

Changes in Taste Function Related to Obesity and Chronic Otitis Media With Effusion

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Objective: To evaluate changes in taste threshold in patients with chronic otitis media with effusion (COME) and their relationship with body mass index. A relationship has been suggested between pediatric obesity and COME, and we hypothesized that changes in taste function may occur in children with COME and that such changes may be associated with changes in body weight.

Design: A prospective, nonrandomized, case-control study.

Setting: A university tertiary care center.

Subjects: The experimental group comprised 42 children with COME who underwent tympanostomy tube insertion, and the control group, 42 children without otitis media with effusion. Patients were enrolled between September 2007 and August 2009.

Main Outcome Measure: Taste threshold was measured by electrogustometry, and 4 standard taste solutions (sucrose, sodium chloride, citric acid, and quinine hydrochloride) were used in chemical taste tests.

Results: Body mass index was significantly higher in the COME than in the control group ($P=.02$). Electrogustometry showed that the anterior part of the tongue had a significantly higher taste threshold in the COME than in the control group (anterior right, $P=.03$; anterior left, $P=.04$), and chemical taste test results showed that sweet and salty tastes were significantly lower in the COME group (sweet, $P=.02$; salty, $P=.04$).

Conclusion: These results showed that COME can cause changes in taste and that these changes may be related to pediatric obesity.

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CHILDHOOD OBESITY AND chronic childhood conditions have increased over the last several decades, particularly for asthma and behavior and learning problems. To our knowledge, the relationship between chronic otitis media and obesity has not been examined. Otitis media with effusion (OME) is a disease with a high incidence in childhood and is a common cause of hearing disturbances in children. Although most children have a good prognosis, 10% of affected children develop recurrent or persistent OME.^{1,2}

Many factors are involved in the development of OME, including host factors such as bacterial infection, eustachian tube dysfunction, allergic and immunologic status, sex, race, and other genetic variations; environmental factors such as communal living, a nonhygienic lifestyle, and indirect exposure to smoke; and anatomical and physiological factors accompanying cleft palate such as Down syndrome and other conditions.³ In addition, obesity has been reported to be associated with the development of OME.⁴ For example, we found that body mass index (BMI) and total serum cholesterol concentration were

significantly higher in children with chronic and recurrent OME than in control children, suggesting an association between pediatric obesity and OME.⁴

Patients with chronic otitis media have been reported to have a higher taste threshold on the affected side of the tongue than on the normal side, and the taste threshold on the affected side was reduced after surgery for otitis media.⁵ These findings suggested that in children with chronic otitis media with effusion (COME), the function of the chorda tympani nerve may have deteriorated in the inflammatory environment of the middle ear, leading to a deterioration in taste. These changes in taste may alter food consumption, thereby causing changes in BMI. We therefore assessed changes in taste and BMI in children undergoing ventilation tube insertion for COME.

METHODS

We enrolled 42 children (24 boys and 18 girls) aged 3 to 7 years (mean [SD], 5.48 [1.55] years) who underwent ventilation tube insertion for COME at the pediatric ear, nose, and throat clinic of Kyung Hee University, Seoul, South Korea, between September 2007 and August

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Table. Concentrations of Taste Test Solutions Used in This Study^a

Sucrose	Sodium Chloride	Citric Acid	Quinine Hydrochloride
0.05	0.016	0.05	0.0009
0.1	0.025	0.09	0.0024
0.2	0.1	0.165	0.004
0.4	0.3	0.3	0.006

^aData are given as grams per milliliter.

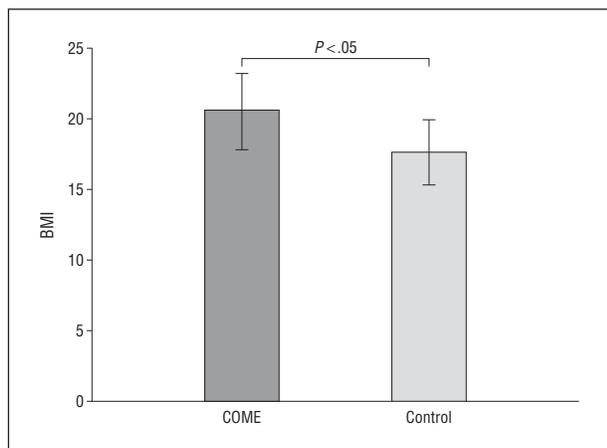


Figure 1. Mean (SD) body mass index (BMI) (calculated as weight in kilograms divided by height in meters squared) in the chronic otitis media with effusion (COME) and control groups. The difference between these 2 groups was statistically significant ($P = .02$).

2009. The control group consisted of 42 pediatric patients (24 boys and 18 girls) aged 4 to 7 years (mean [SD], 6.38 [1.48] years) with no history of otitis media who underwent tonsillectomy or adenoidectomy for snoring or frenotomy or were admitted for epistaxis during the same period. Children in the control group underwent otoscopic examinations, impedance audiometry, and pure tone audiometry to confirm the absence of pathologic conditions in the middle ear and eustachian tube. Children with head or neck deformities or systemic diseases or those suspected of having congenital or acquired immune deficiencies were excluded.

We carefully explained to both children and their parents that the test was a single noninvasive assessment, and we described the aim of our study. We included only subjects who gave signed informed consent and who were also approved by the Kyung Hee University institutional review board.

Otitis media with effusion was diagnosed by the presence of amber-colored tympanic membranes on otoscopic examination of patients with B- or C-type tympanograms. Surgery was performed on patients who did not show improvement after 3 months; on patients who showed progressive retraction of the eardrum; and on patients with progressive hearing loss, as shown by increases in pure tone threshold.

Body mass index for each child was calculated as the directly measured weight in kilograms divided by height in meters squared. Electrogustometry (EGM) and chemical taste tests were performed 1 day prior to surgery. For EGM, all drink and food except for water were prohibited in the hour prior to the test. An electrogustometer (EG-IIB; Nagashima Medical Instrument Co, Tokyo, Japan) was used to measure the EGM thresholds of 4 areas of the tongue—the base, the tip, and both sides. A probe was placed on the area to be tested, and the mini-

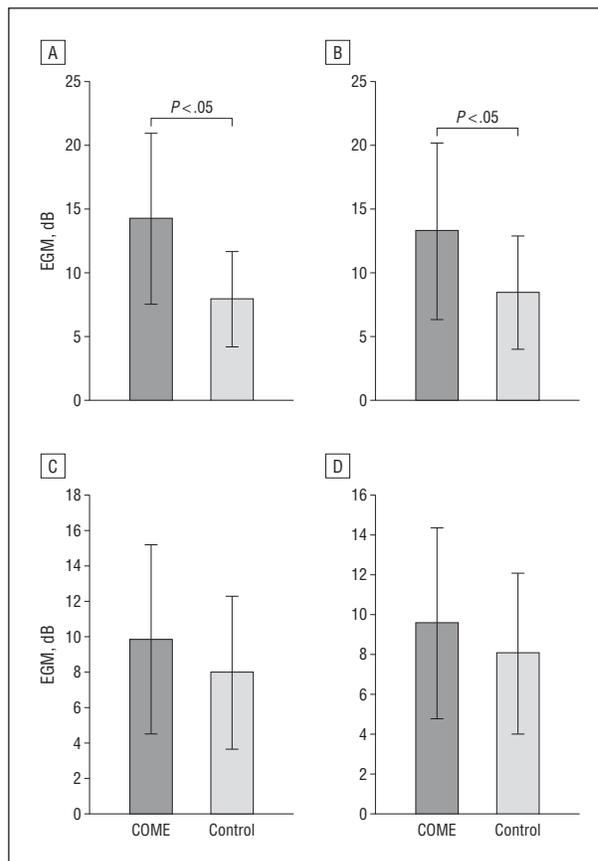


Figure 2. Mean (SD) electrogustometry (EGM) thresholds of each part of the tongue in the chronic otitis media with effusion (COME) and control groups. A, Right anterior; B, left anterior; C, right posterior; and D, left posterior. Significant differences were observed only in the anterior part of the tongue (right anterior, $P = .03$; left anterior, $P = .04$).

um voltage at which the patient could feel a metallic or sour taste was recorded as the taste threshold. In each test, the threshold was increased from 3 μ A (-8 dB) to 400 μ A (34 dB) in 22 steps. In the chemical taste tests, 4 dilutions of each type of taste—sweet (sucrose), salty (sodium chloride), sour (citric acid), and bitter (quinine hydrochloride)—were applied to the entire oral cavity, and the minimum dilution at which the taste could be detected was defined as the threshold for that taste (**Table**).

All statistical analyses were performed using SPSS version 12.0 (SPSS Inc, Chicago, Illinois), with between-group comparisons assessed by the *t* test. $P < .05$ was considered statistically significant. This study was approved by the Kyung Hee University Hospital institutional review board.

RESULTS

The mean (SD) BMI of the COME group was significantly higher than the control group (20.6 [4.6] vs 17.7 [3.3]; $P = .02$) (**Figure 1**).

We found that the taste mean (SD) thresholds on the anterior right (14.3 [6.7] dB vs 8.0 [3.7] dB; $P = .03$) and left (13.3 [6.3] dB vs 8.5 [3.8] dB; $P = .04$) sides of the tongue were significantly higher in the COME than in the control group (**Figure 2**). In contrast, the mean (SD) taste thresholds on the posterior right (9.9 [5.2] dB vs 8.0 [3.8] dB; $P = .12$) and left (9.6 [5.6] dB vs 8.1 [3.6]

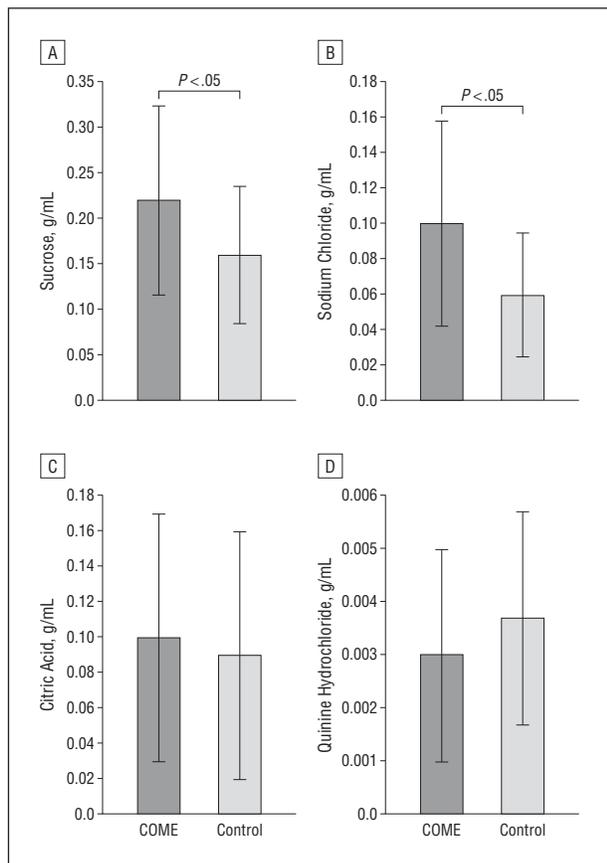


Figure 3. Mean (SD) specific taste thresholds of the entire mouth in the chronic otitis media with effusion (COME) and control groups. A, Sucrose; B, sodium chloride; C, citric acid; and D, quinine hydrochloride. Sensitivity to sweet and salty tastes was significantly decreased in the COME group (sweet, $P=.02$; salty, $P=.04$).

dB; $P=.09$) sides of the tongue did not differ significantly in the COME and control groups (Figure 2).

All COME and control group subjects completed the EGM. However, 28 COME subjects and 24 controls underwent the chemical taste test.

We found that the mean (SD) thresholds for sweet (0.22 [0.12] g/mL vs 0.16 [0.11] g/mL; $P=.02$) and salty (0.10 [0.09] g/mL vs 0.06 [0.06] g/mL; $P=.04$) tastes were significantly higher in the COME than in the control group (Figure 3). However, the thresholds for sour (0.10 [0.07] g/mL vs 0.09 [0.05] g/mL; $P=.13$) and bitter (0.0022 [0.0019] g/mL vs 0.0030 [0.0037] g/mL; $P=.08$) tastes did not differ significantly between the 2 groups (Figure 3).

COMMENT

Otitis media with effusion is a disease without acute symptoms, such as fever or otalgia, in which effusion fluid is retained in the middle ear cavity. Otitis media with effusion may develop following acute otitis media or may be attributable to other noninfectious causes. Although approximately 66% of patients with acute otitis media develop OME, most show spontaneous resolution within 3 months.^{1,2} If, however, effusion fluid within the middle ear cavity persists for longer than 3 months, the rate of

spontaneous resolution is only 20% to 30%, even after several years. The age at which pediatric obesity develops is similar to the age at which OME becomes prevalent.⁶ Infant obesity disappears in the years when physical activity increases. If, however, the rate of reduction of obesity is slow in children up to 2 years of age, there is a high possibility that these children will continue to be obese.

Childhood obesity is associated with increases in the number and size of adipocytes and may thus lead to adult obesity. Moreover, the lifestyle habits acquired during childhood are carried over into adulthood. Childhood obesity has been associated with increased risks of hypertension, diabetes mellitus, atherosclerosis, fatty liver, cardiovascular disease, and other adult diseases, as well as emotional problems and growth hindrance.⁷⁻¹⁰

We have reported that BMI and serum total cholesterol concentration were significantly higher in children undergoing tympanic ventilation tube surgery for COME than in children without otitis media and that childhood obesity may be associated with the development of OME.⁴ However, many factors affect obesity and COME, and we could not explore all relevant parameters because the number of subjects was limited. Thus, we evaluated BMI only in each group, without subject matching.

Serum concentrations of proteins associated with inflammation, including tumor necrosis factor, interleukin 6, and C-reactive protein, as well as erythrocyte sedimentation rate, have been reported to be higher in obese than in normal-weight individuals, suggesting that obesity is a subclinical inflammatory condition.^{11,12} These changes in cytokine concentrations may also be associated with the development of otitis media in obese children. Studies on the association between obesity and asthma have suggested that leptin, produced by an obesity gene, stimulates the production of factors related to inflammation, thus inducing airway hyperresponsiveness.¹³ Similar mechanisms may be involved in the relationship between obesity and otitis media.

The eustachian tube is divided anatomically and histologically into 6 parts, with the longest cartilaginous segment, the tensor veli palatine, playing a very important role in eustachian tube opening. The Ostmann fat pad is located on the superolateral side of the tensor veli palatine. In obese individuals, the volume of this fat pad may be increased, because of fat deposition, hindering eustachian tube opening during contraction of the tensor veli palatine. Because of such incomplete opening, the eustachian tube may not be vented normally, resulting in structural dysfunction and stasis of the middle ear fluid.¹⁴ Assessment of this hypothesis would require radiologic examination of the anatomic and physiologic condition of the eustachian tube or eustachian tube function tests.

If the deterioration in taste observed in COME is induced by chronic stimulation of the chorda tympani nerve caused by the inflammatory condition in the middle ear, eating habits may be altered, leading to weight gain. To assess this association more comprehensively, we examined taste thresholds in children with otitis media. Electrogustometry showed that the taste threshold in the anterior area of the tongue was significantly higher in the

otitis media than in the control group, suggesting that this change in taste may be associated with the chorda tympani nerve, which controls taste in that area. Such a relationship may be a coincidence, or could reflect differences in food preferences caused by taste changes, as we hypothesized. To prove such a relationship, many factors such as eating patterns, the child care environment, lifestyle, and disease history need to be considered and controlled. This is a limitation of our study. The chorda tympani nerve branches from the facial nerves, passes through the middle ear cavity between the malleus and the incus, exits the tympanum via the canal of Huguier, and runs between the pterygoid muscles. It is not yet clear how chronic inflammation within the middle ear cavity can exert effects on taste. In contrast to other facial nerves, the chorda tympani nerve is not protected by surrounding bones but is exposed to the middle ear cavity and therefore may be influenced by inflammatory tissues or molecules. Findings from histopathologic examination of the temporal bones of patients with chronic otitis media showed degeneration of the chorda tympani nerve; the outstanding histologic characteristic was fibrosis of the perineurium, with replacement by granular tissues as otitis media progressed.¹⁵ These findings suggest that inflammation in the middle ear cavity spreads to the chorda tympani nerve and injures that nerve. Thus, the higher taste threshold observed in the otitis media group may be caused by retraction of the tympanic membrane, the stasis of effusion in the middle ear cavity, and/or the secretion of toxic substances.

By simultaneously performing quantitative EGM, which can detect even mild taste disturbances, and qualitative chemical taste tests, we were able to assess both the extent of taste disturbance and its characteristics in pediatric patients with and without COME.¹⁶ Data from adults showed that taste was altered in patients with COME, as measured by EGM, but most of these patients were not aware of any changes in taste before testing.⁵ We considered that the most important difference between adults with chronic otitis media and children with COME was the duration of disease, which is far greater in adults. Thus, any real difference in taste at the beginning of disease may be rendered unimportant by operation of a long-lasting compensation mechanism. However, in children, differences in chemical taste test results may be attributed to a shorter period of disease associated with incomplete development of any compensation mechanism. We found that the thresholds of sweet and salty tastes were significantly higher in the otitis media than in the control group. Although the thresholds of bitter and sour taste were also somewhat higher in the otitis media group, these differences were not statistically significant. Taste has been reported to differ from other sensations by having a compensation mechanism. Thus, if the chorda tympani nerve has deteriorated functionally, at the level of the central nervous system, suppression of taste on the contralateral side is released, increasing the sensitivity of the glossopharyngeal nerve and maintaining the taste sensitivity of the entire oral cavity.¹⁷ Under temporary fasting conditions, there are changes in taste stimulation, peripheral taste receptors, and the sensitivity of

the taste nerve, thus increasing sensitivity to tastes that are important for biological nutrition, such as sweet and salty tastes, whereas little change is noted in the sensitivity to tastes that are present in toxic materials.¹⁸ Our findings of significant elevation in the thresholds for sweet and salty tastes, together with nonsignificant changes in the thresholds of bitter and sour tastes, are in good agreement with previous results.

Our study was performed in pediatric patients, most of whom have shorter attention spans than adults. Because the times required to measure taste thresholds were long, concentration deteriorated and the children became fatigued. To maximize patient compliance, parents or guardians were allowed to be present nearby. Moreover, sweet taste was tested first and bitter taste last. The number of subjects completing the chemical taste tests was rather small, and thus additional studies are required. However, our finding of significant elevations in the thresholds of sweet and salty tastes in the COME group is in accordance with the EGM-measured deterioration of thresholds in the anterior part of the tongue. This suggests that the ability of patients with otitis media to taste sweet and salty foods at the same intensity as experienced by control patients would require ingestion by the former of sweeter and saltier foods, resulting in an excessive intake of calories and liquids, increasing fat deposition and fluid retention and ultimately resulting in obesity.

In conclusion, EGM results showed that taste thresholds on the anterior part of the tongue were higher in pediatric patients with COME than in control patients, whereas chemical taste test results showed that the thresholds of sweet and salty tastes were elevated in the COME group. These findings suggest an association between changes in taste and increased BMI in pediatric patients with COME.

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