

Cross-cultural modification of the University of Pennsylvania smell identification test for the Saudi Arabian population

Validation and normative values

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ABSTRACT

الأهداف: تهدف هذه الدراسة إلى تطوير نسخة موثوقة من اختبار جامعة بانسولفانيا لتحديد الشم لتتناسب مع ثقافة سكان المملكة العربية السعودية ومصادقة نتائجها وتحديد النتائج السليمة لكل الجنسين.

المنهجية: أجريت دراسة الاستقصاء المقطعي هذه على مشاركين متطوعين تم استقطابهم في مدينة الرياض، المملكة العربية السعودية، من أبريل 2018 إلى مايو 2023. تم فيها اختيار الروائح المألوفة ثقافيًا وتم ترجمة الأسئلة والخيارات إلى اللغة العربية للدراسة. خلال الدراسة تم تعديل الاختبار 3 مرات في 4 إصدارات. بعد ذلك، تم جمع عينة عشوائية وتم إجراء النسخة النهائية من الاختبار.

النتائج: 288 فردًا شاركوا في تطوير اختبار جامعة بانسولفانيا لتحديد الشم عبر جميع الإصدارات، بما في ذلك 146 أنثى و142 ذكرًا. بلغ متوسط أعمار المشاركين 28.4±9.9 سنة. في النسخة النهائية، حصل 111 مشاركًا على متوسط درجة 34.5±2.5 للنتيجة الكلية، و35±2.3 للإناث، و34.1±2.6 للذكور. كان معامل موثوقية إعادة الاختبار 0.73، مما يدل على موثوقية مقبولة.

الخلاصة: زادت التغييرات الجديدة التي تم إجراؤها على استبانة اختبار جامعة بانسولفانيا لتحديد الشم النسخة السعودية من متوسط الدرجات وأظهرت موثوقية جيدة، مما يجعلها قابلة للتطبيق السريري لتشخيص اضطراب الشم ومتابعته.

Objectives: To develop a reliable version of the Saudi Arabian-University of Pennsylvania smell identification test (SA-UPSIT) and to establish normative values for both genders.

Methods: This cross-sectional study was carried out on voluntarily recruited normal participants in King Saud University Medical City, Riyadh, Saudi Arabia, from April 2018 to May 2023. Culture-familiar odors were chosen and the kit was translated into Arabic for the study. The test was modified 3 times in 4 versions. Following this, a random sample was collected to carry out a re-test after 6 weeks.

Results: A total of 288 subjects participated in the development of the SA-UPSIT across all versions,

including 146 females and 142 males. The average age of the participants was 28.4±9.9 years. In the final version, 111 participants scored an average of 34.5±2.5 for the total score, 35±2.3 for females, and 34.1±2.6 for males. The test-retest reliability coefficient was 0.73, indicating acceptable reliability.

Conclusion: The new changes carried out to the SA-UPSIT increased the average scores and demonstrated good reliability, making it clinically applicable for diagnosing and monitoring olfactory dysfunction.

Keywords: olfaction disorders, sinusitis, paranasal sinuses, smell, Saudi Arabia, Arabs, anosmia, olfactory training

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Although olfactory dysfunction (OD) affects patients' quality of life by decreasing the pleasure of pleasant smell and food taste, it also serves as a warning system for major threats, such as leaked gases, fire, and spoiled food.^{1,2} Olfactory dysfunction is also associated with various disorders, such as upper respiratory tract infections (URTI), sinonasal disorders, multiple sclerosis, Levy-body dementia, myasthenia gravis, and schizophrenia.³ Moreover, OD appears in specific conditions, such as Alzheimer's and Parkinson's diseases, earlier than in other classical manifestations.⁴ Recently, the high relationship of OD with the emergence of coronavirus disease 2019 (COVID-19) has increased the prevalence and awareness of OD.⁵

Despite the presence of OD in many pathological diseases, it can also be evident in physiological changes, such as pregnancy and aging.^{6,7} Instead of having a reliable olfaction assessment tool, most healthcare providers rely on subjective evaluation by asking patients direct questions to diagnose OD. The University of Pennsylvania smell identification test (UPSIT) is one of the most widely accepted tools for diagnosing and monitoring OD.⁸ An Arabic version of the UPSIT was tested on the Saudi Arabian (SA) population, but the average score was 28.4 in healthy subjects, which is considered low when compared to other versions.⁹ Therefore, in this study, we aimed to develop a reliable version of SA-UPSIT and to establish normative values for both genders.

Methods. This cross-sectional study was carried out with voluntarily recruited participants. It was carried out in King Saud University Medical City, Riyadh, Saudi Arabia, from April 2018 to May 2023. At the time of enrollment and after signing the informed consent form, each patient was screened by filling out a validated Arabic version of the sino-nasal outcome test (ASNOT-22).¹⁰ After developing the SA-UPSIT, a pilot sample of 10 participants underwent the test. The first version of the SA-UPSIT was completed by 30 participants, then it was modified to version 2 and completed by 110. After that, further modifications were carried out, and version 3 was issued and tested on 27 participants. Finally, the fourth and final versions were tested on 111 participants, and a re-test was carried out on 21 participants.

Information on the participants' medical histories was obtained based on self-reports. The study included volunteers between 18-60 years of age from all areas of Saudi Arabia. We excluded patients below 18 or above 60 years of age, who were illiterate, participants who

reported any degree of OD, who scored more than 18 in total or more than 3 in any question of the nasal domain of ASNOT-22, smokers, participants who had a history of any sinonasal disorder, history of nasal or skull base surgery, reported a loss of smell or taste, were diagnosed with COVID-19 within 6 months, URTI within one month, or had a history of severe head trauma or any neurological or psychological disorders.

The UPSIT consists of 40 odors in 4 envelopes, with one odor per page, 4 multiple choices, and one correct answer (Figure 1). A steering committee consisting of 5 investigators from different regions of SA requested and reviewed all the commercially available odors to possibly be incorporated into the UPSIT by Sensonics Inc. (Haddon Heights, NJ). The committee chose 40 odors based on cultural familiarity. All questions were adapted with their original options. Following cross-cultural adaptation guidelines by Beaton et al,¹¹ the questions were then translated into Arabic using forward and backward methods for each question to ensure proper translation and understandability, with the help of native speakers of both languages. Next, a pilot study was carried out with 10 participants before generating the first version of the SA-UPSIT. Subsequently, multiple modifications were carried out throughout the various versions, as summarized in Table 1. Our aim for each version was to increase the average score by improving the identification rate for each odor.

Administration instructions provided by the manufacturer UPSIT™ (Sensonics Inc., Haddon Heights, NJ) were followed. Each participant received a verbal explanation from one of the examiners, then was asked to read the provided instructions on the envelope and started to complete the test in order. Micro-encapsulated odorants were embedded with a strip that was scratched and then sniffed. The test was supervised by an examiner to ensure that the participants understood the instructions and carried out the test correctly.

The study was approved by the institutional review board of King Saud University, College of Medicine, Riyadh, Saudi Arabia, with number 10/0350.

Statistical analysis. Descriptive statistics included mean, standard deviation (SD), and numbers and percentage. Test-retest reliability coefficients were tested using the Pearson correlation coefficient. The data were analyzed using the Statistical Package for Social Sciences, version 23.0 (IBM Corp., Armonk, NY, USA). Each participant signed an informed consent form prior to enrollment.

Results. A total of 288 subjects, 146 females and 142 males, participated in the development of the SA-UPSIT across all the versions. The average age of the participants was 28.4±9.9 years. The average total score of the test fluctuated between 32.4-34.7 across the versions. In the final version, the average scores were 34.5±2.5 for the total score, 35±2.3 for the female participants, and 34.1±2.6 for the male participants (Table 2). The test-retest reliability coefficient for version 4 was carried out on 21 participants and resulted in 0.73, indicating acceptable reliability. The relationship between the average score and age is shown in Figure 2. In the final version, coffee had the lowest identification rate, with

only 21.4% of participants detecting the correct answer. Additionally, orange (55.9%) and cardamom (61.3%) scored lower than 70% (Table 3). However, the overall average identification rate was higher than in previous versions tested on the SA population (Figure 3).

Discussion. The University of Pennsylvania smell identification test is the most widely studied and validated tool for olfactory assessment, with numerous publications and more than half a million participants having used it. It is user-friendly and can be self-administered, taking only 10-15 minutes per test.¹² However, previous exposure to odors in the environment



Figure 1 - The Saudi Arabian University of Pennsylvania smell identification test consists of 4 envelopes and a total of 40 odors.

Table 1 - Modifications carried out throughout versions of the Saudi Arabian University of Pennsylvania smell identification test.

SA-UPSIT	Modifications
Version 2	In question 16, the option (peach) was changed to fish - Odor 7 (coffee) was changed to walnut
Version 3	- In question 3, the option (strawberry) was changed to coffee - In number 39, the option (bubblegum) was changed to musk
Version 4	Odor 7 was changed back from walnut to coffee

SA-UPSIT: Saudi Arabian University of Pennsylvania smell identification test

Table 2 - Comparison between the overall results and between the genders of the Saudi Arabian-University of Pennsylvania smell identification test throughout versions 1-4.

Variables	Albaharna et al ⁹	SA-UPSIT V1	SA-UPSIT V2	SA-UPSIT V3	SA-UPSIT V4
Sample size	80	30	110	27	111
Total score	28.42±4.4	34.7±2.5	32.4±3.4	34.8±2.7	34.5±2.5
Female score	29.5±4.2 (n=38)	35.19±2.5 (n=16)	32.9±3.7 (n=55)	35.2±2.5 (n=14)	35±2.3 (n=58)
Male score	27.3±4.3 (n=42)	34.4±2.5 (n=14)	31.9±3.4 (n=55)	34.4±3.9 (n=13)	34.1±2.6 (n=53)

Values are presented as mean ± standard deviation (SD). SA-UPSIT: Saudi Arabian University of Pennsylvania smell identification test

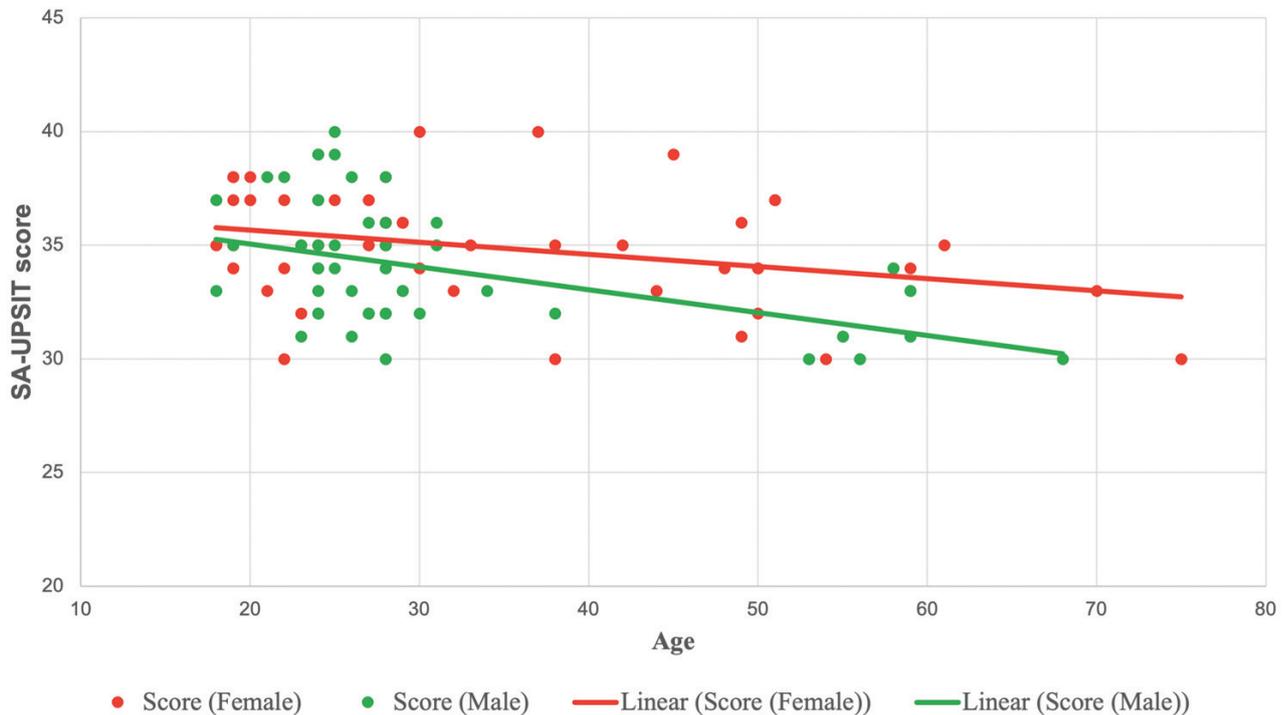


Figure 2 - Scattered plot showing the average Saudi Arabian University of Pennsylvania smell identification test (SA-UPSIT) score in female and male participants in different age groups. The linear pattern shows a decrease in the score with age advancement.

is a major factor in proper identification accuracy. Therefore, modifying each olfactory assessment tool to be culture specific is essential.

In the Middle East, authors from Turkey developed the first modification of the UPSIT, but they have a relatively low normative mean of 21.4 ± 4.7 .¹³ Then, after 3 years, modifications were carried out, and a newer version was developed, and the mean for normal people increased to 34.4 ± 2.8 for males and 36.7 ± 2.9 for females.¹⁴ In the Persian version, the odors were decreased to 24 instead of the standardized 40 odorants per kit.^{15,16} An Arabic version of the UPSIT was developed by Sensonics, which involved the substitution of 14 odors from the original UPSIT and then translating the 40 questions to Arabic language. This Arabic version was tested on the Egyptian population, resulting in a mean of 31.89 ± 1.2 for females and 31.32 ± 1.9 for males.¹⁷ However, when it was tested on the SA population, it showed a relatively low mean for normal values compared to other versions.⁹ Therefore, in our study, multiple versions and modifications were attempted to improve the identification rate for some odors, which resulted in an increase in the mean score to 34.5 for the total score average, 35 for females, and 34.1 for males. This score is considered better than other regional versions. Also, the average overall mean 34.5 is

close to that of other worldwide versions, such as Brazil (35), China (33.18), Japan (34.9), and Central Russia (33).¹⁸⁻²¹ Based on this, with the new modifications, the SA-UPSIT became a reliable tool for clinical and academic use in the SA population.

While Doty et al²² used an identification rate of 70% for each odor as a cut-off in their process of developing the original UPSIT, our modified version showed that coffee, orange, and cardamom scored less than that number. However, our results were surpassed only by Turkey, with only 2 odors lower than this cut-off.¹⁴ The Russian, Japanese, Taiwanese, Spanish, and Thai versions of the UPSIT had more than 3 odors lower than this cut-off.²⁰⁻²⁴

Although all the participants included in the validation process were in their third and fourth decades of age, some of the recruited participants were older. The relationship of age with score was found to be inverse, which is consistent with the literature (Figure 2).²⁵ Additionally, our study found a similar result for olfactory superiority in females compared to males, as recently confirmed in a meta-analysis.²⁶

Coffee is a very popular product, being the second-most traded item worldwide.²⁷ In our results, coffee odor had a low identification rate across 3 different versions among 261 patients (Table 3). This finding was

Table 3 - Percentage of correct answers for Saudi Arabian-University of Pennsylvania smell identification test between versions 1-4.

Odor number	Odors	SA-UPSIT V1 (n=30)	SA-UPSIT V2 (n=110)	SA-UPSIT V3 (n=27)	SA-UPSIT V4 (n=111)
1	Cinnamon	100	94.1	96.0	99.1
2	Rubber tire	90.0	94.1	100	100
3	Pineapple	80.0	34.9 [‡]	92.0	93.7
4	Banana	90.0	80.2	96.0	90.1
5	Leather	90.0	77.9	100	90.1
6	Bubblegum	76.6	80.2	60.0	85.6
7	Coffee-walnut	60.0 (coffee)	45.3 (coffee)	11.5 (walnut)	21.4 (coffee)
8	Grass	83.3	74.4	80.0	93.7
9	Onion	100	94.2	100	97.3
10	Smoke	66.7	60.5	80.0	77.5
11	Natural gas	100	97.7	100	99.1
12	Baby powder	96.7	95.3	96.0	93.7
13	Soap	96.7	97.6	100	98.2
14	Garlic	93.3	94.2	100	94.6
15	Rose	100	72.1	95.8	91.0
16	Fruit punch	56.7 [†]	60.5	79.2	83.8
17	Peppermint	93.3	95.4	96.3	99.1
18	Peanut	93.3	94.2	87.5	94.6
19	Grape	93.3	82.6	100	93.7
20	Clove	96.7	88.3	88.9	99.1
21	Watermelon	96.7	95.3	100	97.2
22	Cheddar cheese	93.3	81.0	87.5	90.9
23	Jasmine	100	96.5	100	93.7
24	Dill pickle	96.7	83.7	91.7	95.5
25	Peach	90.0	86.0	96.3	91.0
26	Coconut	93.3	84.4	91.7	71.2
27	Apple	76.7	56.9	70.8	86.5
28	Chocolate	90.0	87.2	87.5	95.5
29	Motor oil	63.3	54.7	75.0	75.7
30	Gasoline	93.3	69.7	91.7	76.6
31	Strawberry	73.3	77.9	87.5	85.6
32	Orange	100	76.7	70.8	55.9
33	Cumin	96.7	63.9	70.8	73.9
34	Menthol	100	90.7	100	89.9
35	Lilac	93.3	80.2	100	97.3
36	Cherry	96.7	91.8	87.5	93.7
37	Popcorn	90.0	73.2	79.2	69.7
38	Gingerbread	80.0	68.6	83.3	75.7
39	Cardamom	36.7 [‡]	32.6 [†]	62.5	61.3
40	Fish	53.3	54.6	70.8	83.5

Values are presented as percentages (%). [†]One of the options of the question was changed. [‡]Manufacturer was requested to increase the intensity of the odor.

SA-UPSIT: Saudi Arabian University of Pennsylvania smell identification test

unexpected, as coffee is popular in SA culture. After the test, through qualitative assessment, many participants reported a high level of difficulty in identifying odors. They excluded the option of coffee, as it was already familiar to them. Possible explanations for this low

rate are the amount of oil concentration used in the manufacturing and storage temperatures, both of which have been shown to negatively affect encapsulation efficiency and oil retention.²⁸ To overcome this low rate of identification, a substitute odor was searched

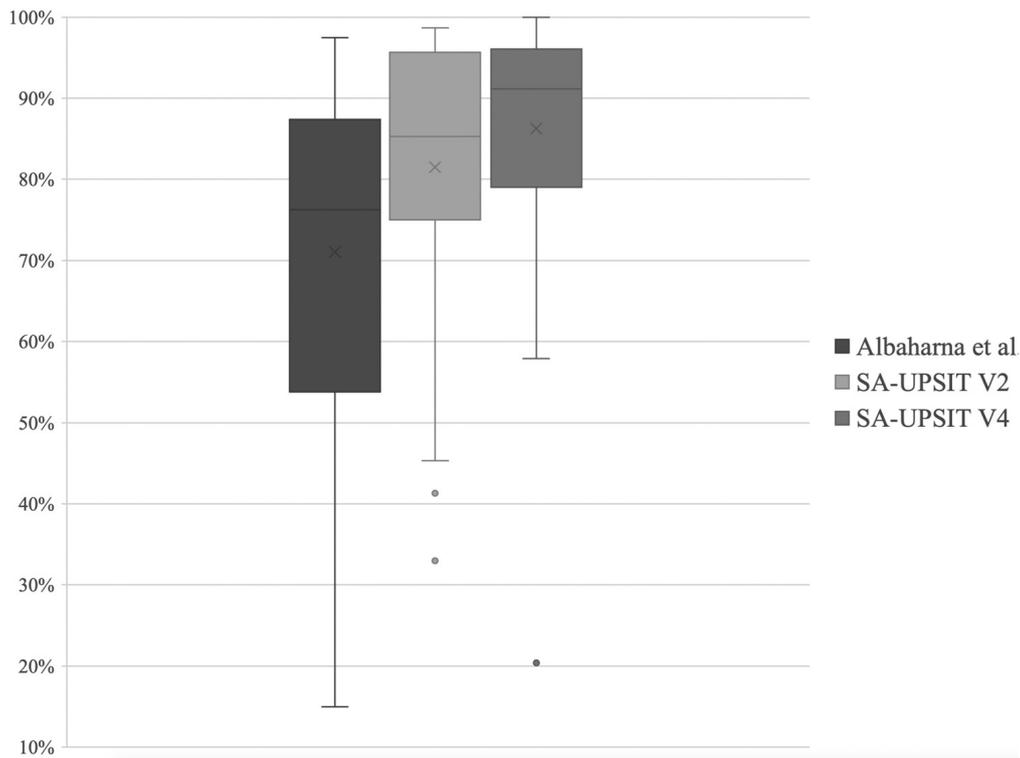


Figure 3 - Box plot comparing the identification rate for each odor between the second and fourth versions of Saudi Arabian University of Pennsylvania smell identification test (SA-UPSIT) with a comparison to the previously proposed version by Albaharna et al.⁹

for among the available options in Sensonics, but no odor was found to be more culturally familiar than coffee. Additionally, we observed a significant drop in the identification rates of orange and coconut in the later version. However, internal consistency among the participants reassured the validity of the test. Based on these findings, we suggest that future UPSIT kits improve the concentration of odors and provide proper storage and shipment instructions.

Study limitations. Despite the findings presented in this study, there are several limitations that need to be addressed in future research. First, the study was limited to a middle-aged group, and further studies should include clustering of age for individuals younger than 18 years old and older than 60 years old to establish normative data for each age group. Second, while we tried to recruit participants from all different areas of SA, future studies should cluster participants based on socioeconomic status, smoking status, and urban/rural living areas. Finally, following the recommendations of cross-cultural adaptation guidelines, the next step is to study the responsiveness and construct validity of the SA-UPSIT.¹¹ These aspects should be studied separately

for different conditions associated with OD, including various areas of neurology, rhinology, psychiatry, and infectious diseases.

In conclusion, the new modifications carried out to the UPSIT-SA have increased the average score to a range of universally similar scores. Additionally, it has provided normative values for females and males, with acceptable internal consistency in the SA population. Therefore, in its current form, it can be used as a helpful tool for the diagnosis and follow-up of patients suffering from OD.

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