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Mastication Patterns in Humans: Gender Differences

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Nineteen young healthy subjects were offered a morsel of hard (walnut) and soft (cake) food, while surface EMG was recorded bilaterally from the *masseter* muscles. The duration of the entire sequence of chewing, chewing rate, number of chewing cycles, time/cycle ratio, and mean and maximum EMG amplitudes of the above muscles were compared in women and men (n = 12 and 7, respectively). The duration of the whole chewing sequence for the soft food and duration of a single chewing cycle for both food types were significantly longer in women (P = 0.000). The masticatory frequencies for both food types were significantly greater in men (soft food: 0.98 ± 0.18 and 1.79 ± 0.18 sec^{-1}, hard food: 1.25 ± 0.29 and 2.03 ± 0.32 sec^{-1} in women and men, respectively; P = 0.000). The numbers of chewing cycles for both food types were statistically similar (P = 0.38 and P = 0.67). The mean and maximum EMG amplitude were found to be nearly similar in women and men, except that the mean amplitude of the right EMG at soft food chewing was significantly higher in men (P = 0.02). Thus, chewing in women occurs, in general, more slowly, while *masseter* muscle activities are rather similar. The food consistency exerts a mild overall influence on the gender differences of chewing.

Keywords: chewing pattern, *m. masseter*, EMG, sex-related difference, food texture, chewing rate, masticatory duration

INTRODUCTION

Like other complex cyclic motor phenomena, chewing is principally controlled by the motor output of the neuronal network qualified as a central pattern generator (CPG). In the case of chewing, this generator is localized at the brainstem level. The parameters of cyclic chewing activity are affected (modulated) by a number of factors including, in particular, anatomical, biomechanical, and psychological ones.

Chewing is a regular obligatory behavioral act performed by animals and human beings in the course of feeding. The influence of gender on such an important routine activity as chewing is worth studying in detail from the neurological, physiological, and behavioral aspects. Gender differences in chewing patterns have been reported in a few previous studies as regards the durations of the whole masticatory sequence or of single chewing cycles, number of these cycles, masticatory frequency (or chewing rate), time/cycle ratio (which can be considered an index of the chewing vigor), and electrical activity of the masticatory muscles (which is closely related to the masticatory force) [1–8]. There are some inconsistencies among the results of these studies. Some authors reported no gender difference in the duration of masticatory sequence and cycles [1, 2, 5], while others described the existence of significant differences [3, 4, 6]. Besides these controversies, there are seemingly some other issues of the context not investigated so far, as one would have expected. In the literature, we found no intergender cooperative study of this motor phenomenon with respect to various food textures (or food consistencies). It has been shown that the food texture affects durations of the chewing sequence and cycles, cycle number, and chewing rate [6, 7].

The aim of our investigation was to compare the chewing patterns for various food textures between the two sexes in humans. Moreover, we focused our attention on the behavioral and psychological discussion of the gender differences in chewing, which has not been adecuately described in the literature.

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METHODS

Nineteen young healthy subjects, 12 women and 7 men, age 19.42 ± 2.27 years (mean ± s.d.) participated in this study. None of the subjects exhibited any signs of jaw dysfunction or any symptomatic dental or chewing problem. All subjects were familiarized with the experiments; to reduce bias, explanations were given with no emphasis on the assessed chewing patterns. Each subject ate a piece of walnut (hard food) and a piece of cake (soft food), while surface EMGs were recorded bilaterally from the *masseter* muscles (Biometrics Ltd, Cwmfelinfach, Gwent, Great Britain). The instrument had a device containing two irremovable electrodes with a fixed distance between them; these sets were placed on the skin by special removable labels steadying the electrodes. Before starting the experiment of chewing the food, the subjects were asked to clench their teeth with the greatest force, and the respective EMG samples were recorded. The pattern of EMG waves occurring during chewing was used to identify the chewing cycles and then to analyze different parameters of the chewing pattern. The parameters, including the durations of the whole sequence of chewing and of the separate chewing cycles, chewing rate, numbers of chewing cycles, and mean and maximum EMG amplitudes of the *masseter* muscles (characterizing the force of the chewing movements), were compared in the two genders while chewing the two food types.

Statistical Procedures. Primary analysis of EMG activity of the *masseter* muscles was done by the EMG software of the mentioned electromyographic set used. Further descriptive and analytical statistics were calculated by SPSS15. To compare the parameters of the chewing patterns of the two genders, the *t*-tests were performed. Values of $P < 0.05$ were considered indicators of statistically significant differences. All numerical data are presented as means ± s.d.

RESULTS

The mean duration of the whole chewing sequence for the soft food was 71.08 ± 11.41 sec in women and 37.09 ± 5.88 sec in men (i.e., significantly longer in women, $P = 0.000$). For the hard food, the respective values were 28.58 ± 15.87 sec in women and 19.20 ± 2.04 sec in men, with a clear trend but insignificant difference ($P = 0.06$), as is shown in Fig. 1A.

The mean duration of a single chewing cycle (time/cycle ratio) for the soft food was 1.06 ± ± 0.24 sec in women and 0.56 ± 0.06 sec in men (statistically longer in women, $P = 0.000$). For the hard food, these were 0.87 ± 0.34 sec in women and 0.51 ± 0.09 sec in men (again significantly longer in women, $P = 0.01$, Fig. 1B).

The mean masticatory rate for the soft food was 0.98 ± 0.18 sec^{-1} in women and 1.79 ± 0.18 sec^{-1} in men, statistically greater in the latter ($P = 0.000$). For the hard food, it was 1.25 ± 0.29 sec^{-1} in women and 2.03 ± 0.32 sec^{-1} in men, again significantly higher in men ($P = 0.000$), as presented in Fig. 1C.

The mean number of chewing cycles for the soft food was 69.17 ± 16.37 in women and 66.14 ± 11.89 in men, i.e., nearly similar in the two genders ($P =$ $= 0.38$). For hard food, it was 32.17 ± 6.51 in women and 38.71 ± 5.94 in men, again rather close to each other in the two genders ($P = 0.67$), as presented in Fig. 1D.

Mean and maximum electrical amplitudes were statistically similar in the two genders, except for the right mean amplitude at the soft food (Table1).

Examples of EMG recordings of a male subject and a female subject are shown in Fig. 2.

Table1. Amplitudes of EMGs Recorded from the *Masseter* Muscles in Men and Women During Chewing of the Two Food Types.

Amplitude	Hard food			Soft Food		
	Women	Men	*P*	Women	Men	*P*
Right mean	0.05 ± 0.09	0.12 ± 0.16	0.21	0.03 ± 0.01	0.18 ± 0.21	0.02
Left mean	0.07 ± 0.11	0.04 ± 0.02	0.47	0.03 ± 0.01	0.14 ± 0.20	0.07
Right max	0.53 ± 0.32	0.39 ± 0.16	0.29	0.46 ± 0.24	0.50 ± 0.24	0.69
Left max	0.39 ± 0.16	0.38 ± 0.23	0.98	0.39 ± 0.16	0.38 ± 0.24	0.85

Footnote: means ± s.d. are shown; P values for the gender differences are indicated.

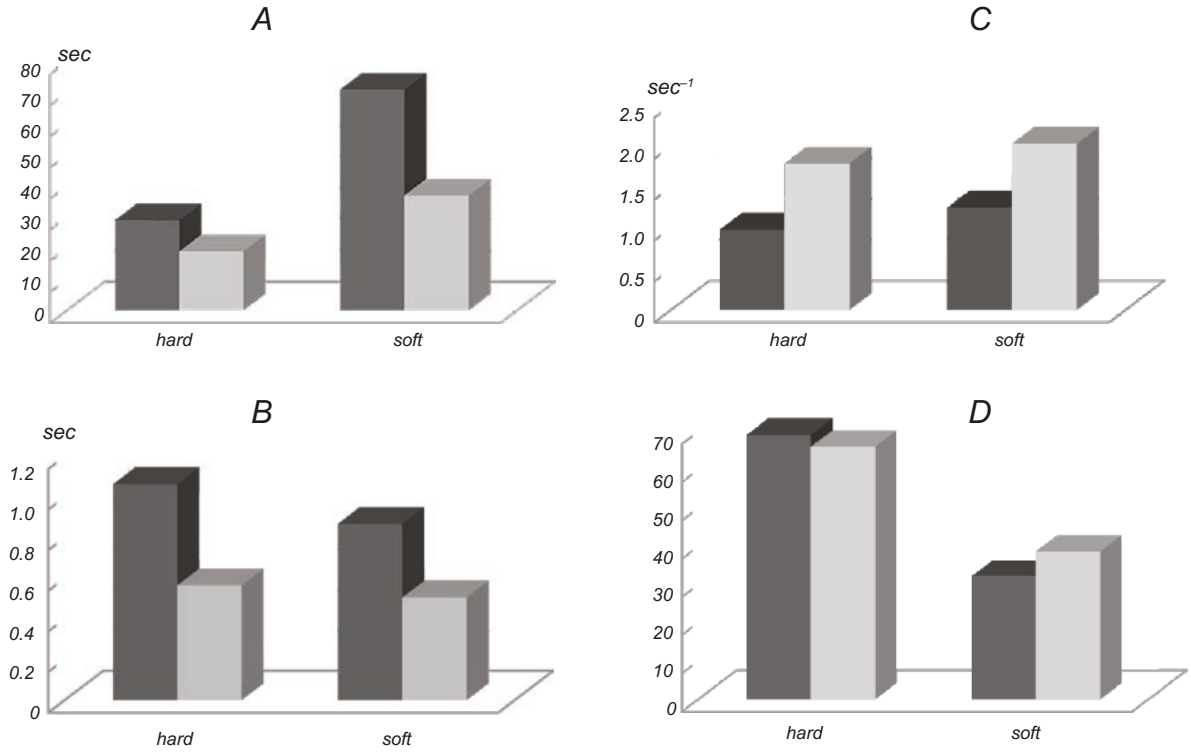

Fig. 1. Mean time characteristics of the masticatory movement sequence while chewing soft and hard morsels, compared for the two genders. Dark and light columns, values for women and men, respectively. A) Duration of the masticatory sequence, sec; B) duration of single masticatory cycles, sec; C) masticatory frequency, sec^{-1}, and D) number of masticatory cycles. Note that sizes of the morsels of the two food types were different; thus, the respective time durations and numbers of masticatory cycles cannot be compared.

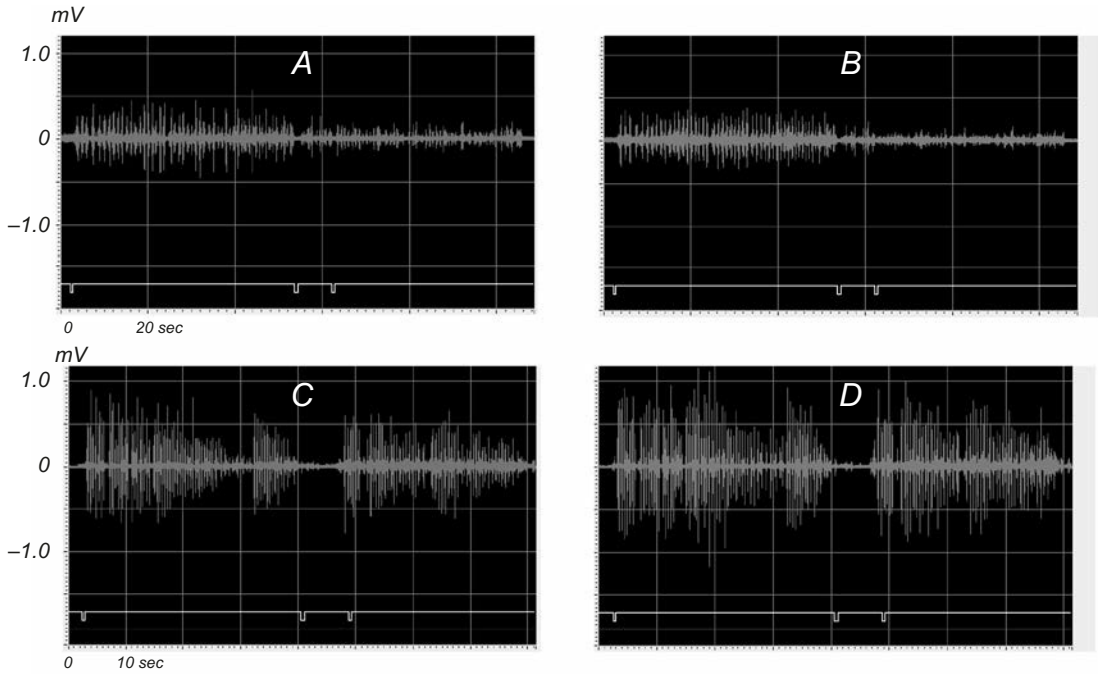

Fig. 2. A and B) Examples of EMG activity of a female volunteer, left (A) and right (B) masseter EMGs. C and D) The same for a male volunteer.

DISCUSSION

Our investigation is an attempt to describe the chewing habits of the two genders of humans while having soft or hard foods. Results obtained indicate a noticeably slower chewing pattern in women as compared to that in men.

The similarities and differences of genders in the chewing parameters were almost consistently the same in the two food types; the genders responded nearly similarly to the hardness of the food, and their difference was repeated while chewing various foods.

According to some reports (similar to our results), men manifest shorter chewing cycles with faster velocities than women do [3, 4, 8]. In contrast, other authors have reported that the duration of chewing cycles does not differ in the two genders [1, 5, 9]. The latter studies were mostly conducted either on normal children or children with Down's syndrome. Moreover, the majority of studies with no attention to gender differences used kinesiography for chewing assessments, while those analyzing the gender difference mostly utilized electromyography for this purpose. It seems more difficult to determine the exact side of some equivocal chewing patterns by kinesiography; this is documented by more bilateral chewing activities recorded by this method [10, 11].

The differences found in chewing patterns of the two genders have been discussed through the structural features of the jaw and the activity of the relevant muscles. At the same time, the behavioral, neurological, and psychological particularities of the two sexes were mostly neglected in such studies. It is well known that men tend to have more risk-taking behaviors [12], and, naturally, they would favor a higher speed in this motor phenomenon. Also, the time/cycle ratio, which roughly equals the duration of chewing cycles, has been claimed to be an excellent index for documenting chewing vigor [2]. It could be anticipated that men would show more vigor in EMG assessments, which is confirmed by our results.

Various electrical parameters have been assessed indicating the muscle force [8]. The EMG activity levels have been reported to be nearly equivalent in the two genders [3]. There are reports on the vertical amplitude and EMG activity per sequence, which indicate these to be higher in men [6]. Besides, the maximum bite force measured directly was also shown to be higher in men [15]. Our results, however, showed nearly similar mean and maximum EMG amplitudes for the two sexes, except for the mean amplitude of the right side for the soft food, which was significantly higher for men. As a result, the overall muscle force was quite comparable in the two genders, with little evidence pointing towards a higher force in men.

Concurrent with our results, significant gender differences have been reported for the number of chewing cycles constituting a masticatory sequence and the duration of the sequence indicating more chews and longer chewing durations for women [3]. Rapid chewing might be considered to be associated with an impulsive personality. This character, however, has been found to be almost equal in the two genders [13]. Nonetheless, women are usually more tender-minded [13], and their relatively unhurried chewing pattern might represent such aspect or the personality trait. Along the same lines, it should be added that in modern societies, in which speed seems to be an indispensable core element, men are apparently more affected by stress and the daily rough-and-tumble of life, and rapid chewing is probably one of the many hurried habits evidenced by this gender. These habits are areas of research that merit further studies. It is, however, a well-entrenched and well-established fact that, as the first step in digestion, complete and slow chewing is indeed a very favorable and beneficial habit for overall health [14].

We used surface electromyography for recording chewing cycles. For observing and recording muscle functions and movements, EMG has frequently been employed in different studies. Naturally recording from the skin surface is a common noninvasive and simple procedure [16–19]. EMG validity for masticatory studies has been assessed in previous investigations. It has been reported that the preferred chewing side determined by EMG and visual observation are significantly correlated ($P < 0.001$) [20]. In other studies, it was concluded that by reducing the influences of electrode relocation, EMG analysis may be adequately used for evaluation of masticatory muscle activity [21]. Some classic studies utilized electromyography for studying mastication [22-24].

Thus, our results indicate that chewing in women occurs more slowly, and the respective cycles are longer. Meanwhile, the muscle activities in the two genders are similar. The food consistency exerts a mild overall influence on the gender differences. Men have usually more hurried chewing habits;

nonetheless, the respective movements are more balanced.

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All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Written informed consent was obtained from all subjects for included in the study.

The authors of this study, S. Khamnei, M. Zamanlu, S. K. Shakouri, S. S. Oskoee, Sh. SalariLak, Y. Houshyar, and Y. Salekzamani, confirm that the research and publication of the results were not associated with any conflicts regarding commercial or financial relations, relations with organizations and/or individuals who may have been related to the study, and interrelations of co-authors of the article.

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