

Research Article

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LIP-CLOSING FUNCTION OF ELDERLY PEOPLE DURING INGESTION: COMPARISON WITH YOUNG ADULTS

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ABSTRACT

In this study the relationship between the functional vertical labial pressure and aging during ingestion in the elderly is examined. The subjects were 84 community-dwelling elderly (mean: 79.4 years old), 109 elderly needing long term care (mean: 81.3 years old), and 59 healthy young adults (mean: 32.0 years old) as control. Labial pressure was measured with a pressure sensor embedded in acrylic plate. There was no correlation between age and labial pressure or the coefficient of variation of labial pressure during ingestion. In people with a history of "choking on food", labial pressure was, however, significantly lower ($p < 0.01$) than people without a history of "choking on food", while the coefficient of variation of labial pressure was significantly higher ($p < 0.05$). Poor labial pressure and movement were noted in subjects who experienced "choking on food", suggesting that lip-closing function also plays an important role in the pharyngeal stage of feeding/swallowing. On the other hand, the coefficient of variation of labial pressure during ingestion was not changed in the elderly group in comparison to the control group. These results showed that skilled movement of lip-closing might be compensated by labial pressure. Labial pressure and skilled movement were, however, decreased in the elderly needing care because of "choking on food".

Key words: Lip-closing Function; Elderly; Ingestion; Labial Pressure

INTRODUCTION

Body functions including feeding/swallowing are susceptible to change with aging (Baum, & Bonder, 1983; McHenry et al., 1999; Sheth, & Diner, 1988; Tomita et al., 2002). Feeding or swallowing function occurs through the coordinated movement of various organs such as the tongue, lips, and pharynx. Among the organs associated feeding/swallowing, the function of the tongue and masticatory muscles decreases with aging (Baum, & Bonder, 1983; McHenry et al., 1999; Sheth, & Diner, 1988). Feeding/swallowing function consists of a series of processes starting with the anticipatory stage when food is taken into the mouth by the lips, and concluding when food reaches the stomach (Leopold, & Kagel,

1983). Lip-closing movement plays an important role in these processes, from ingestion to swallowing (Kaneko, Mukai, & Omoto, 1987). The lips are closed by vertical and horizontal muscle pressure. However, the majority of previous studies investigated only the horizontal labial pressure, which is related to preservation of tooth alignment or denture stability (Floystrand, 1986; Newman, Barnes, & Newman, 1983), and few studies have elucidated the relationship between labial pressure and feeding/swallowing function (Chigira et al., 1994; Takahashi, & Mukai, 2002; Tamura et al., 2004; Tomita et al., 2002). Swallowing is associated with mandibular-closing movement, but the

relationship between mandibular-closing movement and lip-closing movement is unknown. We previously reported that lip-closing pressure of people with an edentulous jaw at the time of swallowing was greater without dentures compared with the pressure when they wore dentures (Tamura et al., 2004).

Baum et al. (1983) reported that the number of people who experienced decreased functional changes in the lips increased with aging. On the other hand, Fucile et al. (1998) reported that functional eating ability did not decrease in healthy elderly people aged 60 to 97 years old. Furthermore, Tomita et al. (2002) reported in their study of the vertical labial pressure that there was no difference in labial pressure and the maximum labial pressure during swallowing between an elderly group with a dentulous jaw and a young adult group.

However, it has not been elucidated how lip-closing function correlated with aging. Thus, the relationship between lip-closing function and aging in the elderly during ingestion was examined in this study.

METHODS

Subjects

The subjects were 84 community-dwelling elderly people who participated in a health seminar (Elderly group: 27 men and 57 women with mean age of 79.4 years old) and 109 elderly people needing care and living in a nursing care facility in Tokyo (Elderly needing care group: 41 men and 68 women with mean age of 81.3 years old). The criteria for the levels of nursing care set by the Japanese Ministry of Health, Labor and Welfare, which are shown in Table 1, were employed. The control group consisted of 59 healthy young adults who had no stomatognathic abnormality (Young adult group: 23 men and 36 women with mean age of 32.0 years old).

This study employed the Eichner classification (Eichner, 1955). The selected subjects were classified into level A1 - B1, in which three or more occlusal supporting areas in both jaws were preserved.

Prior to this study, the objective, method, and expected outcome of this study was explained to the subjects orally and in writing. Their consent was obtained. The procedures used comply with the protection of human rights. This study was approved by the Ethics Committee of the Nippon Dental University, School of Life Dentistry at Tokyo.

Measurement method of labial pressure during ingestion

A strain gauge type of pressure sensor was employed in this study. This sensor was originally developed to measure pressure of fluid and pressure in containers, also widely used in dental research. A strain gauge pressure sensor is appropriate for measurement of the pressure of soft tissue such as the lips and tongue (Chigira et al., 1994; Floystrand, 1986; McHenry et al., 1999; Ono, Hori, & Nokubi, 2004; Takahashi, & Mukai, 2002; Tamura, & Suzuki, 2004).

A measurement device made of acrylic plate with 20 mm width, 150 mm length, and 2 mm thickness, in which a strain gauge type of pressure sensor was embedded, was used to measure labial pressure. The center of the pressure sensor of labial pressure measurement system was embedded 20 mm from the end of the oral cavity side of the plate, and fixed with wax. The sensor was connected to an instrumentation amplifier (WGA-710A, Kyowa Electronic Instruments Co., Ltd., Japan) using a waterproof small pressure transducer with 6 mm diameter and 0.6 mm thickness (PS-2KA, Kyowa) (Chigira et al., 1994) (Fig. 1). Labial pressure during ingestion was measured at the center of the lips. The system was soaked in a water bath at 37°C just before measurement to prevent any effect of temperature change on the pressure sensor. Figure 2 shows the measurement method of the vertical labial pressure between upper and lower lips. The examination was performed while the subjects were sitting. Before starting the examination, the subjects were asked to "eat 1 g of yogurt placed at the end of the measurement device 'as usual', and the vertical labial pressure was measured five times. In terms of the measurement method used in this study, it was expected that the state of mind of the

subjects may significantly influence lip-closing function during ingestion, because the function is voluntary. For this reason, attempts were made to make the subjects feel as relaxed as possible and encouragement was given to them by saying, "Please eat the yogurt as usual", to reassure them and allow them to eat calmly. Furthermore, the yogurt on the measurement device was brought to their mouths horizontally. The device was then withdrawn without changing the angle after the yogurt was eaten, because labial pressure might be influenced by the angle of the device on the lower lip

Data Analysis

In order to examine the skilled movement of lip-closing function during ingestion, the mean

of the 5 repetition was represented as a reading from each subject. The coefficient of variation was obtained to indicate the data variation. Poor skill of movement is indicated by a lower coefficient of variation (Chigira et al., 1994).

Using the data obtained, the statistical significance of differences between the age groups and sex was analyzed using Mann-Whitney U-test, and the correlation between the measurement values was analyzed using Spearman's rank correlation coefficient. Statistical analysis was conducted using SPSS version 9.0J. The significant level in this study was $p < 0.05$.

Table 1. Certification of eligibility for long-term care	
Care level	Criteria for care level
Needing support 1	Slight decline in physical function in some activities of daily living due to impairment, but will improve with preventive support.
Needing support 2	Partial decline in physical function in some activities of daily living due to impairment, but will improve with preventive support.
Needing care 1	Observation and/or assistance needed for all activities of daily living. Support needed for standing up and walking.
Needing care 2	Observation and/or assistance needed for all activities of daily living. Support needed for standing up and walking. Observation and/or assistance needed for eating and toileting.
Needing care 3	Cannot take care of oneself or stand up by oneself. General care needed for toileting, etc.
Needing care 4	Considerable decrease in activities of daily living. General care often needed. Problematic behavior or decreased comprehension.
Needing care 5	Significant decrease in activities of daily living. General care needed. Much problematic behavior or significantly decreased comprehension.

Figure 1 Pressure transducer and instrumentation amplifier to measure labial pressure. An acrylic plate, in which a strain gauge type of pressure sensor was embedded, was connected to an instrumentation amplifier.



Figure 2 Measurement of labial pressure. The subject was seated and the examiner helped the subject to eat, in order to measure labial pressure during ingestion.



RESULTS

Relationship between measurement results and age

There were no significant differences between the under age of 65-year old group and aged 65 or over group (unpaired t-test) (Fig. 3-A and 3-B). The relationship between age and labial pressure during ingestion or the coefficient of variation of labial pressure during ingestion was investigated in all subjects using Spearman's rank correlation coefficient. There was no correlation between age and labial pressure.

Neither was there a correlation for the coefficient of variation of labial pressure during ingestion.

Difference in sex in labial pressure during ingestion and coefficient of variation of labial pressure during ingestion

1) Labial pressure during ingestion

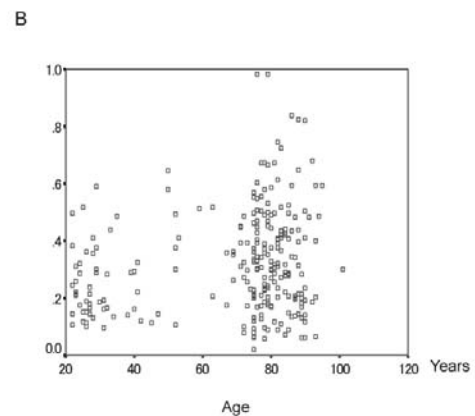
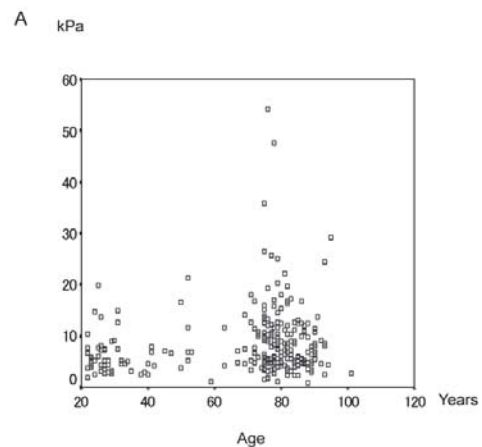
The mean value of labial pressure during ingestion was 6.6 ± 4.2 kPa in the control group (men: 8.0 ± 5.3 , women: 5.7 ± 3.2), 11.2 ± 8.9 in the elderly group (men: 10.5 ± 8.7 , women: 11.3 ± 8.9), and 7.9 ± 4.8 in the elderly needing care group (men: 8.5 ± 5.0 , women: 7.6 ± 4.7). There was no significant difference in sex among all groups (Fig. 4).

2) Coefficient of variation

The mean value of the coefficient of variation of labial pressure during ingestion was 0.26 ± 0.14 in the control group (men: 0.25 ± 0.12 , women: 0.27 ± 0.21), 0.34 ± 0.17 in the elderly group (men: 0.37 ± 0.21 , women: 0.32 ± 0.14), and 0.34 ± 0.19 in the elderly needing care group (men: 0.36 ± 0.18 , women: 0.34 ± 0.21). There was no significant difference in sex among all groups (Fig. 5).

Figure 3-A Labial pressure during ingestion and age. There was no significant difference between under age of 65-year old group and aged 65-year old or over group in labial pressure during ingestion.

Figure 3-B Coefficient of variation of labial pressure during ingestion and age. There was no significant difference between under age of 65-year old group and aged 65-year old or over group in coefficient of variation of labial pressure during ingestion.



Relationship between lip-closing function and “spilling food” and “choking on food” in elderly people during ingestion

The relationship between events such as “spilling food” and “choking on food” and labial pressure during ingestion or the coefficient of variation of labial pressure during ingestion was investigated in the elderly group. No significant relationship between “spilling food” and labial pressure during ingestion or the coefficient of variation of labial pressure during ingestion was noted. However, labial pressure during ingestion and the coefficient of variation of labial pressure during ingestion were significantly lower ($p < 0.01$) in subjects with “choking on food”; and significantly higher ($p < 0.05$) in subjects without “choking on food” (Fig. 6-A and 6-B).

DISCUSSION

Labial pressure during ingesting yogurt and the coefficient of variation of labial pressure were determined and discussed in order to elucidate the effect of aging on labial pressure in this study. The variability in the distribution indicated individual differences in labial pressure. Labial pressure during ingestion during the developmental stage increases with age (Chigira et al., 1994; Floystrand, 1986), and therefore, it was expected that labial pressure would decrease from its peak in adulthood, in a manner similar to other physical organs. However, in contrast to this assumption, the results of this study revealed that the vertical labial pressure during mastication was less likely to be influenced by aging. Considering that tongue pressure decreases with age (Fucile et al., 1998), it is speculated that labial pressure might be maintained to compensate for the weakness of tongue pressure.

Before commencement of this study, it was postulated that labial pressure during ingestion in the elderly group would be lower than that in the young adult group because of decreased function with age. However, the results showed that labial pressure in the elderly

subjects was similar to that in young adults. The results suggested that lip-closing function would be maintained during the aging process to preserve feeding/swallowing function in place of the weakened tongue function because tongue function could decrease with age.

The coefficient of variation of labial pressure during ingestion did not change in the elderly group in comparison to the control group. The elderly group even demonstrated a higher coefficient of variation than the control group although a significant difference was not found. It was suggesting that the reduced skilled movement of lip function with aging was compensated for by the increase in labial pressure. The elderly might have used their lips as an instrument to catch and hold food. Inagaki (1993), reported that young people in recent years have decreased in their physical strength, which may have an effect on their labial pressure and resulted in their demonstrated labial strength similar to the labial strength showed by the elderly.

The elderly needing care group had relatively lower labial pressure during ingestion and poorer skilled movement. This was also indicated by the low coefficient of variation compared to that in the control group and the elderly group, although no significant difference was found. Once the elderly fall into a state of needing care, their worsened general status may have an influence on lip-closing function.

A limitation of this study was not determining interlabial maximal pressure. If maximal interlabial pressure during ingestion of food was low, especially in the young subjects, it could indicate that those subjects may have very efficient mechanisms. If this happens in the elderly, it could mean that they might use a larger percentage of their total lip-strength capacity, which might result in fatigue.

In a previous study the authors reported that events such as “spilling food” and “choking on food”, which may involve lip-closing function, influence life prognosis (Kikutani et al., 2006).

Figure 4 Effect of sexual difference on labial pressure during ingestion. There was no significant difference in sex among all groups.

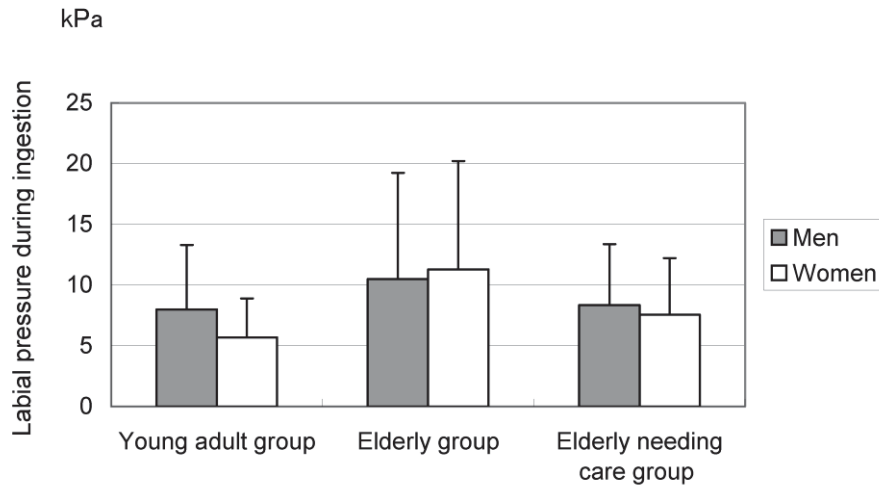


Figure 5 Effect of sexual difference on coefficient of variation of labial pressure during ingestion. There was no significant difference in sex among all groups.

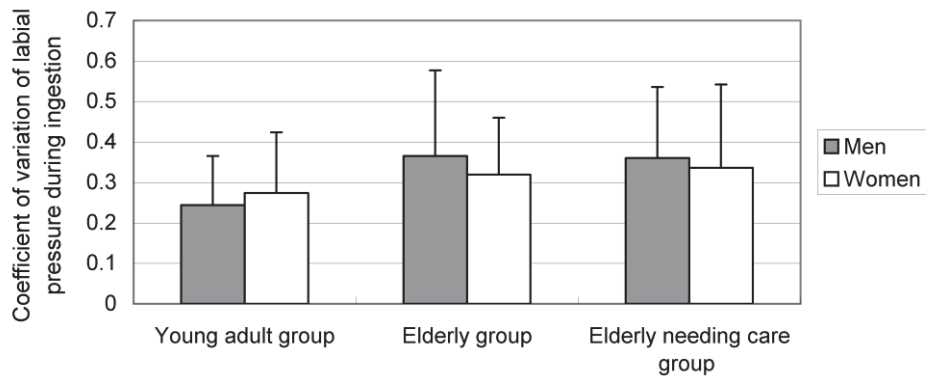


Figure 6-A Relationship between “spilling food” and lip-closing function during ingestion in elderly group. No significant relationship between “spilling food” and labial pressure during ingestion or the coefficient of variation of labial pressure during ingestion was noted.

A

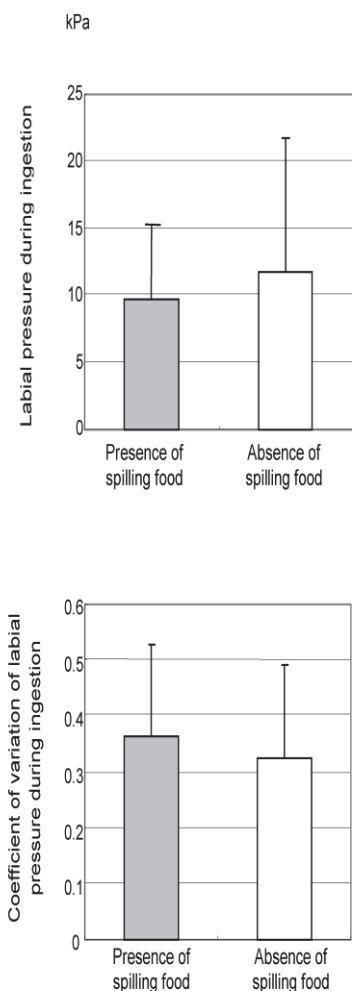
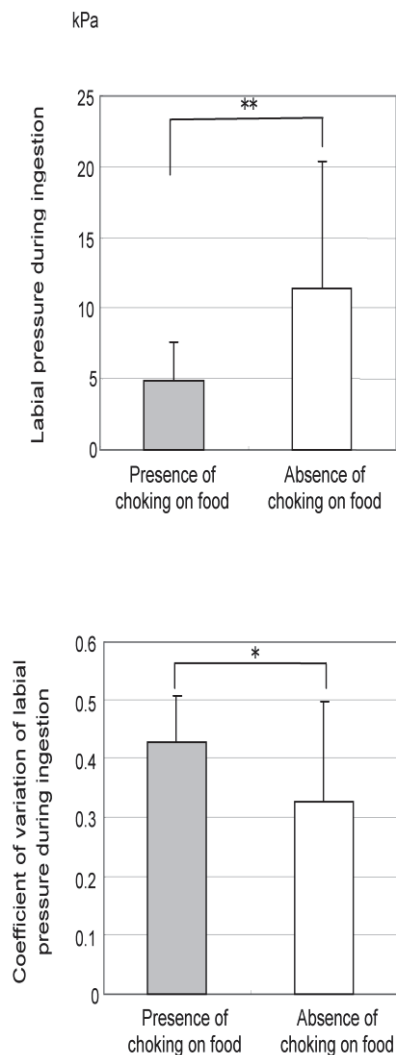


Figure 6-B Relationship between “choking on food” and lip-closing function during ingestion in elderly group. Labial pressure during ingestion and the coefficient of variation of labial pressure during ingestion were significantly lower ($p < 0.01$) and significantly higher ($p < 0.05$), respectively.

B



This promoted the current investigation of the relationship between lip-closing function during ingestion and these events in the elderly group. It was expected that “spilling food” is closely related to lip-closing function, however, there was no significant difference between the groups.

The results suggested that “spilling food” might not be caused by lower labial pressure and poorer skilled movement of the elderly. The elderly who presented with “choking on food”, having an impairment at the pharyngeal stage, showed significantly lower labial pressure and poorer skilled movement. This suggests that lip-closing function may also play an important role at the pharyngeal stage of the feeding or swallowing process. Considering that “spilling food” and “choking on food” are indicators of life prognosis (Kikutani et al, 2006), the maintenance and promotion of lip-closing function may be crucial factors for the prevention or recovery of feeding/swallowing dysfunction in patients with lip-closing dysfunction - which is one cause of feeding/swallowing impairment. Another limitation of the current study is the lack of middle aged individuals and/or children. It is important to carry out further studies including more individuals who are in their 40’s and 50’s or children, by means of a cross-sectional study to elucidate changes in labial pressure

in each generation from children to the elderly. Furthermore, the effect of the presence or absence of dentures on labial pressure during ingestion was determined in edentulous patients by Kawamura (1979). The existence of excess pressure on lip closing was found in persons who had lost posterior occlusal support. The subjects in this study were limited to people with Eichner classification A1 - B1, and therefore, further studies will be needed to examine the relationship between the status of remaining teeth and lip function. Although the eligibility criteria employed in this study eliminated the effects of morphological changes, such as jaw position and/or missing teeth on the data obtained in this paper, the horizontal labial pressure is also influenced by lip morphology (Kawamura, 1979). Lip morphology was not examined in this study. We plan to classify lip morphology and further investigate its relationship in the future.

CONCLUSION

This study indicated that the vertical labial pressure was compensated for by greater power in place of weakened skilled movement with age. However, both skilled movement and labial pressure may decrease in the elderly needing care.

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