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Dynamic Effects of Food Consistency on Chewing Motions

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A B S T R A C T

The purpose of the study was to find evidence of how different types of food consistency affect chewing motions, especially the forward, downward and sidewise extents of motion of the lower jaw. Nineteen individuals with intact tooth sequence, aged from 20 to 37 years, were asked to chew three types of food of different consistency (banana, bread, carrot). The motions of the lower jaw were recorded by ELITE system, i.e. the measurement instrument that by stereo-photo-grametric procedures calculates space co-ordinates of markers on faces of the study subjects. The system enables continuous recording of lower jaw motions in three dimensions, without any possibility of the study subjects' influencing the operation of the instrument, which significantly decreases the possibility of error. Study results have shown that in all 19 subjects a greater food consistency increases the extent of chewing motion. In each individual study subject different average values were found for equal shifts of lower jaw when chewing the same type of food. Although varying from subject to subject, the chewing cycle depends to a great extent on food consistency. By increasing the consistency of a bite, the extent of lower jaw motion has increased in every single study subject.

Introduction

Chewing is a complex process of tearing food into smaller particles and its preparation for deglutition and digestion, during which lateral motions prevail, while other motions are of lesser importance[1–8]. Many authors have so far inves-

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tigated the effects that food consistency produces on chewing motions. Using food of different types of consistency, modes of chewing have been studied and so was their influence on chewing efficiency[8–10]. It has been proved that the mode of chewing changes with regard to the type of food consistency. When chewing solid food the closing motions of the mouth get much more lateral, while during chewing soft food lateral motions are quite rare[1,11].

In 1996 Shiau et al.[12] studied electromyographic activity of the masseter muscle by standard test food of different consistency and confirmed that the increased food consistency almost simultaneously increased muscle activity, mostly manifested as prolonged duration of muscle contractions[13,14].

Mohamed et al.[15] in 1996 studied the number of chewing motions during chewing of banana, peanut and apple; they also found out that by increasing food consistency the number of chewing motions in a chewing cycle also increased.

Subjects and Methods

The study was carried out in 19 subjects (12 men and 7 women) aged from 20 to 37 years. All of them had complete tooth sequence with the exception of those in whom the third molars were absent.

Recording was made by the ELITE measurement system, i.e. by stereo-photo-grametric procedures that enable the follow up and defining space co-ordinates of specific marking points in human body or some other object at simultaneous processing of the recorded signal in real time. As the system follows only the motions of specifically marked points in the body, and not the whole body, passive markers were placed on the faces of our subjects and covered by reflecting material capable of reflecting infrared rays. The 1 cm sized markers were positioned on the side of the face that the study subject defined as a chewing one in the following sequence:

- marker no. 1: philtrum nasi
- marker no. 2: the region between the upper first and second molar at the level of tooth crown
- marker no. 3: the lower edge of mandibular trunk in the region between the first and second lower molars
- marker no. 4: the lower edge of mandibular trunk in the region between the first and second lower premolars
- marker no. 5: gnathion (the lowest point of the mental symphysis).

During recording the subject's head was leaning on back of the chair and was additionally fastened in order to avoid head motions and reduce recording errors. Following test recordings, during which the study subjects were only performing chewing motions but without food, recordings were made of chewing in the way that each study subject was chewing for five times three types of food of different consistency. The following food types were used for study purposes:

- soft food – banana,
- food of moderate consistency – white bread,
- solid food – carrot.

All three types of food were cut in slices of the same size that made one mouthful. The recording was commenced when the lower jaw was at maximum intercuspidation position. In the course of chewing the study subjects were not receiving any additional instructions, while recording lasted until the moment of swallowing of food and returning of the lower jaw to the intercuspidation position. Chewing of banana was recorded for 15 seconds, of bread for 20 seconds, and carrot for 25 seconds.

TABLE 1
AVERAGE VALUES OF LOWER JAW MOTIONS IN STUDY SUBJECT NO. 18 (MM)

	Forward	Downward	Sidewise
Banana	2.98	8.18	3.03
Bread	3.23	8.51	3.27
Carrot	4.01	9.18	4.01

During data processing by Microsoft Excel software program it was decided to follow the course of marker no. 5, i.e. the one positioned in the gnathion region. Other markers were the control ones so that their position within the reference co-ordination system indicated accuracy of measurement.

The course of marker no. 5 was followed with regard to axis x, y and z, i.e. their declinations from the position of maximum intercuspidation forward, downward and sidewise within the entire chewing cycle. Since the recording frequency was 50 Hz, a great number of data were obtained during recording indicating the position of markers in the coordinate system in a given moment. The average extent of the lower jaw forward, downward and sidewise motions was calculated in the middle of the chewing cycle, whereas the initial and final hundred frames were excluded.

Results

The average forward motion of the lower jaw in all 19 study subjects was 2.65 mm when chewing banana, 2.96 mm when chewing bread, and 3.64 mm when chewing carrot.

The average downward motion of the lower jaw in all 19 study subjects was 6.79 mm when chewing banana, 7.17 mm when chewing bread, and 8.09 mm when chewing carrot.

The average sidewise motion of the lower jaw in all 19 study subjects was 2.46 mm when chewing banana, 2.80 mm when chewing bread, and 3.40 mm when chewing carrot.

Table 1 contains average values of forward, downward and sidewise motions of the lower jaw for our study subject no. 18. His average extent of forward motion when chewing banana was 2.98 mm, when chewing white bread it was 3.23 mm, and it was 4.01 mm when chewing carrot. The average value for downward motion of the lower jaw was 8.18 mm when chewing banana, 8.51 mm when chewing bread and 9.18 mm when chewing carrot. The average extent of sidewise motion of the lower jaw in the same study subject was 3.03 mm when chewing banana, 3.27 mm when chewing bread, and 4.01 mm when chewing carrot.

In Figure 1 the average values of the lower jaw sidewise motions are presented for all 19 study subjects when chewing three types of food of different consistency.

Discussion

In the majority of studies carried out so far the motions of the lower jaw were strictly controlled by the use of instruments of different precision and sensitivity. The use of such instruments during recording of the chewing cycle often interferes with normal spontaneous chewing[1,16–19]. Therefore, in our study a highly sophisticated instrument was used that enables continuous recording of the lower jaw motions in three dimensions without any influence of the study subject upon the instrument, in which way the possi-

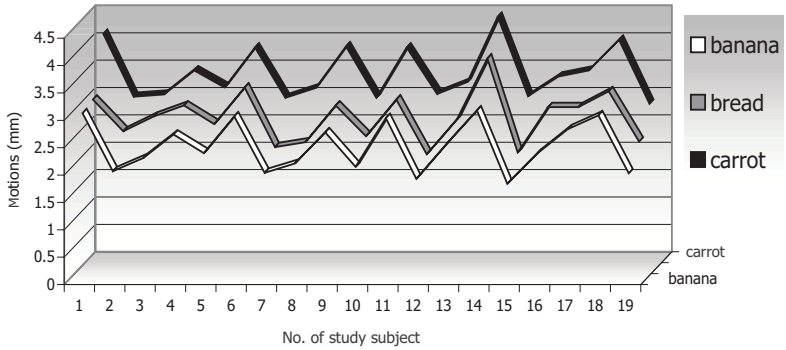

Fig. 1. The average values of lower jaw sidewise motions for each individual study subject when chewing food of different types of consistency (mm).

bility of error was significantly reduced. The entire chewing cycle was followed, from the moment of taking a mouthful until swallowing and returning of the lower jaw into the position of maximum intercuspidation.

A great number of authors have been studying the chewing motions »on empty mouth«, i.e. without using food[20–23]. Based on the assumption that food consistency significantly affects the extent of motion during chewing, in our study we used three types of food of different consistency.

The obtained results have proved that food consistency influences the lower jaw chewing motions, especially the extent of forward, downward and sidewise motions. The complex process of chewing depends on many factors, whereas the mode of chewing is an entirely individual trait. Different average values of the same motions of the lower jaw on chewing the same type of food have been found in our study subjects. Although each study subject exhibited his/her own individual mode of chewing and diversity in the extent of motions, in all 19 subjects it could be clearly seen that the increase in food consistency increased the extent of the chewing motion.

Conclusions

- The extent of the lower jaw motion increases with food consistency.
- The size of mouthful and its consistency determine the number of chewing motions within a chewing cycle.
- The average extent of the lower jaw forward motion in all 19 subjects when chewing soft food is 2.65 mm, when chewing medium consistency food it is 2.96 mm, and it is 3.64 mm when chewing solid food.
- The average extent of the lower jaw downward motion in all 19 subjects is 6.79 mm when chewing soft food, 7.17 mm when chewing medium consistency food, and 8.09 mm when chewing solid food.
- The average extent of the lower jaw sidewise motion in all 19 study subjects is 2.46 mm when chewing soft food, 2.80 when chewing medium consistency food, and 3.40 mm when chewing solid food.
- The chewing cycle of each individual is a specific one.
- The chewing cycle is a complex process dependent on many factors, in particular on food consistency.

- Despite individual characteristics of chewing, food consistency significantly changes the course of motion in the lower jaw and in the entire chewing cycle.

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DINAMIČKI UTJECAJI KONZISTENTNOSTI HRANE NA ŽVAČNE KRETNJE

SAŽETAK

U našem smo istraživanju željeli dokazati kako različita konzistentnost hrane značajno utječe na žvačne kretnje, posebice na veličinu pomaka donje čeljusti prema naprijed, dolje i u stranu. Devetnaest ispitanika s intaktnim zubnim nizom od 20 do 37 godina, žvakalo je tri vrste hrane različite konzistencije (banana, kruh, mrkva). Pomaci donje čeljusti snimljeni su sustavom ELITE, mjernim instrumentom koji stereofotogrametrijskim postupcima izračunava prostorne koordinate markera postavljenih na licu ispitanika. Ovaj sustav omogućava kontinuirano snimanje kretnji donje čeljusti u tri dimenzije, bez ikakvog utjecaja ispitanika na aparaturu, čime se značajno smanjuje mogućnost pogreške. Rezultati istraživanja pokazuju kako u svih 19 ispitanika povećanje konzistentnosti hrane uzrokuje i povećanje opsega žvačnih kretnji. Kod svakog su ispitanika pronađene različite prosječne veličine istovjetnih pomaka donje čeljusti prigodom žvakanja iste vrste hrane. Žvačni ciklus premda različit u raznih ispitanika, uvelike ovisi o konzistentnosti hrane. Povećanjem konzistentnosti zalogaja, opseg se pomaka donje čeljusti povećava u svakog ispitanika.