of submission. This had no impact on the peer review process and the final decision.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/falgy.2024.1292342/full#supplementary-material>

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