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Reproducibility of Electromyogram of Human Masseter and Anterior Temporal Muscles During Chewing

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Electromyographic studies have been done to evaluate the functional state of the masticatory system in individuals with different types of dental status. Especially aspects of chewing, swallowing, biting, posture, reflexes have been investigated[1-6]. In order to undertake longitudinal changes of functional aspects of the masticatory system, it is necessary to obtain reliable recording and measurement of electromyogram (EMG). However, it is known that comparison of electromyographic recordings on different days represents a difficult problem[7]. Therefore, the selection of repeated electromyographic recording to evaluate possible changes in muscle function is still a matter of discussion[8]. In spite of these situations, some investigators reported good results when recording conditions are carefully controlled[9-13]. These conditions include changes in head and body posture, skin resistance, temperature and humidity, muscle fatigue, emotional factors, the continuous activity of the eye muscles, topographical location of the electrodes over the muscle areas, and the factor of removing and replacing the electrodes[1,9,10,14-16]. In particular, it is considered that the major factor of variability between days is inaccurate relocating of the electrodes over the relatively small masticatory muscle. Nouri et al.[11] studied the masticatory muscle activity and concluded that under very standardized condition of relocating on the face reproducible results could be obtained during the same day and between days. Various template and/or tatoos on the skin over the muscle areas have been also used in order to relocate the electrodes accurately[10-13,15,16].

The present study was undertaken to determine the reproducibility of the electromyogram of the masticatory muscle during chewing not only in the same day but also between days under simple and no time consuming standardized condition.

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MATERIAL AND METHODS

Three male dentists and three dental nurses volunteered as test subjects. Their age ranged from 20 to 36 years (mean age: 27.8 years). All of them possessed good natural dentition in normal occlusion, and had no evidence of disturbances of the masticatory system. Their oral status did not change over the registration period.

EMG recordings during chewing were made with a DISA electromyograph (DISA Elektronik As, Copenhagen, Denmark). Activity of the muscles was recorded with bipolar surface electrodes (diameter: about 8 mm) from bilateral masseter muscles and right anterior portion of the temporal muscle. For registration of the EMG activity, the subject was seated comfortably with neck supported and head held according to three planes of reference with the Frankfort plane horizontal. The position of the head and body did not vary during the experiment. A plastic template was constructed to allow the accurate repositioning of the electrodes for each daily session of each subject (Fig. 1). Two straight lines were drawn on the template; one was from the outer corner of the eye to the upper attachment of the ear, and the other was in accordance with the Camper's plane. Eye angle, tragus, porion and nasal line were also illustrated on it. The position of the one electrode was standardized as follows partly in accordance with Ingervall et al.[17]; for the masseter, it was 10 mm below the Camper's plane and 20 mm back posterior from the anterior border of this muscle. The position of the anterior portion of the temporal muscle was 30 mm from the outer corner of the

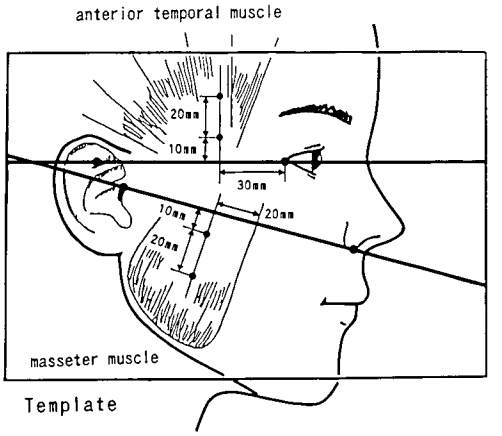

Fig. 1. A plastic template for accurate repositioning of the electrodes for masseter and anterior temporal muscles.

eye in accordance with the upper straight line and 10 mm up with right angle. The position of the other electrode was determined 20 mm apart from the first one respectively parallel to the longitudinal axis of the muscle fibers. Thereafter, these positions were palpated to confirm them as the middle part on correspondence with their muscle morphology, and allowed to be corrected. These determined final positions were pointed on the template and afterwards punched out to allow the passage of the ink-pen in order to mark on the facial skin. The skin was swabbed with 95% alcohol and the positions were marked by ink dots through the holes previously made. The electrode was applied to the same muscle in each session between days. The first recording was induced from the activity of the muscles which was elicited by chewing Swedish hard bread (20×20×4 mm). The first three and the last three chewing cycles in the recording were eliminated and thereafter the following measurements were made.

1. The duration of the chewing cycle (Cycle)
2. The duration of act of chewing (Duration)
3. The interval between two durations of act of chewing (Interval)

Number of chewing cycles was also measured from the first chewing cycle until the first swallowing. All measurements on the EMG activity were made manually. Three recording sessions were made at the regulated time in the afternoon on each of three days.

T-test for paired observation was used to test the difference between the registrations with regard to the measurement in chewing. Registrations at the three sessions in the same day were tested against each other and also were they tested at paired sessions on different days.

RESULTS

Most of the cycles did not differ between the three sessions in the same day. Some variations of the cycles were seen between the three sessions when comparing Session 2 with Session 3 and Session 3 with Session 1. These variations had a clear tendency that the cycles were always longer in the first session than the later one and that these differences were statistically significant. Several durations significantly differed between the three sessions and these were always longer in the first sessions than in the later ones as similar to the tendency of the cycles. However, the intervals did not show the difference between the three sessions with only two exceptions. One was longer and the other shorter in the first session between the three sessions (Table 1).

In Session 1, the cycles did not show any differences between days when compared Day I with Day II, Day II with Day III and Day III with Day I. Some of the durations and the intervals did significantly differ between days, which were shown to be always longer on the first day than on the later days. In Session 2, there was no statistically significant difference in not only the cycles but also the intervals. Some of the durations did differ with the similar tendency mentioned above. In Session 3, comparison showed no statistically significant difference with the other sessions with one exception (Table 2). Table 3 showed total mean and standard deviation of the cycle, duration and interval in each muscle. Variation of the number of chewing cycle within the day and between days was shown to be small. On each day and in each session there was no statistically significant difference between all registrations, despite of the fact that one significant difference was seen to be smaller on the first day than on the second day (Table 4).

DISCUSSION

Despite of the fact that some statistical differences of EMG activity between the sessions were recognized during chewing within the day, EMG activity is deemed to be rather stable.

It has been considered that the major factors which contribute to the production of the reproducible result are

Table 1. The variation of cycle, duration and interval within the day

Session	LM			RM			RT		
	1 vs. 2	2 vs. 3	3 vs. 1	1 vs. 2	2 vs. 3	3 vs. 1	1 vs. 2	2 vs. 3	3 vs. 1
Cycle									
Day I	−	−	+*	−	−	+*	−	−	+*
Day II	−	+*	+*	−	−	+*	−	−	++*
Day III	−	−	−	−	−	−	−	−	−
Duration									
Day I	−	+*	−	−	+*	−	−	++*	−
Day II	−	−	−	+*	−	+*	+*	−	−
Day III	−	−	+*	+*	−	+*	+*	−	−
Interval									
Day I	+*	−	−	−	−	−	−	−	−
Day II	−	−	−	+**	−	−	−	−	−
Day III	−	−	−	−	−	−	−	−	−

Abbreviations: LM, left masseter; RM, right masseter; RT, right temporal; − not significant; + significant ($p<0.05$); ++ significant ($p<0.01$)

* First session longer than the following one

** First session shorter than the following one

Table 2. The variation of cycle, duration and interval between days in each session

Day	LM			RM			RT		
	I vs. II	II vs. III	III vs. I	I vs. II	II vs. III	III vs. I	I vs. II	II vs. III	III vs. I
Session 1									
Cycle	−	−	−	−	−	−	−	−	−
Duration	−	+*	−	−	++*	−	−	−	−
Interval	−	−	+*	+*	−	+*	−	−	+*
Session 2									
Cycle	−	−	−	−	−	−	−	−	−
Duration	−	+*	−	−	++*	+*	−	−	+*
Interval	−	−	−	−	−	−	−	−	−
Session 3									
Cycle	−	−	−	−	−	−	−	−	−
Duration	−	−	−	−	++**	−	−	−	−
Interval	−	−	−	−	−	−	−	−	−

Abbreviations: LM, left masseter; RM, right masseter; RT, right temporal; − not significant; + significant ($p<0.05$); ++ significant ($p<0.01$)

* First day longer than the following one

** First day shorter than the following one

recording technique, electronic equipment, environment of experiment, the position of head and body and electrode[10,11,15]. These factors except environment of experiment could be regarded to be standardized at each registration in each day. Yet in a human study, it would be unwise to assume that the subject would be in the same situation of psychological and physiological aspects during three registrations in a day. Thus, the input signal might be expected to vary[9], particularly in the first registration with the explanation that this chewing pattern is based on conscious reflexes. Since differences were shown to be always longer in the first session than in the later one and

Table 3. Total mean and standard deviation of cycle, duration and interval in each muscle (ms)

	LM		RM		RT	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Cycle	602	82	602	83	602	83
Duration	282	41	291	50	298	42
Interval	320	51	311	49	304	53

Abbreviations: LM, left masseter; RM, right masseter; RT, right temporal; $\bar{X}$, total mean; S.D., standard deviation

Table 4. The variation of the number of chewing cycle within the day and between days

Session	Within the day			Day	Between days		
	1 vs. 2	2 vs. 3	3 vs. 1		I vs. II	II vs. III	III vs. I
Day I	−	−	−	Session 1	+*	−	−
II	−	−	−	2	−	−	−
III	−	−	−	3	−	−	−

Abbreviations: − not significant; + significant ($p<0.05$)
* Day I smaller than the following one

this finding may indicate the transfer to subconscious reflexes, the small significant variation of the chewing rhythm could be explained by the adaptation to the test procedure and the environment of the experiment following repeated registrations.

In regard to the variations between days, the cycles were completely stable not only in the first session but also in the other sessions and this is well accorded with the results by Jemt et al.[18]. Some significant variations, however, were seen in the durations and intervals between days. Chewing rhythm was thus more stable in the third session in comparison with the first and the second sessions. Concerning the between-day variation of chewing rhythm, the repositioning of the electrode has been stressed to be necessary in the context of reproducibility[10,11]. In the present study, the plastic template was used in order to make it possible to reposition the electrodes on the same site on each day and this ability to accurately relocate electrodes undoubtedly contributes to obtain the stable results in agreement with the other works[10,11,13]. In fact, some significant variations of the durations and intervals were found mainly in the first and the second registrations and only one in the third registration. The change of the position of the head and body is recognized as one of the contributors to the variations of the EMG activity[14]. This factor may be regarded to be contributive in this study. As Garnick[15] stressed, factors responsible for the variation in the parameters were carefully standardized as much as possible in the present study. However, suitable control of the influence of the central nervous system was difficult to be done. These small variations, therefore, would be acceptable and this might well be also explained by the adaptation to the test situation. Jemt et al.[19] found in their study that the duration of chewing cycle showed a good correlation between repeated registrations but not reached the exactly same mean values which were exhibited significantly difference, and they concluded that such small changes brought the role of the adaptation to the test situation into focus dealing with the repeated tests.

Registrations were limited to three times daily and three times in a week in the present study. This seems to be sufficient because some authors[10,11] had obtained reproducible results. The fact that the chewing rhythm in the third session was the most stable in comparison with the other two sessions suggests that some trial sessions should be run in order to acquaint the subjects with the experimental method and the environment. Such trainings could also contribute to make it possible to decrease the adaptation factor and to achieve the desired subconscious reflex performances for the subject.

The mean cycle was around 600 ms and this coincides

with Jemt et al.[19] by the different test method, Selspot system. This value was, however, on the lower side compared with other study on chewing[20]. The Swedish hard bread used in the present study and in the work by Jemt et al.[19] is evidently easy to chew, thus allows the shorter time of the duration of cycles.

The results in this study indicate that the chewing rhythm is quite stable and repeatable in a small group of individuals under simple and no time consuming standardized conditions. These findings suggest that the chewing rhythm is regarded to be useful in order to investigate the longitudinal change of the masticatory function and that some training sessions are recommended to be performed to adapt to the whole test situation.

SUMMARY

In six individuals the chewing rhythm was investigated repeatedly over 1 week. The chewing rhythm was found to be quite stable not only in the same day but also between days, particularly in the later registrations. These findings may suggest that the chewing rhythm is acceptable for use in a long-term study on the functional state of the masticatory system.

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