



Original Article

Comparison of maximal tongue strength and tongue strength used during swallowing in relation to age in healthy adults

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Abstract. [Purpose] The aim of this study was to measure and compare the maximal tongue strength and tongue strength used during swallowing in young and older adults. [Subjects and Methods] The study recruited 80 healthy young (aged 20 to 39 years) and older adults (aged ≥ 65 years) in public places. The Iowa Oral Performance Instrument was used to measure maximal tongue strength and tongue strength used during swallowing. For each subject, the peak value of three measurements was recorded and analyzed. [Results] Maximal tongue strength was statistically significantly higher for the young adults group than the older adults group. Conversely, tongue strength used during swallowing was statistically significantly higher for the older adults group than the young adults group. The percentages of tongue strength used during swallowing for the young adults and older adults groups were approximately 38.8% and 53.8%, respectively. [Conclusion] This study confirmed that older adults have a lower maximal tongue strength than young adults, but a higher tongue strength used during swallowing.

Key words: Aging, Swallowing, Tongue

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INTRODUCTION

The tongue is a skeletal muscle of the stomatognathic system¹⁾. It is involved in normal swallowing and is responsible for bolus mastication, formation, and transport in the oral phase²⁾. Moreover, tongue strength contributes to safe swallowing by increasing intraoral pressure during transit of the bolus from the oral phase to the pharyngeal phase. Therefore, it is important to maintain appropriate tongue strength.

Decreased skeletal muscle strength, including the strength of the tongue, is a common age-related change caused by sarcopenia³⁾. Older adults are vulnerable to sarcopenia; in particular, individuals aged 60 years and older show considerable atrophy and loss of muscle mass⁴⁾. This leads to decreased tongue strength in older adults, which can cause sarcopenic dysphagia in the oral and pharyngeal phases, including premature spillage of the bolus into the pharynx, pharyngeal residue, and aspiration/penetration^{5, 6)}.

Several previous studies have reported that maximal tongue strength (MTS) is lower in older adults compared with young adults because it declines with the progression of age^{7, 8)}. However, during swallowing, the tongue does not use its maximal strength. The difference between the MTS and actual strength used is referred to as the reserve of strength. Previous studies related to tongue strength usually reported only MTS⁹⁾; therefore, it is unclear whether there is a difference between young adults and older adults in actual tongue strength used during swallowing (TSDS). The TSDS was defined as the average of the tongue strength during swallowing across three trials. The present study aimed to compare the MTS and TSDS of young

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adults and older adults living in the community.

SUBJECTS AND METHODS

In total, 80 subjects were recruited from public places and offered the opportunity to participate. They were divided based on age into a young adults group (male participant, n = 20; female participants, n = 20; age range, 20 to 29 years) and older adults group (male participants, n = 20; female participants, n = 20; age range, 65 to 80 years). The study ensured that the ratio of male to female participants was the same for the two groups, and the same number of samples was obtained. All subjects were healthy volunteers with no reported neurologic or structural damage affecting speech or swallowing function. Exclusion criteria included the following: significant malocclusion; facial asymmetry; parafunctional habit, such as clenching, bruxing, or tongue thrusting; and trigeminal neuropathy. All participants provided written informed consent. This study was approved by the Inje University Institution Review Board (2-1041024-AB-N-01-2015-HR-255).

The Iowa Oral Performance Instrument (IOPI) (IOPI Medical LLC, Carnation, WA, USA) was used to measure MTS and TSDS in all subjects. The IOPI includes a tongue bulb, connecting tube, and main body. The bulb, which is made of soft rubber and approximately 3.5 cm in length and 4.5 cm in diameter, is filled with approximately 2.8 mL of air. The bulb is connected to the IOPI main body by an 11.5-cm flexible tube⁷⁾. When strength is applied to the bulb, the liquid crystal display panel displays the strength value in kilopascals (kPa).

MTS was measured based on the method of a previous study⁷⁾ with the tongue bulb positioned longitudinally 10 mm posterior to the tongue tip. The subjects were instructed to push the bulb toward the hard palate with the tongue as hard as possible for 2 s. The instructions were as follows: *“I will place the bulb in your mouth. Please push the bulb as hard as possible for 2 s.”* During measurement, the subjects were verbally encouraged to give their best effort to achieve the MTS. To measure the TSDS, the bulb was placed in the same position as for MTS measurement. Following this, the mouth was gently closed, and the subject was instructed to swallow saliva normally so that the bulb was pushed between the tongue and the hard palate. The percentage of maximal tongue strength used during swallowing was defined as the quotient of tongue strength during swallowing divided by the MTS.

The outcomes were analyzed using statistical analysis software (IBM SPSS Statistics, Version 20), with descriptive statistics presented as the mean ± standard deviation. The independent t-test was used to compare the difference in outcome measures of the two groups. The significance level was set at $p < 0.05$.

RESULTS

All subject demographics are summarized in Table 1. Upon measurement, the young adult group had a significantly higher MTS than the older adults group (65.29 ± 5.64 kPa vs. 50.45 ± 6.67 kPa, $p < 0.05$). Conversely, the TSDS was higher for the older adults group than the young adults group (25.15 ± 4.12 kPa vs. 26.71 ± 4.23 kPa, $p < 0.05$). Also, when the percentages of TSDS were compared, the percentage was higher for the young adults group than the older adults group (38.8% vs. 53.8%, $p < 0.05$) (Table 2).

Table 1. Characteristics of participants

Characteristics	Young adults (n=40)	Older adults (n=40)
Age (years)	23.3±2.5	68.3±5.5
Gender, male/female	20/20	20/20
Height (cm)	162.4±9.5	160.2±6.7
Weight (kg)	58.4±7.7	63.6±8.2
BMI (kg/m ²)	22.7±1.6	24.1±1.9

The values are shown as the mean ± standard deviation

Table 2. Comparison of between young and older adults

Measurement	Young adults	Older adults
MTS (kPa)	65.29±5.64	50.45±6.67**
TSDS (kPa)	25.15±4.12	26.71±4.23*
TSDS/MTP x 100 (%)	38.84±7.5	53.89±11.18**

The values are shown as the mean ± standard deviation. MTS: maximal tongue strength; TSDS: tongue strength used during swallowing.

* $p < 0.05$, ** $p < 0.01$

DISCUSSION

Weakness of the tongue muscle is related to aging, and this is known to be closely related to sarcopenia. A weakened tongue muscle causes a variety of problems in the oral and pharyngeal phases, making normal swallowing difficult. Therefore, swallowing problems can occur even in healthy older adults with no neurologic disease, which is referred to as presbyphagia¹⁰.

In this study, when the MTS of the young adults group was compared with the older adults group, there was a significant difference between the two groups. This result was somewhat expected and was consistent with previous study results⁸. However, contrary to the MTS results, TSDS was significantly higher in the older adults group. Moreover, when TSDS was calculated as a percentage of the MTS, the young adults group was found to use approximately 38.8% of the maximal strength during swallowing, whereas the older adults group used 53.8%.

This study confirmed that MTS is affected by age, which is thought to be the result of age-related sarcopenia as reported by previous studies^{7, 8}. Aging leads to a decrease in muscle fibers and motor units, gradual denervation, and a decline in nerve conduction speed^{11, 12}. This causes a decline in muscle strength and, in particular, a clear decrease in MTS. However, this study revealed that the TSDS was higher in the older adults group than in the young adults group. Generally, during the process of swallowing, the tongue uses less than the MTS; the difference between the TSDS and its MTS is its reserve of strength. According to several previous studies, MTS decreases because of aging, but there is no difference in swallowing-related strength compared with that of young adults¹³, supporting the results of the present study. There is no exact explanation for why older adults have a higher TSDS than young adults, but it can be partially explained as follows. Older adults use various compensatory mechanisms to reinforce impaired swallowing-related functions and muscle strength. For this reason, older adults tend to show an increase in intrapharyngeal pressure during swallowing more than young adults¹⁴. In addition, compared with young adults, older adults have lower orofacial muscle (e.g., cheek, lip) strength and tone¹⁵. An overall decrease in orofacial muscle strength and tone is one of the reasons for weakening of intraoral pressure during swallowing. Similarly, the results of this study show that older adults use more TSDS than young adults to compensate for reduced swallowing-related strength in the oral and pharyngeal phases.

This study confirmed that MTS was higher in young adults than older adults. However, TSDS was higher in older adults; this is thought to be a compensatory mechanism to achieve safe swallowing. The results of this study can be used as foundational data for future treatment of age-related swallowing impairments.

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