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Case Study

# Effects of a Sternocleidomastoid Muscle Exercise Protocol on Masticatory Muscles: A Case Study

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## Abstract

**Introduction:** TThe temporomandibular joint (TMJ) is fundamental for the postural tonic system, influencing and being influenced by postural alterations. Recent research emphasises the impact of sternocleidomastoid (SCM) stiffness on the range of movement of the cervical spine, especially during head rotation.

**Materials and Methods:** A healthy adult woman (24 years, 1.65 m and 45 kg) participated in the study. Range of motion (ROM) was measured using the Euleria LabTM system and muscle activation was measured using the mDurance® surface electromyograph (sEMG). After the first measurement (T0), a protocol based on SCM resistance and flexibility exercises was administered. At the end of the procedure, the tests were repeated (T1).

**Results:** In T0, asymmetries in temporal muscle activation (±38%) and significant differences in active and passive cervical ROMS were found, especially in rotation (-17°) and extension (-8°) movements. In T1, muscle activation levels are normalised with symmetry indices falling within the sufficiency ranges (±17%) and differences between active and passive ROMS significantly reduced in rotation (-9°) and absent in extension (-1°).

**Discussion:** After the procedure there were improvements in the sEMG of all muscles examined and in the active cervical ROM. The study confirms the link between anterior neck muscles and masticatory muscles and demonstrates the immediate impact of improved distal muscle tension on proximal muscles.

Future research aims to expand the sample size and evaluate the short term and long term effects of the procedure, as well as explore synergies with other treatment modalities for the comprehensive resolution of postural problems.

**Keywords:** Posture; Temporomandibular Joint; Surface Electromyography; SCM Muscle

## Introduction

The temporomandibular joint (TMJ) is one of the proprioceptors of the postural tonic system, which can be both a cause and a consequence of postural alterations. The cranio-mandibular sub-unit is one of the buffer systems for flexion-extension, lateral flexion and torsion movements expressed by the muscle-binding system, aiming to protect the spine [1].

### Biomechanics of the temporomandibular joint

When exploring the biomechanics and kinematics of the TMJ, it is important to examine mandibular movements both without food (free movements) and during biting and chewing [2]. The two fundamental free movements are rotational (hinge movement) and translational (sliding movement). Rotation occurs mainly between the disc and the condyle in the lower part of the joint, while translation occurs between the glenoid fossa, the disc and the mandible [3]. It is important to note that translational movements do not require symmetry between the left and right joints.

Antero-posterior movements are mainly translational. Pushing the mandible forward (protrusion) involves forward movement of the condyles with the articular discs, while retrusion involves reverse translational motion. Retrusion from the centred occlusion is limited by the joint capsule, ligaments [4,5] and bony structures.

Opening and closing movements combine translation and rotation. Opening involves the disc and condyle moving forward and downward, allowing a wide opening. The lateral movement occurs with a lateral displacement involving rotation around a vertical axis [4].

Muscle functions are described based on electromyographic (EMG) data. Three main muscle groups influence mandibular movements: elevators (temporalis, masseters, medial pterygoids), depressors (digastrics, myloioids, genioioids) and protrusors (lateral pterygoids). Mandibular retractors include digastrics and portions of the temporalis [3].

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The protrusion is mainly guided by the lower heads of the lateral pterygoids. Chewing involves a significant application of force, with chewing cycles categorised into opening, closing and power strokes. The incision and chewing cycles differ, especially during the power stroke, where strong tooth-to-tooth contact occurs [6,7].

### Correlation between masticatory muscles and neck muscles

Spinal imbalance, linked to incorrect body posture, arises from various factors such as age, obesity, genetic predisposition and metabolic imbalances. Despite specific spinal conditions such as scoliosis, arthritic problems or trauma, the most common causes involve functional imbalances in muscle activity [8].

Maintaining an upright posture and skeletal balance, both static and dynamic, depends on the delicate balance provided by the postural tonic system [9]. This system, acting as a structured network with multiple inputs, is based on afferent and efferent signals. Receptors, including neuromuscular spindles, eyes, feet, ear, and the stomatognathic system, capture environmental and internal information. However, these receptors – crucial for posture – can function adaptively or causatively [8].

The "disruption" of the body's balance due to imbalances in the receptor system stems from the fact that the system relies on defined muscle chains [10]. Brodie [11] started the study of the relationship between chewing muscles, swallowing muscles, neck muscles and posture by creating his own model (Brodie's Theory). According to Brodie, the skeletal components of the head and neck lack balance, requiring the muscles to compensate for mass and weight imbalances. This is due to the head's centre of gravity being anterior to the atlanto-occipital joints, the support points of the head on the cervical spine [12].

In the upright position, the head tends to tilt forward due to weight distribution, requiring tonic activity from the cervical extensor muscles. This action is opposed by antagonistic muscles, including the cervical spine flexors and sternocleidomastoid muscles. Brodie's theory helps to understand how the anterior muscles of the neck interact with the cervical spine.

Leeuw and Klasser (2013) describe the stomatognathic system as a functional and anatomical unit involving teeth, jaw bones, temporomandibular joints and masticatory muscles, creating a direct connection with the cervical spine, forming the "cranio-cervical-mandibular system [13].

When discussing the stomatognathic system, attention is drawn to the functions associated with the oral cavity, with particular focus on the mandible. These functions include actions such as chewing, swallowing, breathing, speaking, yawning, and facial expressions [12,14,15].

Some studies have identified a correlation between masticatory muscles, temporomandibular joints, and the degree of muscle elongation with the position of the occipital joint and upper cervical spine [16,17]. Reduction in vertical dimension and subsequent shortening of the masticatory muscles lead to hypertonia in the sub-occipital muscles [1].

It is also well recognised how altered mandibular posture and occlusion modify paravertebral muscle function and stability [18,19]. Ohmure (2008) [20] described how hypertonia in the masticatory muscles leads to a posterior position of the jaw and anteversion of the head, mediated by inhibition of the cervical extensors and hypertonia in the sub-occipital muscles for adequate vision and balance [12]. In the study by Eshaghi Moghadam et al. (2017), it is noted that the sternocleidomastoid muscle (SCM) does not show significant tonic changes in the neutral position or in the forward head position (FHP) [21]. Recent studies highlight that the rigidity of the SCM affects the range of movement of the cervical spine, especially in the rotation of the head, which is reduced in subjects with FHP compared to the neutral situation [22].

### Aim of the study

As extensively highlighted above, much has been said about the correlation between neck muscles and masticatory muscles. In particular, the literature focuses on the effects of an intervention on the proximal muscles and how this affects the distal muscles. The aim of this study will be to assess an intervention protocol on the anterior neck muscles and how this may induce an effect on the masticatory muscles.

## Materials and Methods

### Subject

The subject was a healthy adult woman aged 24 years, 1.65 m tall and weighing 45 kg. The subject reported that she was not a smoker, did not usually consume alcohol and did not take drugs.

### Protocol

Before proceeding with the intervention protocol, the subject was informed of the protocol itself and invited to report any onset of pain or potential problems. All exercises were performed with the subject in a sitting or lying position, and each movement was previously demonstrated by the practitioner. The subject was instructed on the execution of each exercise as to control each movement by associating correct breathing. Exercises involved flexion, extension, lateral flexion and head rotation movements in a slow and controlled manner, combined with breathing. Isometric exercises (figure 2) and auxotonic exercises [23] were added to the programme. Finally, stretching exercises focused on the bilateral stretching of SCM muscles were incorporated.

The participant was asked to lie down in a supine position, keep the neck extended and then rotate the head to the right as far as possible within a pain-free range to stretch the SCM muscle to the pain-free limit. With one hand positioned just above the left ear, the participant self-applied one final maximal stretch lasting 15 seconds, without causing pain. This was followed by a 10-second rest period before repeating the exercise on the other side [24].

The protocol had a total duration of 15 minutes, as described in Table 1.

| | | |
|---|---|---|
| 10 rep | Neck flexion | Mobility |
| 10 rep each side | Neck rotation | Mobility |
| 10 rep each side | Neck lateral flexion | Mobility |
| 10 rep each direction | Neck circumduction | Mobility |
| 10 sec each side (2 times) | Neck anti-rotation (fig) | Isometric contraction |
| 10 sec each side (2 times) | Neck rotation with elastic band | Auxotonic contraction |
| 10 rep (2 times) | Neck flexion with elastic band | Auxotonic contraction |
| 30 sec (2 times) | Neck extension | Stretching |
| 15 sec each side (2 times) | Neck lateral extension | Stretching |
| 15 sec each side (2 times) | Neck rotation | Stretching |

**Table 1:** Intervention protocol.

**Figure 1:** Head rotation with IMU sensor. The sEMG (surface electromyography) was not removed from the subject to avoid encountering differences in pre-post intervention positioning.

**Figure 2:** SCM isometric exercise.

Tools

IMU Measurement System – Euleria Lab.

Euleria Lab (CoRehab, Trento, Italy) is an adaptive system composed of several inertial measurement units (IMUs) wirelessly connected to a computer. It is developed to improve standard rehabilitation programs by guiding the user in performing prescribed physical exercises, through a video interface (biofeedback).

IMUs used come from Xsens, each weighing 10 grams and operating at a sampling rate of 240 Hz [25]. These sensors register nine degrees of freedom: a 3D accelerometer (scale: ±160 m/s2, noise: 0.003 m/s2/√Hz), a 3D gyroscope (±2000°/s, 0.05°/s/√Hz), and a 3D magnetometer (±1.9 Gauss, 0.15 m Gauss/√Hz) with internal sampling at 1000 Hz [26].

Units must be positioned on the front of the body segments, using elastic bands. In the context of this study, equipment was applied to the head to monitor the motion range (ROM) of the cervical spine.

Rotation angles are calculated using a proprietary algorithm based on Kalman filter theory [27]. In this process, differentiated weights are assigned to the position and orientation signals by the accelerometer (ka), gyroscope (kg), and magnetometer (km), making sure that the sum of ka + kg + km equals 1. Weighted signals collected are combined to yield an overall measure of spatial orientation (pitch, roll, yaw) for each IMU.

A software calibration algorithm eliminates any offsets associated with initial misalignments, which typically arise from inaccurate positioning of the IMU and/or the specific shape of the body segment [27]. Static calibration, which requires the user to maintain a seated posture, is essential for measuring the neutral joint position of the IMU. This value is considered the initial offset used for joint ROM assessment [27].

**Figure 3:** Riablo inertial sensor system.

## Surface Electromyography - mDurance

The mDurance ® System (mDurance Solutions SL, Granada, Spain) is a three-part portable surface electromyography (sEMG) system. The first is a Shimmer3 EMG unit (Realtime Technologies Ltd, Dublin, Ireland), which is a bipolar sEMG sensor for detecting superficial muscle activity. Each Shimmer sensor is composed of two sEMG channels, with a sampling frequency of 1024 Hz. Shimmer applies a bandwidth of 8.4 kHz, the resolution of the EMG signal is 24 bits and an overall amplification of 100-10,000 V/V. The second part consists of the electrodes, of Ag/AgCl type pre-gelled with a diameter of 10 mm and positioned at an inter-electrode distance of 20 mm. The third and last part is the mobile application mDurance (Android), whereby data is received from the Shimmer unit and send to a cloud service. sEMG signals are stored in the mDurance cloud service, filtered and analysed, generating complete reports [28].

**Figure 4:** Surface electromyography mDurance®.

## Results

Pre-operative measurements of active cervical ROM (aROM) and passive cervical ROM (pROM) were performed, together with electromyographic assessment of the anterior temporalis and SCM muscles bilaterally, analysing their baseline activity. The data were reported in Table 2 and Table 3, respectively.

**Table 2:** Pre-intervention cervical joint ROM.

| | (°) | (°) | (°) | (°) | (°) | 176 |
|---|---|---|---|---|---|---|
| Active | 68 | 63 | 72 | 71 | 51 | 57 |

**Table 3:** Pre-intervention sEMG.

| | (µV) | (µV/s) |
|---|---|---|
| Right Temporalis | 2.89 | 0.16 |
| Right SCM | 3.25 | 0.18 |
| Left Temporalis | 4.69 | 0.26 |
| Left SCM | 3.33 | 0.18 |

Another useful piece of information for the current study is the symmetry index of the muscles examined by comparing the electromyographic activity of each with its contralateral counterpart. Below, in Figures 5 and 6, the symmetry indices of the temporalis and sternocleidomastoid muscles pre-intervention are depicted, respectively.

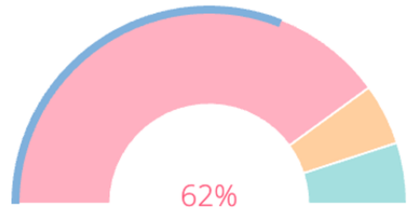

**Figure 5:** Pre-intervention simmetry of temporal muscles.

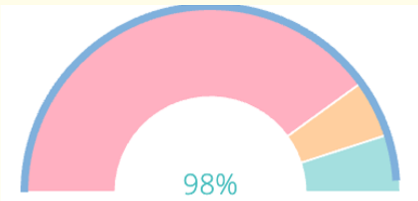

**Figure 6:** Pre-intervention simmetry of SCM muscles.

At the end of the experimental intervention protocol, tests were repeated and their results are shown in Tables 4 and 5.

**Table 4:** Post-intervention cervical joint ROM.

| | FLEXION (°) | EXTENSION (°) | R ROTATION (°) | L ROTATION (°) | R LATERAL LEXION (°) | L LATERAL FLEXION (°) |
|---|---|---|---|---|---|---|
| Active | 67 | 70 | 82 | 83 | 55 | 56 |
| Passive | 68 | 71 | 91 | 92 | 63 | 65 |

**Table 5:** Post-intervention sEMG.

| | RMS mean (µV) | RMS mean per second (µV/s) |
|---|---|---|
| Right Temporalis | 2.93 | 0.05 |
| Right SCM | 4.20 | 0.07 |
| Left Temporalis | 3.51 | 0.06 |
| Left SCM | 3.68 | 0.06 |

Below are the post-intervention symmetry indices of the muscles examined.

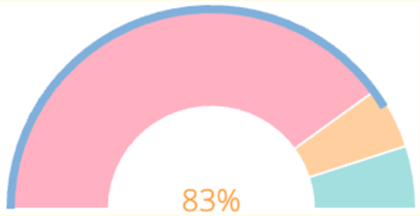

**Figure 7:** Post-intervention simmetry of temporal muscles.

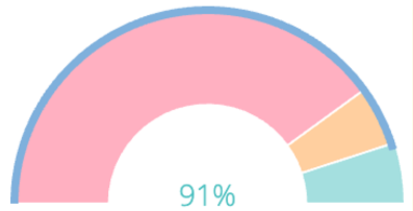

**Figure 8:** Post-intervention simmetry of SCM muscles.

## Discussion

Pre-intervention testing on the subject revealed results indicating asymptomatic asymmetry in temporal muscle activation. In particular, the left temporalis muscle showed greater basal activation compared to the contralateral side. Another noteworthy observation was the significant difference between active and passive joint ROMs, especially in bilateral head extension and rotation. From these data, it was deduced an excessive muscle stiffness of the sternocleidomastoid muscles responsible for rotation on the opposite side of the head, when contracted individually, and acting as competitors in head flexion, when simultaneously engaged [24].

After the intervention protocol which, as previously described, focused exclusively on the stretching and contraction of the anterior neck muscles, substantial differences emerged compared to the pre-test in both active joint ROM and surface electromyography (sEMG). Significant improvements were observed in clockwise rotation, counterclockwise rotation, and head extension, +10°, +12°, and +7°, respectively. Other parameters of the aROM remained unchanged or negligible: these were expected results, as the intervention protocol mainly involved the muscles responsible for head extension and rotation.

The sEMG data showed an improvement in symmetry in the temporal muscles, going from insufficient pre-surgery symmetry (62%, Figure 5) to sufficient post-surgery symmetry (83%, Figure 7). Furthermore, a significant reduction in root mean square (RMS) per second [29] was noted: in the pre-intervention measurement, the values of the two sternocleidomastoid muscles were comparable, while the left temporalis muscle (0.26 μV/s) showed a superior activity compared to the contralateral side (0.16 μV/s) of 62.5%. Following the intervention, these values decreased for all four muscles analysed, normalising them to an almost identical activation level (0.06 μV/s ± 0.01).

## Conclusion

The results obtained confirm the close correlation between the anterior neck muscles and the masticatory muscles [11,12]. The entire scientific literature has focused on a cranio-caudal approach to solve muscle problems at the TMJ level. In this case study, it is clear that an exercise protocol aimed at improving muscle tension in the distal muscles has an immediate effect on proximal muscles.

Although this was a case study, the next aim will be to enlarge the sample examined and assess not only the acute effects of the intervention protocol, but also how a similar, structured intervention programme over 8-12 weeks could have chronic effects on such dysfunctions. Another interesting aspect to be explored in future studies would be the potential synergy of this exercise protocol with osteopathic and/or physiotherapy treatments on the caudal muscles, as well as verifying the cranial effect.

This study could be the first step towards a new, increasingly multidisciplinary approach to SCM muscle problems, moving towards more effective and faster resolution of postural problems.

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## Conflict of Interest

None declared.

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