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[原著]

Impact of differences in neck angle on tongue pressure and motor function of the tongue and lip in young, healthy people

Yukako Setaka[1)], Tasuku Watanuki[2)], Miwa Motomura[3)]

1) Department of Physical Therapy, Ibaraki Prefectural University of Health Sciences
2) Rehabilitation Center, Aizawa Hospital
3) Department of Nursing, Ibaraki Prefectural University of Health Sciences

Summary

Changes in the head and neck angle influence muscle activity and swallowing. However, the effects of these changes on tongue pressure and motor function of the tongue and lip are unknown. This study aimed to clarify the extent to which changes in neck angle bring about changes in tongue pressure and motor function of the tongue and lip in young, healthy people.

Twenty healthy individuals (mean age 20.3 ± 0.7 years) in a reclined sitting position of 45° had their neck angle set with three conditions: 30° neck flexion, intermediate position (0° flexion and extension), and 30° extension. Tongue pressure and oral diadochokinesis were measured in each posture.

The results revealed that the mean maximum tongue pressure was highest overall and for males and females at a mild 30°neck flexion. Additionally, there was a significant difference in tongue pressure for males between 30° neck flexion and 30° neck extension. The mean oral diadochokinesis was highest overall in the intermediate neck position overall and for both males and females. No significant differences were observed between each condition. Additionally, no significant differences between sexes were observed for tongue pressure and oral diadochokinesis.

The study's findings showed that temporary changes in neck angle hardly affected tongue pressure and motor function in the tongue and lip in young, healthy individuals. However, abnormal posture is developed gradually, so the effects of chronic posture need to be considered.

Keywords: tongue pressure, oral diadochokinesis, angle of the neck

Introduction

The tongue is an important organ involved in the oral cavity's mastication, swallowing, and speech functions. Particularly during mastication, the role of the tongue in the preparatory stage is to place the ingested food on the dentition on the left and right sides and mix the food with saliva 1). Then, during the oral stage, it transports the food

瀬高　裕佳子

〒300-0394　茨城県稲敷郡阿見町阿見 4669-2
茨城県立医療大学理学療法学科
e-mail: okunoyu@ipu.ac.jp

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bolus to the base of the tongue and pharynx 1). Deterioration of these functions contributes to dysphagia. When food remains in the oral cavity, the tongue cannot be pressed against the palate due to smooth tongue movement and reduced tongue lifting force, which is thought to be primarily due to the space created between the palate and the tongue 2). A study on patients with dysphagia reported a correlation between maximum tongue pressure and swallowing contrast findings in the oral cavity, bolus formation, bolus transport, and epiglottic vallecular residue 3). Maximum tongue pressure is vital for evaluating tongue movement and tongue lifting force. Additionally, a screening evaluation of eating and swallowing functions measured tongue pressure and oral diadochokinesis (ODK) as a functional evaluation of the tongue, introducing tongue muscle strengthening and vocal exercises for cases with deteriorated functions.

Posture significantly impacts eating and swallowing. Particularly among older adults, the time taken for bolus movement through the oral cavity and pharynx increases due to postural abnormalities such as scoliosis and hunched back, decreased masticatory function, and decreased saliva secretion 4). Changes in the head and neck angle also influence tongue pressure 5), muscle activity and swallowing dynamics during swallowing 6). However, the effects of these changes in the head and neck angle on maximum tongue pressure and motor function of the tongue and lip have not been clarified. In this study, we focused on the neck angle and sought to clarify the relationship between angle differences and tongue pressure and motor function in the tongue and lip.

Materials and Methods

1. Participants

The participants were 20 healthy volunteers (10 males, 10 females) without swallowing, respiratory, or oral function-related disorders. To select participants, we put up the posters requesting research cooperation on bulletin boards at our university and recruited the participants. Prior to the study, a nurse co-researcher conducted a medical check on the subjects and we excluded the subjects with the above disorders from our study. The participants' mean age, height, and weight were 20.3 ± 0.7 years, 165.5 ± 10.0 cm, and 57.5 ± 8.0 kg, respectively. For the males, the mean height and weight were 173.1 ± 6.0 cm and 63.0 ±5.6 kg; for the females, the mean height and weight were 157.9 ± 6.6 cm and 52.0 ± 6.1 kg. Before the experiments, the participants were provided verbal explanations of the study's purpose, methods, precautions, and data management method, and their consent for participating in the experiment was obtained. This study was approved by Ibaraki Prefectural University of Health Sciences Ethics Committee (No. 588).

2. Evaluation items

The measurement limb position was a reclined sitting position of 45°, which was generally used as the posture to prevent aspiration.

The neck angle was based on the joint range of motion established by the Japanese Orthopaedical Association and Japanese Association of Rehabilitation Medicine7, and set to the following three conditions: mild neck flexion (30° neck flexion), intermediate neck position (0° neck flexion and extension), and mild neck extension (30° neck extension). Pillows and towels were used during the measurement as needed to stabilize the

Figure 1.
Tongue pressure measurement device and probe

Figure 2.
Oral diadochokinesis measurement device

neck position, and care was taken to avoid muscle activity to maintain the measurement posture. The maximum tongue pressure and ODK were measured under these three conditions.

A tongue pressure measurement device (TPM-01; JMS, Tokyo, Japan) was used to measure the maximum tongue pressure (Fig. 1). We referred to the previous report 8) regarding the method for measuring tongue pressure and established the measurement method through our pilot study. This device consisted of a digital tongue pressure meter, connecting tube, and balloon-shaped tongue pressure probe (JF-TPP; JMS, Tokyo, Japan); the tongue pressure probe was connected to a digital tongue pressure meter with a connecting tube. Before measurements, the tongue pressure probe was calibrated by applying pressure outside the oral cavity. Afterward, the tongue pressure probe was inserted into the participant's oral cavity, the hard ring at the base of the probe between the upper and lower incisors was gently held to fix the lower jaw, and the probe was fixed between the front of the participant's tongue and hard palate. The pressure with which the participant pressed their tongue against the hard palate as hard as possible for 5-7seconds was then measured. Because of fatigue, measurements were conducted only twice in this study, and the higher value was adopted as the maximum tongue pressure value.

An oral diadochokinesis measurement device (Kenkou-Kun, Takei Scientific Instruments Co., Ltd., Japan) was used for ODK (Fig. 2). We referred to the previous report 9) for the measurement procedure and established the procedure through our pilot study. The

Table 1. Mean tongue pressure and ODK values under three conditions

	Neck angle	30° flexion	Intermediate position	30° extension
Tongue pressure (kPa)	Overall	44.97 ± 9.82	43.95 ± 7.62	43.18 ± 7.99
	Male	47.59 ± 7.61*	45.57 ± 7.64	44.70 ± 8.02
	Female	42.34 ± 11.42	42.33 ± 7.64	41.66 ± 8.08
ODK (count/second)	Overall	8.04 ± 0.80	8.20 ± 0.61	8.03 ± 0.75
	Male	8.26 ± 0.90	8.36 ± 0.58	8.08 ± 0.75
	Female	7.82 ± 0.66	8.04 ± 0.62	7.98 ± 0.80

*Significant difference between 30° neck flexion and 30° neck extension

measurement procedure was conducted by connecting a microphone to the device and using an oral five-second mode. In this mode, the four sounds of “Pa,” “Ta,” “Ka,” and “Ra” were uttered in succession for five seconds, and the number of sounds uttered per second was measured. The participants practiced twice, and then measurements were conducted three times under each condition, with the maximum value adopted.

The measurement order for each condition was randomly determined using a lottery by envelope method. We paid attention to the participants’ level of fatigue at all times and provided breaks as appropriate, and a break of at least 30 seconds was provided between each measurement. We set this break time based on the results of our pilot study.

A one-way analysis of variance (ANOVA) or the Friedman test was used to compare neck angle, tongue pressure, and ODK. The Mann–Whitney U test was used to compare tongue pressure and ODK between males and females. All statistical analyses were conducted using SPSS Statistics version 26 (IBM), and the significance level was set at 5%.

Results

Table 1 shows the mean tongue pressure and ODK values under the three conditions. The mean maximum tongue pressure was highest overall and for both males and females at 30° neck flexion. Furthermore, there was a significant difference between the pressures at 30° neck flexion and 30° neck extension only in males. There was no significant difference observed in females between each condition.

The mean ODK was highest overall and for both males and females in the intermediate neck position. No significant differences were observed between each condition. There were no significant differences according to sex.

Discussion

Swallowing motion is closely related to posture. Poor posture necessitates the swallowing muscles to stabilize posture, resulting in decreased swallowing motion. It is said that the neck being in an extended position can result in decreased swallowing function, including (a) laryngeal elevation failure and epiglottic inversion failure, (b) narrowing of pharyngeal cavity, (c) esophagus opening failure, and (d) tracheal expansion and increased risk of aspiration 10).

The standard values for tongue pressure in Japan are 45 ± 10 kPa for adult men (20-59 years old) and 37 ± 9.0

kPa for adult women (20-59 years old)11). The results of this study showed that the average values of tongue pressure were slightly exceeded at 0° neck flexion and extension and at 30°neck flexion in males. Furthermore, the that of tongue pressure were higher than the standard values11) under all conditions in females. It was showed that the young, healthy participants have sufficient tongue pressure.

The present study's results showed that tongue pressure was most likely to be exerted in the neck flexion overall and for both males, females, and overall. Hori 5) showed that chin-down posture increases the tongue pressure during bolus swallowing and the results of our study showed the similar trend. There was a significant difference between the pressures at 30° neck flexion and 30° neck extension only in males. There was no significant differences due to posture in females. because the standard deviation of tongue pressure at 30 degrees of neck flexion was larger.
It was easier to exert the tongue pressure in the neck flexion position because the base of the tongue is closer to the posterior pharyngeal wall. Regarding the neck extension position, the duration of muscle activity of the suprahyoid and infrahyoid muscles during swallowing in a previous study was prolonged at 40° extension, making swallowing difficult 6). In the present study, the angle change was limited to 30°, so measurements with an increased angle will be considered in the future. Furthermore, measurements in the present study were taken in a reclined sitting position. In the reclined sitting position, the pelvis tilts backward, which leads to a kinetic chain in which the lumbar vertebrae have decreased lordosis and the thoracic vertebrae have increased kyphosis, making it easier for the neck to assume an extension position 10). The sub hyoid muscle group is extended in this state, which limits the elevation of the larynx and the movement of the tongue. However, this is only a problem caused by continuous changes in posture. The young, healthy participants have sufficient muscle strength, and it can be said that the temporary changes in posture hardly affected tongue pressure and motor function in the tongue and lip.

Regarding ODK, only compound syllables were evaluated from the viewpoint of evaluating comprehensive motor function in the tongue and lip. ODK requires the smooth functioning of many muscle groups, including the muscles around the neck and lips, and the hyoid muscles.

The results showed that the intermediate neck position had the highest value overall and for both males and females because when the neck was in a flexed or extended position, these muscles also helped maintain posture. However, there were no significant impacts observed in changes in the neck angle, because the young healthy participants have sufficient neck and lips, and the hyoid muscles.

The continuous movement of the lips and tongue due to compound syllables exhibits dynamics similar to the preparatory and oral stages, from capturing food to transporting it to the pharynx 12). However, monosyllabic evaluation is generally used, with reference values 13) published for these cases. Evaluations using single syllables and examining the influence of changes in neck angle are needed in the future. Generally, tongue muscle strength decreases when the head shifts forward. The forward protrusion of the head has a major impact on the area around the

lower jaw, and positioning the head forward results in passive stretching of the sub hyoid muscles, such as the sternohyoid and omohyoid muscles, which pull the hyoid bone downward. The hyoid muscle, one of the external tongue muscles, is attached to the hyoid bone, and the downward deviation of the hyoid bone inhibits tongue movement 14). Furthermore, the shoulder joint flexion angle decreases as the head protrudes forward 15). Therefore, poor posture has various effects on tongue movement and eating movements that control eating utensils. We would also like to investigate the functions of the shoulders and upper limbs in the future.

This study had some limitations. The sample size was insufficient, limiting the generalizability of the results. The changes in posture under the measurement conditions of the present study were limited to temporary changes only in the neck, and the participants were young, healthy individuals with sufficient muscle strength. In addition, the measurements were taken in an experimental environment with the reclined sitting position of 45°. As a result, changes in the neck angle did not significantly affect tongue pressure and motor function of the tongue and lip. Furthermore, we only evaluated the performance under maximum effort in this study. Simulating the hunched position from the perspective of the kinetic chain, measuring tongue pressure when swallowing, expanding the age range of the population to include middle-aged and older people, and comparing these results with those of the present study will further clarify the mechanism of decreased swallowing and lip motor function due to poor posture.

Poor posture makes it difficult to transport the bolus and increases the risk of aspiration, so posture correction through positioning, tongue pressure, and lip movement training should be routinely conducted. Temporary changes in neck angle hardly affected tongue pressure and motor function in the tongue and lip in young, healthy individuals. Further research is needed to prevent aspiration and lead to more efficient approaches.

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頸部角度の違いが若年健常者の舌圧及び舌口唇運動機能に与える影響

瀬高　裕佳子[1)]，綿貫　佑[2)]，本村美和[3)]

1）茨城県立医療大学理学療法学科
2）相澤病院リハビリテーションセンター
3）茨城県立医療大学看護学科

要旨

本研究では、若年健常者において、頸部角度の変化により舌圧および舌口唇運動機能がどの程度変化するかを明らかにすることとした。

対象者は健常者 20 名(平均年齢 20.3±0.7 歳)で、リクライニング座位 45°の状態で、頸部屈曲 30 度、中間位（屈曲伸展 0 度)、伸展 30 度の 3 条件を設定した。それぞれの姿勢で、舌圧およびオーラルディアドコキネシスを測定した。

その結果、最大舌圧の平均は、全体および男性・女性ともに頸部軽度 30 度で最も高値を示した。また、男性の舌圧において、頸部屈曲 30 度と伸展 30 度との間で有意差がみられた。オーラルディアドコキネシスの平均は、全体および男性・女性ともに頸部中間位で最も高値を示した。なお、各条件間で有意差は認められなかった。また、舌圧とオーラルディアドコキネシス共に性別による有意差も認められなかった。

今回の結果より、若年健常者では一時的な頸部角度の変化によって舌圧および舌口唇運動機能への影響はほとんどみられないことが分かった。ただし、異常姿勢は徐々に構築されていくものであり、慢性的な姿勢の影響も考える必要がある。今後は中高齢者でのデータを蓄積し、異常姿勢との関連について検討を重ねたいと考える。

キーワード：舌圧、オーラルドコキネシス、頸部角度