The Discourse on Measuring Frequency of Tongue Strength

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Abstract

Iowa Oral Performance Instrument (IOPI) is an instrument used to measure tongue strength. The standard protocol of operating IOPI is three trials separated by 10-15 seconds of rest. The highest pressure of these three trials is recorded as the tongue strength. The purpose of this study was to investigate the difference of three trials. Forty-one healthy adults were taken as research subjects. Repeated-measurements analysis of covariance (RANCOVA) was used to analyze the anterior and posterior tongue strength under four conditions: maximum isometric pressure, dry swallowing, 5 c.c. and 10 c.c. of water swallowing. The results showed that there were no statistically significant differences among three trials of anterior and posterior tongue strength. It is suggested that before measuring the tongue strength, the participants should be provided with the opportunity to practice, and one or two trials in formal measurements can be adopted to reduce their fatigue.

Keywords: Intraoral pressure; Swallowing; Dysphagia

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Introduction

Dysphagia (or deglutition) refers to the abnormality in the process of transmitting the food bolus from the oral cavity to the oropharynx, and under the protection of the respiratory tract to transmit the food bolus into the stomach spontaneously [1]. The prevalence rate of dysphagia in general adults is 4% [2], and 13-60% of healthy elderly people suffer from dysphagia [3]. There are more than 400,000 elderly people with dysphagia in Taiwan, and 10,000 elderly people eat for nearly 2 hours per meal [4]. The tongue is responsible for transferring food bolus from the oral cavity to the pharynx, and the movement of the tongue will also stimulate the nerve receptors in the oropharynx and laryngeal pharynx to trigger swallowing action. The prolonged swallowing duration generally occurs in the oral phase, i.e. when the tongue is
transferring food bolus, so the tongue strength plays an important role in people's swallowing [5]. Iowa Oral Performance Instrument (IOPI) is currently one of the most commonly used instruments for measuring tongue strength and it can be used to evaluate changes in people's tongue pressure. IOPI measures maximum pressure in an air-filled bulb that is pressed with the tongue. The shape of bulb is proxy for a bolus of food. The standard protocol of operating IOPI is three trials separated by 10-15 seconds of rest. The highest pressure of these three trials is recorded as the tongue strength. During the process of collecting tongue strength measurement data from healthy adults, some participants responded that the whole oral muscle was not very comfortable, although it is mentioned in the User Manual that: client may experience "sore throat" symptoms for 24 hours due to normal muscle fatigue. In view of the fact that after the establishment of the norm of Chinese tongue strength, patients, disabled persons, etc. will be taken as the subjects in the future. Whether these research population can endure the measurement for three trials, the motivation to explore the relationship among three trials has arisen. The purpose of this study was to investigate the difference of three trials in anterior and posterior tongue strength under the conditions of maximum isometric pressure, dry swallowing, and water swallowing.

Methods

Participants: This study protocol was approved by the ethics committee of the JEN – AI HOSPITAL (No. 107-35). Forty-one healthy participants (13 men and 28 women; age range, 20–59 years; mean age, 28.07±10.12 years), gave their consent to participate in this study. All were in excellent medical condition with no history of orthodontic treatment, oromotor/ swallowing defect, or neurologic conditions.

Experimental Setting: Participants were asked to sit on a chair with their head vertical to the floor. The maximum isometric pressure (MIP), dry swallowing pressure and water swallowing pressure of anterior and posterior tongue were measured according to the examiner’s instruction. Participants repeated three times with bulb against the hard palate in every situation. Examiner held on to the pressure bulb tube when it is in the participant’s mouth for safety. The participants were allowed to take a rest for 10-15 seconds between 2 measurements.

Data Analysis: This study used the software IBM SPSS 23.0 (IBM, Armonk, NY, USA) to analyze the data. Repeated–measures analysis of covariance (RANCOVAs) was used to analyze the differences among three measurements. Before performing repeated measurements of ANOVAs, the three measurement values were subject to spherical verification. If \( p > 0.05 \), it means that the three repeated measurements are not correlated and conform to spherical verification. Otherwise, if \( p < 0.05 \), it means that the three measurements are highly correlated and do not conform to spherical verification, and must be corrected by Greenhouse-Geisser. When repeated measurements of ANOVAs showed significant differences, then LSD (least significance difference) was further used to perform pairwise comparisons among the three measurement values.

Results

Maximum Isometric Pressure

(Table 1) shows that the three measurements of maximum isometric pressure in anterior and posterior tongue strength did not conform to the spherical test (\( p > 0.05 \)). Therefore, after Greenhouse-Geisser correction, the frequency of measurements had no effect on the maximum isometric pressure of anterior tongue strength \( F (1.69, 89.59)=2.39 \), and posterior tongue strength \( F (1.61, 32.69) = 0.72 \ (p > 0.05) \).
Dry Swallowing of Tongue Strength

(Table 2) shows that under the condition of dry swallowing, the three measurements of anterior and posterior tongue strength conformed to spherical verification ($p>0.05$). The measuring frequency had effect neither on anterior tongue strength $F(2, 48.42)=1.34$, and nor on posterior tongue strength $F(2, 15.13)=0.55$ ($p>0.05$).

| Variable                     | Mean (SD) | Sphericity test ($p$) | $F$            | $p$     |
|------------------------------|-----------|-----------------------|----------------|---------|
| Anterior tongue strength (kPa) |           | 0.018                 | $F(1.69, 89.59)=2.39$ | 0.107   |
| 1st                          | 50.95(15.37) |                      |                |         |
| 2nd                          | 52.49(15.49) |                      |                |         |
| 3rd                          | 53.66(15.29) |                      |                |         |
| Posterior tongue strength (kPa)|           | 0.004                 | $F(1.61, 32.69)=0.72$ | 0.461   |
| 1st                          | 50.37(11.04) |                      |                |         |
| 2nd                          | 50.54(10.13) |                      |                |         |
| 3rd                          | 49.07(11.91) |                      |                |         |

Water Swallowing of Tongue Strength

After drinking 5cc of water, the measured values of three times of posterior tongue strength conformed to the spherical test, and the measuring frequency had no significant effect on the posterior tongue strength $F(2, 37.11)=1.05$ ($p>0.05$). The three measured values of anterior tongue strength did not conform to the spherical test, and Greenhouse-Geisser correction was performed. The measuring frequency had no significant effect on the anterior tongue strength $F(1.63, 46.01)=0.87$ ($p>0.05$) (Table 3). Three trials of anterior and posterior tongue strength in 10cc water swallowing conformed to spherical test. The measurement times had no effect on the anterior tongue strength $F(2, 102.11)=2.26$ and on the posterior tongue strength $F(2, 39.00)=0.94$ ($p>0.05$) (Table 4).

| Variable                     | Mean (SD) | Sphericity test ($p$) | $F$            | $p$     |
|------------------------------|-----------|-----------------------|----------------|---------|
| Anterior tongue strength (kPa) |           | 0.911                 | $F(2.48.42)=1.34$ | 0.267   |
| 1st                          | 45.39(14.74) |                      |                |         |
| 2nd                          | 43.44(15.30) |                      |                |         |
| 3rd                          | 43.59(14.06) |                      |                |         |
| Posterior tongue strength (kPa)|           | 0.099                 | $F(2.15.13)=0.55$ | 0.581   |
| 1st                          | 45.29(15.53) |                      |                |         |
| 2nd                          | 45.39(15.23) |                      |                |         |
| 3rd                          | 46.39(14.66) |                      |                |         |
Discussion

The three trials of anterior and posterior tongue strength under the conditions of the maximum isometric pressure, dry swallowing, 5cc and 10cc of water swallowing were not achieved the statistically significant difference. These results were consistent with the findings of past study [6]. Vanderwegen et al. [6] have found if healthy participants were allowed to look at the IOPI, there was no significant difference in the three measurement values of tongue strength. If they were not allowed to look at IOPI, the first measurement value was usually the highest. The reason might originate from the healthy participants seeing the IOPI, they will expect themselves to achieve higher or at least the same value as the former measurement. The tendency of the highest value was in the third trials from Table 1 to Table 4 in this study. It seemed to support this viewpoint. Tongue strength is a crucial factor in oral phase swallowing. Once tongue weakness is assessed, oral motor exercise will be initiated to strengthen tongue muscle. The goal is setted with 60-80% of maximum isometric pressure of tongue strength. This is the biofeedback aspect of the IOPI to motivate patients to achieve the goal of tongue strength increasing [7]. It needs to be adequately explored whether the participants in this study are alluded to enhancing performance. More than 80% of the participants in this study are young people, aged between 20 and 39, with an average age of 28.07 years (±10.12 years). When measuring the tongue strength of each condition, the participants in this study expressed some tiredness. In fact, it may result from muscle strain. Hence, the resting time must be sufficient. Providing visual, auditory or tactile stimuli associated with swallowing can activate mirror neurons and enhance safe swallow [8]. Although IOPI provides sensory triggers to increase upward tongue movement, safe swallow involves complex sensory and motor control. Different kinds of oral motor exercises to complete the safe swallow needs to be reinforced for a disabled population other than tongue strengthening exercise. Although there was no significant difference in the three trials of the anterior and posterior tongue strength

| Table 3: 5cc Water swallowing of tongue strength (kPa) (N = 41). |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Variable        | Mean (SD)       | Sphericity test (p) | F               | p               |
| Anterior tongue strength (kPa) | 0.006 | $F_{(1.63, 46.01)} = 0.87$ | 0.404 |
| 1st             | 43.73(14.43)    |                 |                 |                 |
| 2nd             | 44.17(14.59)    |                 |                 |                 |
| 3rd             | 45.56(16.92)    |                 |                 |                 |
| Posterior tongue strength (kPa) | 0.472 | $F_{(2, 37.11)} = 1.05$ | 0.356 |
| 1st             | 41.95(15.33)    |                 |                 |                 |
| 2nd             | 41.02(14.24)    |                 |                 |                 |
| 3rd             | 42.93(14.62)    |                 |                 |                 |

| Table 4: 10cc Water swallowing of tongue strength (kPa) (N = 41). |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Variable        | Mean (SD)       | Sphericity test (p) | F               | p               |
| Anterior tongue strength (kPa) | 0.965 | $F_{(2,102.11)} = 2.26$ | 0.114 |
| 1st             | 41.85(13.06)    |                 |                 |                 |
| 2nd             | 45.74(16.01)    |                 |                 |                 |
| 3rd             | 43.85(15.37)    |                 |                 |                 |
| Posterior tongue strength (kPa) | 0.213 | $F_{(2, 39.00)} =0.94$ | 0.397 |
| 1st             | 37.89(15.53)    |                 |                 |                 |
| 2nd             | 39.56(15.51)    |                 |                 |                 |
| 3rd             | 40.22(14.90)    |                 |                 |                 |
under the condition of maximum isometric pressure, dry swallowing, 5cc and 10cc of water swallowing, it is because the probability of reaching the statistically significant difference is less than 0.05. Owing to the variability of the participants, the standard deviation of the measurement values of the anterior and posterior tongue strength were wide (10.13 ~ 15.53 kPa) (Table 1~Table 4). In view of the measurement of the tongue strength, it will be popularized to clinical practice in the future, facing patients, people with physical and mental disorders, or the elderly. The reliability and validity of the measured values are very important, so it is still advisable to hold a conservative attitude. In addition to specifying the location of the bulb and the procedure before measurement, participants should have the opportunities to place the pressure bulb in the mouth so as to practice and become familiar with the feeling of the pressure bulb in the mouth. Once the participants have the opportunity to practice before the formal measurement, the formal measurement can be taken once or twice to reduce participants’ fatigue.

Conflict of Interests

None of the authors has financial or other relationships that would influence assessment of the data or that would constitute a conflict of interests.

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