The Effect of Jaw Clenching on the Electromyographic Activities of 2 Neck and 2 Trunk Muscles

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Aims: *Symptoms of jaw dysfunction are often associated with neck muscle dysfunction or other musculoskeletal problems. This study attempted to quantify the effect of jaw clenching on the electromyographic (EMG) activity of certain neck, trunk, and jaw muscles.* **Methods:** *The authors recorded EMG muscle activity in the sternocleidomastoid, trapezius, paravertebral, and rectus abdominis muscles in 10 university students at rest and during strong jaw clenching in supine and sitting positions.* **Results:** *In both positions, jaw clenching resulted in increases in neck muscle activity ranging from 7.6 to 33 times resting muscle activity; for the trunk muscles, the increases ranged from 1.4 to 3.3 times resting activity.* **Conclusion:** *These results add further information to the concept of the interrelatedness of jaw, neck, and trunk muscle activity.*

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Key words: jaw clenching, electromyography, trunk muscles, neck muscles, masseter, sternocleidomastoid, trapezius, paravertebral muscles, rectus abdominis

This study reports on an investigation of the effects of jaw clenching on the electromyographic (EMG) activity of 2 neck muscles and 2 trunk muscles. The relationships between neck, trunk, and masticatory muscle activities are of interest, since it is claimed that problems of the masticatory apparatus, such as temporomandibular disorders, may be associated with increased masticatory muscle activity. Can this lead to increased activities of neck and trunk muscles and postural and other effects? Are these effects reciprocal? Are tense trunk muscles associated with increased tension in the masticatory muscles and hence aggravated conditions affecting the masticatory apparatus?

Increases in the motor command of the cortex lead to increases in tension of a number of muscle groups.[1] A previous study reported on keyboard workers' high levels of EMG activity in the "holding" muscles of the upper limb while entering data.[2] Increases in masticatory muscle tension are of particular interest, not only with respect to temporomandibular disorders but also with respect to the effects of this tension on other muscles and associated tissues. Miralles and coworkers[3] noted that voluntary jaw clenching led to an increase in EMG activity in the sternocleidomastoid. Kohno and coworkers[4] found in normal subjects that electrical activity near the insertion of the sternocleidomastoid increased as occlusal force increased. Clark and coworkers[5] confirmed that there is a functional connection between the masticatory and cervical motor systems. Yoshimatsu et al[6] confirmed an increase in the activity of the sternocleidomastoid and trapezius muscles upon isometric contraction of the jaw muscles and postulated a possible link between neck and shoulder symptoms and oral habits. Miyahara et al[7] found that voluntary jaw clenching resulted in facilitation of the soleus H-reflex, which indicated that the effects of the motor command that leads to jaw clenching reached the lumbar cord segmental level to modify this reflex.

The present study set out to quantify the effect of jaw clenching on the EMG activity of neck and trunk muscles, namely, the sternocleidomastoid, the trapezius, the lumbar paravertebral muscles, and the rectus abdominis.

Methods

Subjects

The subjects were 10 university students, 6 female (mean age 20 ± 0.5 years) and 4 male (mean age 20 ± 0.5 years). They were selected following a notice in the medical school on the basis of no history of neck or jaw pain or musculoskeletal problems. Each subject was thoroughly examined to ensure that there were no signs of temporomandibular or cervical dysfunction.

Electromyography

Bipolar surface electrodes 1 cm in diameter were combined with preamplifiers into an electrode-preamplifier unit. The electrodes were placed 10 mm apart on the unit. The skin at the recording site was abraded and cleaned with an alcohol swab. The unit was placed in the middle of each muscle (Fig 1) with adhesive tape, along with conducting jelly at the skin contact of each electrode. A neutral electrode was placed over the bony prominence of the right acromion process in each subject. The sternocleidomastoid and trapezius electrodes were placed approximately 12 cm and 18 cm from the masseter, respectively.

The electrodes were connected to an electromyograph (Medelec) with low-pass filters set at 16 Hz and high-pass filters set at 1600 Hz. The raw signals were rectified, integrated, and transmitted to a computer, where custom-designed software eliminated background activities and converted readings into muscle activity as a percentage of maximum activity.

Experimental Protocol

After the electrodes were applied to the 4 muscle sites, background activities and activities for maximum voluntary contractions (MVC) of each of the muscles were recorded.

Electromyographic recordings of maximum contractions, maintained for 10 seconds, were performed in triplicate, with 1-minute rest intervals, by instructing the subject to contract his or her muscle against resistance provided by the experimenters. For the sternocleidomastoid, the experimenter's hand was placed against the subject's head to resist the rotation of the head; for the trapezius, a hand was placed over the outer area of the shoulder and the subject was instructed to elevate the shoulder as strongly as possible; for the rectus abdominis, the subject lay supine and flexed the trunk against resistance; for the lumbar paravertebrals, the subject lay prone and extended the trunk against resistance provided by the experimenters. The highest value obtained within each set of triplicate readings was taken as the EMG activity of the MVC for that muscle.

Electromyographic activities for each MVC were keyed into the computer. These values were then used to provide EMG values (corrected for background), which were then expressed as a percentage of the MVC.

Records were obtained in triplicate for each procedure. Resting muscle activities for the 4 muscles were obtained with the subject seated in a comfortable chair and lying supine comfortably on a soft surface. Then the subject was requested to clench the jaw for 10 seconds as strongly as possible. Measurements were then repeated in triplicate, with 1-minute intervals, in the seated and supine positions.

Statistical Analyses

Electromyographic activities were calculated in terms of the percentage of the EMG activity of an MVC and expressed as means and standard deviations. Analysis of variance (ANOVA) with repeated measures was performed with SYSTAT

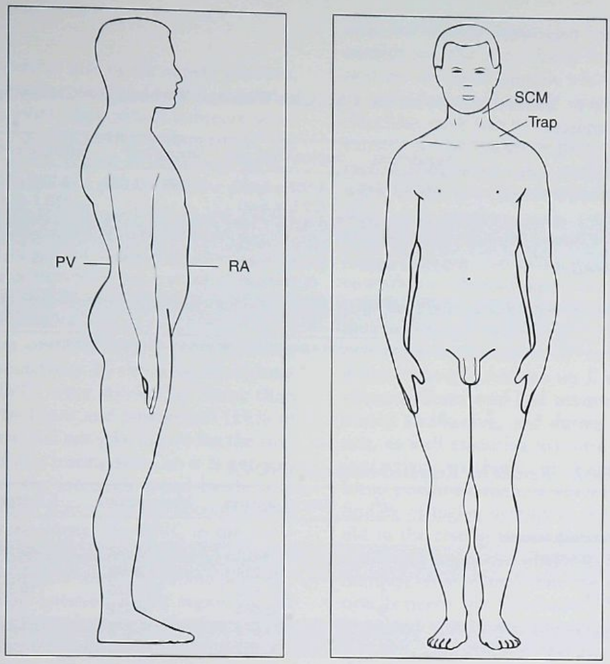

Fig 1 The figure on the left shows the positions of the surface electrodes on the rectus abdominis (RA) and paravertebral muscles (PV). The figure on the right shows the position of the electrodes on the sternocleidomastoid (SCM) and the trapezius (Trap).

software. This repeated-measure ANOVA was performed for each muscle in both sitting and supine positions as well as for each muscle in each position.

Results

Table 1 presents the mean values and variabilty (as reflected in standard deviation values) for the activities of the 4 muscles in the 2 positions, with the jaw unclenched and clenched. At rest, activities for the 4 muscles were less than 0.2% of MVC activity. Jaw clenching elicited much greater increases in neck muscle activity than in trunk muscle activity. Increases in muscle activity during clenching were (supine position/sitting position): sternocleidomastoid, 22.5 times resting activity/33.0 times resting activity; trapezius, 17.4/7.6; paravertebral, 3.3/2.7; and rectus abdominis, 2.7/1.4. Thus, the neck muscles showed increases in activity upon clenching that ranged on average from 7.6 to 33 times resting activity, whereas trunk muscles showed increases ranging from 1.4 to 3.3 times resting activity.

Table 2 shows the results for repeated-measure ANOVA. Note that the effect of jaw clenching on increased activity for the 4 muscles was statistically significant when results were combined for the 2 positions. For the 2 neck muscles, increases due to jaw clenching for each position also achieved significance.

Table 1 EMG Activities for the 4 Muscles With and Without Jaw Clenching in 10 Subjects

Muscle	Supine/rest	Supine/clenched	Sitting/rest	Sitting/clenched
Sternocleidomastoid	0.182 ± 0.348	4.102 ± 2.143 (22.5 × rest)	0.099 ± 0.126	3.273 ± 1.929 (33.1 × rest)
Trapezius	0.052 ± 0.087	0.905 ± 1.136 (17.6 × rest)	0.135 ± 0.139	1.024 ± 1.356 (7.6 × rest)
Paravertebral	0.124 ± 0.320	0.403 ± 0.441 (3.3 × rest)	0.061 ± 0.083	0.165 ± 0.234 (2.7 × rest)
Rectus abdominis	0.067 ± 0.052	0.181 ± 0.176 (2.7 × rest)	0.184 ± 0.382	0.255 ± 0.371 (1.4 × rest)

Values are corrected for background and expressed as a percentage of maximum voluntary contraction.

Table 2 Results for Repeated-Measure ANOVA

	df	Sum of squares	Mean square	F factor*
Sternocleidomastoid				
Both positions	1	1530.281	1530.281	143.130
	9	96.224	10.692	
Supine	1	751.820	751.820	116.533
	9	58.064	6.452	
Sitting	1	778.577	778.577	77.680
	9	90.202	10.002	
Trapezius				
Both positions	1	453.629	453.629	43.182
	9	94.545	10.505	
Supine	1	366.745	366.745	42.309
	9	78.015	8.668	
Sitting	1	120.344	120.344	13.166
	9	82.265	9.141	
Paravertebral muscles				
Both positions	1	251.818	251.818	15.213
	9	148.977	16.553	
Supine	1	185.611	185.611	13.112
	9	127.400	14.156	
Sitting	1	77.756	77.756	10.875
	9	64.350	7.150	
Rectus abdominis				
Both positions	1	82.900	82.930	21.180
	9	35.240	3.916	
Supine	1	55.301	55.301	11.933
	9	41.708	4.634	
Sitting	1	29.617	29.617	8.913
	9	29.906	3.323	

*Where $P < 0.05$; critical F = 14.5.

The effect of jaw clenching on increased activity of the 4 muscles was statistically significant when results were combined for the 2 positions. For the 2 neck muscles, increases for each position also achieved significance.

Discussion

When subjects were at rest in the supine position, the trapezius and rectus abdominis muscles showed less activity than when subjects were seated upright. For the sternocleidomastoid, the greater activity in the supine position was probably due to the absence of a pillow. For the paravertebral muscle, the greater activity in the supine position, or conversely, the lesser activity in the sitting position, is consistent with other observations in our laboratory, in which paravertebral muscle activity decreases in subjects when they are seated in a comfortable position.

The values we obtained for the effect of jaw clenching on the activity of the sternocleidomastoid (4% of MVC) were somewhat lower than those obtained by Clark and coworkers[5] (14% of MVC). Clark et al did not give values for the sternocleidomastoid in a resting state, so it is not possible to calculate the increases found by them in sternocleidomastoid activity due to cocontraction. In the present experiments the MVC in the sternocleidomastoid- increased 22-fold from resting to clenching when subjects were in a supine position.

A methodologic question arises regarding the specificity of surface electrodes. Is the activity recorded over the sternocleidomastoid and trapezius muscles, for instance, a result of the spread of activity from the tightly clenched jaw muscles? Grieve and coworkers[8] discussed this question with respect to muscle action potentials behaving as miniature electric dipoles. The electrical field of such dipoles diminishes in inverse proportion to the square of the distance. For the sternocleidomastoid and trapezius muscles, electrical activity from the contracted masseter muscle would be diminished at the recording sites by 1:144 and 1:324, respectively. This would result in signals much lower than those detected in the 2 muscles during jaw clenching. In support of this interpretation is the evidence for cocontraction in the rectus abdominis and paravertebral muscles, where the effect of distance would clearly be of little consequence. Similarly, the work referred to here by Clark et al[5] and by Kohno et al[4] (who used both surface and needle electrodes in their studies) are based on the relative specificity of the surface electrodes' recording of the underlying muscle.

The present results are thus able to quantify the effect of jaw clenching on the electrical activity of representative neck and trunk muscles. The data revealed an increase between 7 and 33 times the resting state in neck muscles and 1.6 and 3 times the resting state in trunk muscles. The differences were statistically significant for all muscles when considering the 2 positions together and significant for the neck muscles when testing the effects at individual positions. It is noteworthy that jaw clenching gave rise to greater increases in muscle activity in the supine position for the trapezius, rectus abdominis, and paravertebral muscles, whereas for the sternocleidomastoid muscle the effect was greatest in the sitting position. The finding of a widespread effect on muscles due to jaw clenching conforms with McCloskey and coworkers' observation that the central motor command can result in widespread excitation of the musculature of the body.[1]

A study by Palazzi et al[9] studied the effect of different body positions on EMG activity in the sternocleidomastoid and masseter muscles at rest, during swallowing, and during jaw clenching. At rest, as well as during maximal voluntary clenching, activity was higher in supine and lateral decubitus positions than in seated positions. Their finding of higher activity in the sternocleidomastoid in the resting supine position compared with the sitting position is similar to our findings. Their findings serve to underline the important connection between the functional state of the musculoskeletal system and the activities of individual muscles. Our findings are the mirror image of this: that the activities of individual muscles affect the functional state of the musculoskeletal system in widely different muscles, which would likely affect posture.

Our interest in the association between muscle activity in the masticatory and other body muscles relates to the possible significance for pathogenesis of orofacial, neck, and trunk conditions. Palazzi et al[9] suggested that their evidence of the correlation between increased activity in the sternocleidomastoid and masseter muscles could explain the symptomatology of patients with cranio-cervical-mandibular dysfunction. Although Hu et al[10] obtained evidence in the rat that a noxious stimulus applied to dorsal neck tissues gave rise to increased electrical activity in neck and jaw muscles, this finding requires further investigation in human subjects. Our evidence adds to the concept of the interrelatedness of muscle activity between the jaw, neck, and trunk muscles. The findings may relate to the putative association of jaw, neck, and trunk muscle functions and dysfunctions.

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