Original

Changes in oral stereognosis of healthy adults by age

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Abstract: Rehabilitation for dysfunctions of eating and swallowing should be considered in terms of not only motor but also sensory function. Sensory information from a bolus in the mouth plays an important role in eating and swallowing. Therefore, this study investigated oral stereognosis in 184 healthy adults with normal eating and swallowing function in order to obtain normative data. Oral stereognosis was assessed by using 20 intra-oral test pieces with different shapes. The subjects manipulated the test pieces in the mouth and identified their shapes. At this time, the test scores and response times for answering were recorded. The results revealed differences in oral stereognosis depending on the age of the subjects and the test pieces employed. The younger group had higher test scores and shorter response times than the older group, except for comparisons between the 20s and 30s age groups. In addition, response time was negative correlated with test scores ($r = -0.956$, $P < 0.001$). These results indicate that oral stereognosis decreases with age.

Keywords: stereognosis; oral sensation; aging.

Introduction

Stroke is frequently followed by dysphagia. Approximately 11% of patients with stroke are expected to develop dysphagia within 6 months. Dysphagia significantly affects the quality of life (QOL) of patients with stroke and may cause complications such as aspiration pneumonia, malnutrition, and dehydration, which impact

on prognosis (1,2). Therefore, it is crucial to evaluate stroke patients for dysphagia at an early stage and devise suitable intervention plans (3).

Several studies (2,3) have indicated that there are remedial approaches for improvement of eating and swallowing function, and these are divided into motor and sensory strategies. Motor strategies are approaches that focus on improvement of motor function, and include the Mendelson maneuver, Masako exercise, and Shaker exercise. Motor strategies have been widely used for eating and swallowing rehabilitation in patients with stroke (3,4) because their effects on the strength of the tongue, lip pressure, and strength of the buccinators can be measured objectively through biomechanical measurements such as the Iowa Oral Performance Instrument (5). Sensory strategies are approaches that focus on improvement of sensory functions, such as thermal, mechanical, and chemical stimulation. However, their use is limited because it is difficult to measure their effects objectively (6). Therefore, it is important to establish objective data that can help to determine the effects of such measures by focusing on improvement of sensory functions.

Most patients with stroke have facial palsy that affects the tongue and lower face, and therefore they are not able to recognize the sizes and shapes of objects placed in the mouth, thus impacting on oral stereognosis (OS) (7). OS is the process by which sensory information is perceived from mucosal receptors, the tongue, and receptors in the gums, lips, and temporomandibular joints, and then interpreted. OS has been shown to decline after stroke, thus negatively impacting on normal eating and swallowing. Therefore, patients with stroke have poorer OS than healthy individuals (8).

Several studies (7-11) on the standardization of OS in healthy people have been conducted in order to objectively measure the effects of interventions for improving OS in patients with stroke. However, most of these studies have investigated the changes in OS based on age

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Fig. 1 The 20 shapes of the test pieces.

differences in elderly people. Hence, it has been difficult to present normative data for all ages because most of the study subjects were elderly. In addition, it was difficult to confirm OS precisely in elderly individuals with dentures (9-11). Thus, there have been limitations in applying the results for deciding the level of OS representative of the healthy population.

Therefore, the author conducted a preliminary study to further measure differences in the level of OS in healthy adults by age using a large sample in order to obtain normative data for OS. It was anticipated that the data would allow clinical therapists to compare our normative data with data for patients with problems related to oral sensory function after interventions for improvement of OS.

Materials and Methods

Subjects

This study was conducted from July 3, 2015 to January 1, 2016. A total of 184 healthy volunteers (83 men and 101 women) between the ages of 20 and 89 years were recruited for the study. All subjects completed a questionnaire on their general health status and medical condition. Subjects were excluded if they reported eating and swallowing dysfunction, neurological disorders, or had participated in any dysphagia therapy programs that may have affected the results of the study. In addition, both subjects with dentures and those who had complained of discomfort in the mouth were excluded.

The purpose and methods of this study were explained to all subjects, who gave their voluntary consent to participate. This study was approved by the local health-related institution (May 9, 2015-May 8, 2016) and performed

according to the code of ethics of the World Medical Association (Declaration of Helsinki, 2004 version).

Test of oral stereognosis

OS testing has been conducted using test pieces with various complex shapes and forms but with similar dimensions; the patients feel the form and shape of the test pieces placed in the mouth through intra-oral manipulation and compare them with the actual form and shape of the test pieces (7,8).

In this study, OS tests were conducted using intra-oral test pieces with 20 different shapes (Fig. 1). The shapes were approximately 2 mm thick and 13 mm in diameter or length. The test pieces were categorized into six groups as follows: 1) polygonal-shaped group (No. 1-4); 2) triangular-shaped group (No. 5-7); 3) star-shaped group (No. 8-10); 4) circular-shaped group (No. 11, 12); 5) convex-shaped group (No. 13-16); and 6) concave-shaped group (No. 17-20) (4). These shapes had been developed by the American National Institutes of Health (12). A fine thread was attached to each test piece in order to prevent choking.

The tests were conducted between 10:00 and 12:00 a.m. in a quiet room where the subjects were seated comfortably in an upright position. Pictures of all the test pieces were shown to each subject on the chart, and one of the pieces was selected randomly and placed on the mid dorsum of the tongue with the subject's eyes closed. The subjects were asked to manipulate the test piece freely in the mouth to confirm its shape and choose the corresponding shape from the 20 pictures on the chart. Each test was terminated when all 20 test pieces had been evaluated in this manner. The subjects were allowed

Table 1 Oral stereognosis test scores

Age	<i>n</i>	Mean	SD	F	<i>P</i>	Scheffe
20-29 ^a	24	37.42	1.74	150.360	0.000	a, b > c > d > e > f > g
30-39 ^b	23	36.26	2.22			
40-49 ^c	28	32.96	2.03			
50-59 ^d	25	29.96	3.20			
60-69 ^e	34	27.29	2.37			
70-79 ^f	34	23.37	2.53			
80-89 ^g	16	20.37	2.99			

Table 2 Response times for answering

Age	<i>n</i>	Mean (s)	SD	F	<i>P</i>	Scheffe
20-29 ^a	24	5.08	0.44	340.870	0.000	a, b > c > d > e > f > g
30-39 ^b	23	5.29	0.28			
40-49 ^c	28	5.87	0.25			
50-59 ^d	25	6.43	0.30			
60-69 ^e	34	6.71	0.18			
70-79 ^f	34	7.35	0.23			
80-89 ^g	16	7.96	0.15			

to choose the same test piece multiple times and were not informed of the correct answers at any time during testing (4,10). The time in seconds taken for choosing the answer was noted using a stop watch, and the answers were recorded using a three-point rating scale with reference to Smith and McCord (13,14). The Smith and McCord scoring system is as follows: 1) correct identification of the shape of a test piece is scored as two points; 2) incorrect identification of the shape of a test piece in the same group is scored as one point, and 3) incorrect identification of the shape of a test piece is scored as zero. The total scores range from 0 to 48. Therefore, the higher the score, the higher the accuracy of OS. To prevent any learning effect, no practice trials were allowed. During the test, the examiner reduced extraneous noise levels in order to minimize any variability in data collection.

All data analyses were conducted using SPSS version 20.0 (IBM SPSS Statistics, IBM Corp, Somers, NY, USA). Descriptive statistics were used to analyze the mean and standard deviation of the OS test scores and the response times for answering. Analysis of variance was applied to compare the test scores and response times among age groups. Spearman's rank correlation coefficient was used to investigate the relationship between response time and OS test score.

Results

Oral stereognosis test scores

Subjects in their 20s showed the highest scores (37.42 ± 1.74) whereas those in their 80s showed the lowest scores (20.37 ± 2.99). There were significant differences in the test scores among the age groups; relatively younger

groups had higher test scores than older groups, except for comparisons between the 20s and 30s age groups (Table 1).

Answering response time

Subjects in their 20s showed the shortest response time (5.08 ± 0.44) whereas those in their 80s showed the longest response time (7.96 ± 0.15). There were significant differences in the response times among the age groups; relatively younger groups had shorter response times than older groups, except for comparisons between the 20s and 30s age groups (Table 2).

Shape recognition

The ratios of correct answers (two points) for each of the 20 test pieces are indicated in Fig. 2. The highest ratio of correct answers was 94.0% for test piece No. 12 in the circular-shaped group and the lowest ratio was 25.5% for test piece No. 17 in the concave-shaped group. In the polygonal-shaped group, the ratios of correct answers were 40.8% (No. 1), 41.3% (No. 2), 46.2% (No. 3), and 74.5% (No. 4), respectively. In the triangular-shaped group, the ratios of correct answers were 53.3% (No. 5), 40.8% (No. 6), and 44.0% (No. 7), respectively. In the star-shaped group, the ratios of correct answers were 78.8% (No. 8), 53.3% (No. 9), and 48.9% (No. 10), respectively. In the circular-shaped group, the ratios of correct answers were 82.6% (No. 11), and 94.0% (No. 12), respectively. In the convex-shaped group, the ratios of correct answers were 48.7% (No. 13), 43.5% (No. 14), 40.2% (No. 15), and 31.0% (No. 16), respectively. In the concave-shaped group, the ratios of correct answers were

Fig. 2 The percentage of correct answers for each of the 20 test pieces.

Fig. 3 The correlation between response times and oral stereognosis test scores.

25.5% (No. 17), 34.8% (No. 18), 46.7% (No. 19), and 68.5% (No. 20), respectively.

Correlation between response time and test score

The results of Spearman's rank correlation were significant, indicating that response time had a negative relationship with test score ($r = -0.956$, $P < 0.001$) (Fig. 3).

Discussion

OS plays an important role in normal eating and swallowing (15). In accordance with the importance of OS,

several studies using objective and quantifiable assessment tools to assess OS have been reported (7-9,15,16). However, most of these studies have focused on OS in elderly people. Therefore, this study was conducted to overcome the limitations of previous studies by providing normative OS data for healthy adults by age. Our results showed that the younger group had higher test scores than the older group, except for comparisons between the 20s and 30s age groups. This result is consistent with previous studies (17-20). The older the subjects, the more frequently they misidentified test pieces in other groups rather than in the same group. This result may be

explained by the fact that oral perception of the size and shape of a bolus declines with age, irrespective of dental status, due to a decrease in information from the tongue and palate (9,21). As a result, older adults have difficulty in distinguishing complex shapes. Second, OS involves some motor activity of the lips, tongue, and teeth. Motor activity tends to be reduced with age, thus impacting on the test score (21).

In this study, younger subjects had shorter response times than older subjects, except for comparisons between the 20s and 30s age groups, suggesting that aging negatively impacts on OS in terms of the speed in which sensory information is processed. This is because the conduction speed of nerve impulses in sensory fibers decreases with age (22). In addition, sensory inputs are used for comparison with previous sensory memories to identify the shapes of test pieces. Cognitive functions including memory normally decline as a result of aging, beginning from middle age. Thus, these changes may negatively affect response time (23,24).

The results of Spearman's rank correlation showed that as the response time increased, the test scores decreased. Singh et al. (25) also reported similar results. Response speed is important in OS because response time is increased when intra-oral sensation is impaired (25). Therefore, an increase in the response time can indicate low OS. As a result, there were differences in the test scores depending on the shapes of the test pieces. In each group, the ratio of correct answers increased as the size of the test pieces increased because a large object has a wider contact area that a subject can feel, thus providing more sensory information (26). In addition, the ratio of correct answers was higher for test pieces with sharp angles, such as Nos. 4, 8, 11, and 12, or for asymmetrical test pieces such as Nos. 19 and 20. On the other hand, the ratio of correct answers was lower for test pieces with obtuse angles, such as Nos. 9 and 10. These results suggest that information on unique characteristics such as sharp angles or asymmetrical shapes may be useful for recognizing the shapes of test pieces, being consistent with the results of the previous study (4). This was because the subjects easily differentiated the shapes of the test pieces in each group based on unique characteristics, providing a strong input that served as clues during the tests (4,26).

There were several limitations to this study. First, it was cross-sectional in design and did not examine the process of aging in relation to OS. Second, it did not suggest any approach for improving OS in subjects with impairment of eating and swallowing through rehabilitation. Therefore, longitudinal cohort studies will be required in

the future to develop a rehabilitation method designed to improve OS. In spite of these limitations, the present results are significant because they represent valuable normative age-related reference information relevant to rehabilitation designed to improve OS.

Conflict of interest

The author has no conflict of interest to declare.

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