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Korean J Otorhinolaryngol-Head Neck Surg 2015;58(6):402-6 / pISSN 2092-5859 / eISSN 2092-6529
http://dx.doi.org/10.3342/kjorl-hns.2015.58.6.402

Assessing Olfactory Function in Healthy Korean Children Using the Cross-Cultural Smell Identification Test and Butanol Threshold Test

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한국인 소아에서 Cross-Cultural Smell Identification Test와 Butanol Threshold Test를 이용한 후각기능 평가

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Received January 19, 2015
Revised April 6, 2015
Accepted April 8, 2015
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Background and Objectives There are no reported studies of olfactory function of Korean children, and the existing tests of olfactory function for Korean adults may not be suitable for very young children. This study assessed the applicability of the Butanol Threshold Test (BTT) and Cross-Cultural Smell Identification Test (CC-SIT) to children.

Subjects and Method A total of 79 children were included in the study: they were between 6–12 years of age, and had visited University Hospital Health Care Center between January 2012 and December 2013. All children were administered the BTT and CC-SIT.

Results Using BTT, 69.62% of the sample was classified as moderate hyposmia. On the other hand, when CC-SIT was used, 45.57% of the sample was classified as moderate and 43.04% as mild hyposmia. CC-SIT and BTT scores were not correlated. Although gender and age were not taken into account in the test results, the CC-SIT could measure age-specific olfactory development.

Conclusion Our study provides fundamental data on the clinical use of the CC-SIT and BTT in healthy Korean children. Korean J Otorhinolaryngol-Head Neck Surg 2015;58(6):402-6

Key Words Children · Olfactory identification test · Olfactory threshold test.

Introduction

Olfaction is used to detect environmental risk, is involved in the digestion of foods for survival purposes, and performs various additional roles crucial to the propagation of the species.[1,2] The loss of sensory function impacts upon normal development and learning; although evaluation methods for hearing and vision currently exist for young children, the optimal means of indexing olfactory function in this population is subject to conjecture.[2,3] Olfaction development commences before birth; neonates can recognize the smell of their mother's body at birth, and react accordingly. Furthermore, olfaction continues to develop, to external stimuli, up to 40 years of age, following which it declines gradually.[4] Olfactory loss is caused by various factors such as inherited traits, allergies, upper airway infection, rhinosinusitis, head injury, and endocrinopathy; exposure to such factors in young children affects their overall development.[5] Several studies have suggested clinically feasible methods of evaluating olfactory function in young children, but no such reports have concerned Korean children.[2,3,5-9] Currently, the Butanol Threshold Test (BTT) and Cross-Cultural Smell

Identification Test (CC-SIT) are used to assess olfactory function in Korean adults.[10,11] The CC-SIT is a clinically feasible instrument with a high rate of concordance with the olfactory threshold test when applied to Korean adults.[12,13] We herein assess the suitability of both the BTT and CC-SIT for evaluating olfactory function in young Korean children.

Subjects and Method

Olfactory function tests were conducted in a total of 79 young children between 6−12 years of age, who attended the hospital for health examinations between 2012 and 2013. No evidence of disease within the previous two weeks (e.g., upper airway infection, rhinosinusitis, or allergic rhinitis) was reported by any of the participants. There was also no previous history of severe head injury, hypothyroidism, neurological disorder, psychological disorder or olfactory dysfunction at birth, nor any olfactory function abnormality according to a preliminary survey. The study was approved by the Institutional Review Board of our hospital; subjects and their parents provided written informed consent prior to the olfactory function tests.

All participants were tested using the CC-SIT and BTT, with the time between test items set to a minimum of 20 seconds, and the time between tests to a minimum of 5 minutes. Tests were conducted in a quiet, well-ventilated location free from extraneous odors. For the BTT, N-butanol was diluted in 12 stages (0−11) using distilled water. Each threshold level is3-fold serially diluted from 100% N-butanol (concentration level 0) to concentration level 12. The test began with the most-dilute solution: butanol and control bottles were presented to the nasal cavity of participants, who selected the bottle they believed contained butanol. This procedure was repeated five times, with the odor threshold defined as the concentration level at which the butanol bottle was correctly identified by the examinee during five consecutive trials. The Smell Identification Test™ Kit (Sensonics Co., Haddon Heights, NJ, USA) consists of 12 items and is used in conjunction with the CC-SIT. The tester scratches panels with a pencil and instructs the examinee to smell them and select one from four possible answers, recorded in a separate answer sheet; the examinee does not know whether their answer was correct.[8] If the examinee cannot read or understand the answer sheet, the assisting inspector can explain and present figures, which are consisted of the examples. Olfactory function is categorized as follows: anosmia, 0−3; severe hyposmia, 4−5; moderate hyposmia, 6−8; mild hyposmia, 9−10; and normosmia, 11−12.[14,15]

Statistics

The SPSS for Windows software package (ver. 16.0; SPSS Inc., Chicago, IL, USA) was used for statistical analyses. The chi-squared test was used to assess the impact of age and gender on each test result, with Pearson's correlation used to measure the relationship between CC-SIT and BTT scores. A value of $p<0.05$ was taken to indicate statistical significance.

Results

Gender and age distribution

Test results were analyzed according to gender and age, with the latter divided into two groups, between 6−9 (n=50) and 10−12 (n=29) years of age. Of the 79 total participants, 35 were male and 44 were female; 50 were between 6−9 years of age (27 males and 23 females) and 29 were between 10−12 years of age (8 males and 21 females) (Table 1).

BTT and CC-SIT findings

Using the BTT, the majority of the participants were clas-

Table 1. General characteristics of subjects

	6−9 years	10−12 years	Total
Boys	27	8	35
Girls	23	21	44
Total	50	29	79

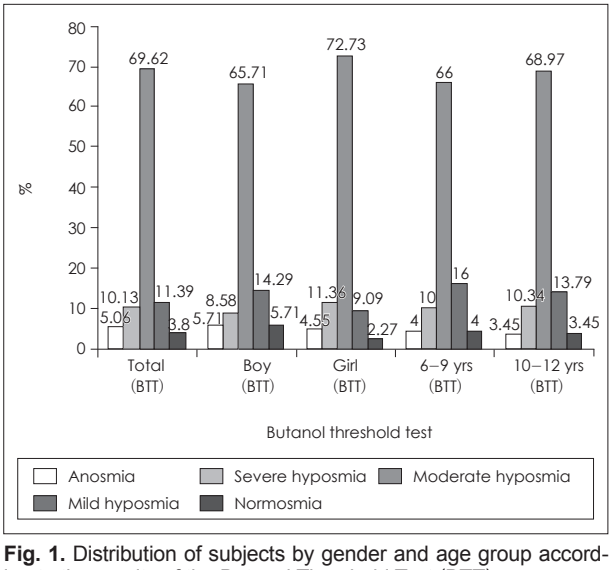

Fig. 1. Distribution of subjects by gender and age group according to the results of the Butanol Threshold Test (BTT).

Table 2. Distribution of subjects according to the results from the Cross-Cultural Smell Identification Test (CC-SIT) and Butanol Threshold Test (BTT)

	BTT (%)	CC-SIT (%)
Anosmia	4 (5.06)	0 (0)
Severe hyposmia	8 (10.13)	5 (6.33)
Moderate hyposmia	55 (69.62)	36 (45.57)
Mild hyposmia	9 (11.39)	34 (43.04)
Normosmia	3 (3.80)	4 (5.06)
Total	79 (100)	79 (100)

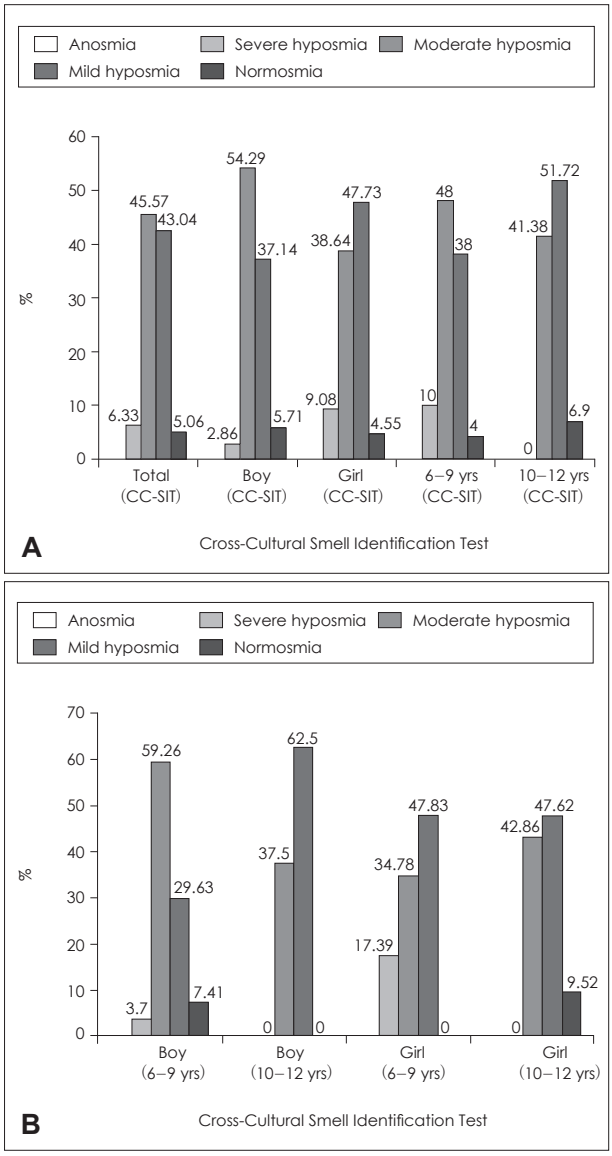

Fig. 2. The results of the Cross-Cultural Smell Identification Test (CC-SIT). Distribution of subjects by gender and age group (A). Distribution of subjects by age goup in each gender (B).

sified as moderate hyposmia (69.62%; n=55) (Table 2). A total of 65.71% of the male (n=23), and 72.73% (n=32) of the female, participants were classified as moderate hyposmia; 66% (n=33) and 68.97% (n=20) of the 6−9 years and 10−12 years groups were classified as moderate hyposmia, respectively (Fig. 1). However, there was no significant group difference in gender or age (p>0.05). Using the CC-SIT, 45.57% (n=36) and 43.04% (n=34) of the participants were classified as moderate and mild hyposmia, respectively (Table 2), with 54.29% (n=19) of the males classified as moderate, and 37.14% (n=13) as mild, hyposmia. For females, 38.64% (n=17) and 47.73% (n=21) were moderate and mild hyposmia, respectively. Of the 6−9 year-olds, 48% (n=24) were classified as moderate hyposmia, and 38% (n=19) as mild hyposmia. However, in the 10−12 year-olds, 41.38% (n=12) and 51.72% (n=15) were classified as moderate and mild hyposmia (Fig. 2A). CC-SIT results were sub-divided into four groups according to gender and age. In male participants between 6−9 years of age, severe hyposmia was observed in 3.7% (n=1) of the sample, with moderate and mild hyposmia present in 59.26% (n=16) and 29.63% (n=8) of participants, respectively. Normosmia was observed in 7.41% (n=2) of cases. In male children between 10−12 years of age, moderate hyposmia was observed in 37.5% (n=3) of cases, vs. 62.5% (n=5) for mild hyposmia. In female children between 6−9 years of age, severe hyposmia was observed in 17.39% (n=4) of cases, vs. 34.78% (n=8) for moderate, and 47.83% (n=11) for mild, hyposmia. In female children between 10−12 years of age, moderate hyposmia was observed in 42.86% (n=9) of cases, vs. 47.62% (n=10) and 9.52% (n=2) for mild hyposmia and normosmia, respectively (Fig. 2B).

Concordance between BTT and CC-SIT

Across the entire population, BTT and CC-SIT results were not significantly correlated (r=0.0582, p=0.6107, p>0.05).

Discussion

Sensory organ functioning plays a crucial role in our daily lives and influences the development of younger children.[1] Hearing and vision have been extensively studied, with both objective and subjective functional evaluations reported.[3] However, few studies have addressed olfactory function, but with increasing interest in the impact of the olfactory sense on daily life, neurological disorders, psychoneurotic disorders in younger children (such as attention deficit hyperactivity disorder), and associations with general development, more research is now being conducted.[2,3,5-8] Several reports have evaluated olfaction in younger children, but none of

these involved Korean children.

This study applied two tests, the BTT and CC-SIT, which had previously been used in our hospital to assess adult olfactory function, to Korean children. Participants had no prior history of olfactory function abnormalities. Using the BTT, 69.62% of the sample were classified as moderate hyposmia; moderate and mild hyposmia were at 45.57% and 43.04% respectively using the CC-SIT. There were few normosmia cases. The previous studies have been reported that younger children are characterized by reduced olfactory function compared with adults, with lower University of Pennsylvania Smell Identification Test scores.[7] This could be due to insufficient olfactory development, with olfaction improving with experience.[6,7]

Because previous studies indicate that both gender and age influence olfactory function, we also analyzed the impact of these variables in both tests.[8,9] Two age groups were devised, between 6−9 and 10−12 years of age, based on previous research pertaining to olfactory development in young children.[2,6] In the BTT, the majority of the participants were classified as moderate hyposmia, regardless of group classification, but for the CC-SIT female children, and 10−12 year-olds, exhibited superior olfaction test results compared with males and 6−9 year-olds. However, this difference was not statistically significant (Fig. 2A). Male and female participants were also sub-categorized into four groups, according to age, prior to a re-analysis which demonstrated that 10−12 year-olds exhibited superior olfactory function compared with the 6−9 year-olds. This suggests that, with increasing age, olfaction improves. For males, greater improvements are evident commensurate with increasing age compared with females. In the 6−9 year-olds, female olfactory function was superior, but functioning was similar between the 10−12 year-old males and females (Fig. 2B). Previous studies have demonstrated no gender differences in olfactory threshold and discrimination tests in children between 6−12 years of age, but differences have been reported for the identification test.[8,9] In adults, gender differences have not been reported, but young female children have superior olfaction compared with males.[8] Olfactory functioning changes in accordance with age are reflected in our sample's CC-SIT results (for the identification test), per the existing literature indicating differences in threshold and identification test results in young children commensurate with increasing age, and with greater olfactory sensitivity in female vs. male children. The limitations of this study were was the relatively small sample size (79 participants), which may have prevented the results from reaching significance. Differences in olfactory functional development in accordance with gender and increasing age could be observed in future studies employing larger populations.

In conclusion, this study provides fundamental data concerning olfactory testing in young children, using the BTT and CC-SIT. Although the results of neither test achieved statistical significance, reflecting the fact that the olfactory sense of young children is less sensitive compared with adults (and the small sample size employed), the results of the CC-SIT indicate that it could be a suitable test of olfactory development because it is a more sensitive instrument compared with the BTT. Future research using the BTT and CC-SIT tests should employ larger samples to establish separate olfactory functioning criteria for children and adults; additional research is also required on olfactory change according to age using the CC-SIT.

Acknowledgments

This study was supported by the Dong-A University Research Fund.

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