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Review Article

Taste Perception in Pediatric Clinical Settings: A Review

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Abstract

Changes of taste perception in a sick population of children, and partly of adolescents, have been reviewed. The articles cited in this review used either strip-filter taste disc measures or a whole mouth test for evaluating taste perception. In a healthy population, the frequency of the impaired taste perception in 4 major tastes (sweet, salty, sour, bitter) has been reported as the percentages of between 6.0 and 40.0. In obese children, lower sensitivity to sweet, especially in males, and 6-n-propylthiouracil was described. However, since there was the opposite data, this issue needs further investigation. In thin children, there exists one report demonstrating that 6-n-propylthiouracil tasters tended to be underweight. Furthermore, patients with anorexia nervosa have been shown to have impaired perception in 4 major tastes and umami. Cancer patients undergoing chemotherapy and bone marrow transplantation, and those with chronic kidney disease and dental caries were found to have a general decrease in 4 basic tastes or 6-n-propylthiouracil perception. The effect of zinc supplementation is thought to be limited. Since the number of reports is still limited, the studies using more subjects with adequate control should be necessary to draw definitive conclusions.

Keywords: Taste perception; Children; Obesity; Thinness; Diseases

Introduction

Taste perception plays an important role in a nutritional life in both healthy and sick populations. In adults, several reports have reviewed the changes of taste perception in various disorders [1-5]. An initial review on this issue by Schiffman presented that a range of disease states, pharmacologic and surgical intervention, aging, radiation, and environmental exposures can result in changes of taste perception [1]. In an analysis of 2278 patients with various diseases visiting "Taste and Smell Clinic" at a single hospital, women and aged patients have been found to have more impaired taste perception irrespective of their diseases [2]. Recently, Syed et al. [5] reviewed the association between dysgeusia and medical status, and demonstrated that dysgeusia is more common in the elderly, especially those admitted to hospitals or residing in long-term care facilities. They nominated chronic hepatitis C, Chronic Kidney Disease (CKD), diabetes mellitus, cognitive disorders, cancer, and dental/oral problems as medical conditions associated with impairment of taste perception. On the other hand, reviews dealing with taste perception at various clinical settings in children are quite scanty. In a systematic review on quantitative evaluation of taste in childhood by Moura et al. [6], they only mentioned 2 disorders including otitis media with effusion and developmental delay such as autism. Furthermore, Schriever et al. [7] reviewed taste perception in diseases with olfactory dysfunction, and discussed specifically roles of traumatic injury, cancer, and psychiatric diseases. Considering the lack of comprehensive literature on taste perception at various clinical settings in children, we retrieved the articles on taste perception from Pub Med and Web of Science, and discussed the following points, (i) measures used for evaluation of taste perception, (ii) impairment of taste perception in a healthy population, (iii) taste changes in obese and thin populations, and (iv) various diseases including cancer, CKD, and dental caries. This review deals with articles on these issues in children, but some in adolescents are also included for considering the role of transition to adulthood.

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Measures for Evaluating Taste Perception

General aspects

One of the important issues in evaluation of taste perception in children is determining at which age children begin to perceive taste accurately, considering their cognitive development. According to the model of Piaget's states of development, 4 elements, namely, motivation, attention, understanding of tests, and decision-making process in children, should be considered [8]. By using a test-retest in a whole mouth taste test, Knof et al. [8] and Majorana et al. [9] have shown that children at the age of 5-7 and 5-12 years can perceive accurately sweet, salty, bitter, and umami tastes. However, such a test-retest in sour taste has not existed.

Specific measures

There are 4 measures, including a strip test [10], a filter paper disc test [11,12], a whole mouth test [13], and Electromyography (EMG) [14], currently used for evaluation of taste perception. The first 2 measures are almost similar, since a strip or a filter paper disc soaked with differing concentration of a solution that contains, for example, sweet (sucrose), salty (sodium chloride), sour (citric acid or tartaric acid), bitter (quinine hydrochloride), umami (Monosodium Glutamate: MSG), is put on either the anterior part of the tongue innervated by the chorda tympani nerve, or the posterior part of the tongue innervated by the glossopharyngeal nerve [15]. Then,

examinees are asked to report a Detection Threshold (DT) and a Recognition Threshold (RT). DT represents the lowest concentration of each solution discriminated from a pure solvent, whereas RT represents the lowest concentration where the substance is both perceived and identifiable as having a specific perceptual quality. In one study by Webb et al., among 5 basic tastes DT and RT were positively correlated except for salty [15]. The third measure of a Suprathreshold (ST) uses several suprathreshold concentrations of testants and the examinees report their intensity by general labeled magnitude scale [15,16]. These measures are useful for evaluating the specific place of the tongue for taste perception [15,17]. On the other hand, a whole mouth method is done with a small amount of solution into the mouth [13]. This measure is thought to be easier and may be suitable for testing in young children. EMG evaluates several facial and chewing muscles in response to taste stimuli [14]. Armstrong et al. [18] reported the possibility that this method can be useful for infants.

Impairment of Taste Perception (Hypogeusia) in a Healthy Population

Four major tastes

Although the definition of Hypogeusia is diverse, there are several articles that have examined its frequency in a healthy pediatric population. In a study of Australian Aboriginal (n=166) and non-Aboriginal (n=266) children, 12.0% and 7.9% showed Hypogeusia, respectively. Among them, a sweet disorder was most common [19]. Ohnuki et al. [20] reported that among 237 primary and 112 junior high school students, the frequency of Hypogeusia in one of 4 major tastes was between 6.0% and 20.9%, and the frequency for sour was highest. In 80 children aged 6-17 years, Hypogeusia was identified at the rate of 40% in the United States [21]. In adolescents, Nagai et al. [17] have shown that Japanese female students aged 19-27 years exhibited a high frequency of Hypogeusia in 4 basic tastes (42.1%-62.1%), especially for sweet. Salt taste testing in 421 adolescents (average age 15.8 years) showed 36.1% of them had a high threshold [22].

Umami

Although umami is now recognized as the fifth basic taste [23], as far as we know, a large scale data of evaluating umami taste perception in children have not existed. Satoh-Kuriwada established the cutoff value of MSG using 102 young (18-25 years old) and 82 older (65-89 years old) subjects. They also found the value was almost similar between young and older individuals [24]. In 42 Japanese female adolescents, Kubota et al. [25] reported that 23.8% of them were categorized as hypo-tasters of umami based on Satoh-Kuriwada's cutoff value.

6-n-propylthiouracil (PROP)

PROP is a synthetic bitter compound, which is widely used for evaluating the bitter taste perception [26,27]. PROP perception is thought to be strictly regulated by the allelic variation of TAS2R38 [26]. According to a review by Tepper, the estimated frequency of PROP non-tasters is high among Caucasians (~30%), and lower in populations from East Asia or Sub-Saharan Africa (~10%-20%) [26]. The actual measurement of PROP tasters in children (3-6 years old) was 32/42 (76.2%), 43/67 (64.2%, preschool children), and 85/120 (70.8%, 4-6 years old) in New Zealand [28] and the United States [29,30], respectively. In Japan, the tasters were 218/323 (67.5%) (4-6 years) [31] and 111/135 (82.2 %) (18-24 years old) [32].

Taste Perception in Various Disorders

Obesity

The relation between taste perception and Body Mass Index (BMI) is rather complex, because BMI is a function of multi-factors, such as environmental factors, eating attitude, and genetics, especially in children [33]. Overberg et al. [34] showed lower intensity perception of sweetness in 99 obese subjects than that in 94 normal weight controls but it was specifically observed only in males [35]. They also reported lower detection rate of salty, bitter, and umami taste [34]. Recently, Mameli et al. [36] demonstrated impaired sweet, sour, and bitter perception in comparison with normal controls. This well correlated with the number of Fungi form Papillae [36]. On the other hand, in children at a mean age of around 14 years, 39 massively obese participants (mean BMI, 39.5) were shown to have higher sweet and salty perception in comparison with 48 non-obese counterparts (mean BMI, 21.0) [37]. Review on the relation between PROP sensitivity and obesity risk considered the possibility that non-tasters are prone to obesity [27,38]. Keller and Adise postulated three possible mechanisms; an association of thyroid hormone, higher dietary fat intake, and expression of TAS2R38 receptors in the gastrointestinal tract [27]. On the other hand, there are reports demonstrating that the association of PROP phenotype and BMI status is weak [32,39] or that it is influenced by maternal attitude in food life or familial economic status [40,41].

Thinness

In contrast to obesity, the epidemiological reports on the association between thinness and taste perception are quite limited. In 500 children aged 3-6 years, approximately 60% of PROP tasters were found to be underweight, whereas 73% of non-tasters were in overweight category [42]. During the weight reduction treatment for 60 obese children, changes of taste perception were examined. Although total taste identification scores remained stable, increased sour and decreased sweet taste discrimination has been observed after weight loss [43]. Anorexia nervosa is the representative eating disorder that leads to a decreased BMI. Szalay et al. [44] have demonstrated diminished taste perception for sweet, salty and umami at low concentrations in 11 patients with anorexia nervosa. A recent review has confirmed the reduction of taste perception in patients with anorexia nervosa, but this effect is highly influenced by confounding variables, especially a patient's cognitive status [45]. Finally, food refusal seen in 43 patients with autism aged 2-11 years were associated with PROP sensitivity, which may be used as a device to orientate tailored food proposals for these patients [46].

Cancer

It is well known that patients with cancer suffer from taste disorders after starting chemotherapy and radiotherapy. However, taste perception before starting cancer treatment is largely unknown at present. After starting chemotherapy, patients experienced changes of taste perception and taste recognition errors [47,48], which persisted up to 9 months after cessation of treatment [48]. Nagai et al. [12] demonstrated that cancer patients at least 6 months after completion of chemotherapy did not show any significant difference in the 4 major tastes as compared to the controls. In contrast, 14 out of 51 (27.5%) childhood cancer survivors more than 5 years since treatment completion, had taste dysfunction, which was higher than that in the non-cancer population [49]. In an initial study in leukemia patients undergoing Bone Marrow Transplantation (BMT), the patients exhibited only minor changes in sweet, bitter, and salt

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perception [50]. Cohen et al. [51] reported that at 1 month post BMT, one-third of recipients displayed abnormality of taste perception, especially in sour and bitter tastes, but there were not any patients with the abnormality at the 2-month assessment.

Chronic renal failure and CKD

More than three decades ago, Shapera et al. [52] found that taste perception for sweet, salt, and bitter in 20 pediatric patients with chronic renal failure did not show any significant changes compared to normal controls. In the early 2000s, the clinical entity of CKD was introduced based on the level of the estimated Glomerular Filtration Rate (eGFR). Armstrong et al. [53] evaluated taste perception in various stages of 20 CKD patients. They found that CKD stage 3-5 group patients exhibited significantly lower taste perception, and taste scores of 4 major tastes correlated well with the eGFR levels. Reduced taste function was also reported by measuring taste papillae density on the anterior tongue in 12 CKD children. The density was significantly correlated with eGFR [54].

Dental caries

A higher intake of sweetness is apparently the major cause of development of dental caries. A recent cross-sectional study in 669 children 13-15 years old from three countries (Italy, Mexico, and Saudi Arabia) indicated that sweet perception was weakly correlated with the occurrence of dental caries, especially at their initial stages [55]. In a genetic study of the sweet taste receptor genes, total caries experience was associated with TAS1R2rs35874116 and TAS1R3rs307355 gene polymorphisms. In addition, severe caries (>8 carries) experiences were associated with TAS1R2rs35874116 [56]. Of interest is that bitter taste sensitivity also plays a role on the development of dental caries. Recent investigators reported that PROP non-taster children were more prone to dental caries than tasters [57,58].

Treatment

Despite numerous reports on taste disorders in children, the information of their treatment is quite sparing. Zinc supplementation has been widely used for taste disorders both in adults and children [2,59], but the effect is limited except for inherited zinc deficiency [60]. In fact, Watson et al. tried to administer zinc in pediatric patients with chronic renal failure without any significant effects [61]. Since several reports also indicated a role of trace metals other than zinc, and vitamins on taste disorders [62,63], the fortification of these compounds in diet may be another approach in the nutritional treatment of taste disorders.

Conclusion

Taste perception at various clinical settings in children, and partly in adolescents, has been discussed in this review. Several changes of taste perception have been reported in obesity or thinness, but it remains unclear whether these results may be the cause or the effect of obesity or thinness. In addition, patients with cancer, especially after treatment, those with CKD or dental caries have altered taste perception. In cancer patients, how long the observed changes will last after cessation of treatment is an important issue for further investigation. Although any of topics in the present issue are not conclusive because of the limitation of epidemiological studies in general, physicians should keep these results in mind when they try to give them a nutritional support.

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