Effects of the Antigravitary Modification of the Myotension of Asset (MAGMA) Therapy on Myogenic Cranio-Cervical-Mandibular Dysfunction: A Longitudinal Surface Electromyography Analysis

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ABSTRACT: This study was aimed at evaluating the effects of a novel physiotherapy machine called MAGMA (AntiGravitary Modification of the Myotensions of Asset) on postural and masticatory muscles of subjects with myogenic cranio-cervical-mandibular dysfunction (CMD), by using surface electromyography (sEMG). Fifteen subjects, nine males and six females (mean age 27.6 years), with CMD were included in the study. The bilaterally monitored muscles were: masseter, anterior and posterior temporalis, digastric, posterior cervical, sternocleidomastoid, and upper and lower trapezius. All muscles were monitored at rest, with a second record of maximal voluntary clenching (MVC) for both the masseter and anterior temporalis. Patients were subjected to MAGMA therapy for one session/week of 30 min over ten weeks. The surface EMG activity was recorded twice, at the baseline and at the end of the therapy. After MAGMA therapy, the sEMG activity at rest of the monitored muscles was significantly better when compared to the baseline; the only exception was the anterior and posterior temporalis muscles which did not improve. On the contrary, with the MVC, all the monitored muscles (masseter and anterior temporalis) significantly improved their sEMG activity. Although more investigations are needed, these results indicate that the use of such antigravitary therapy can provide a tool for resolving myogenic CMD.

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The existence of connections between the masticatory system and body posture has been discussed previously.[1-3] More specifically, the activity of jaw muscles has been shown to be related to that of the neck and trunk. Consequently, alterations of the body muscular equilibrium can influence both the mandibular position[4-9] and facial morphology.[10] To date, the dental literature includes several articles on the influence of head and body postures on mandibular rest position, range of functional movements, and position of initial tooth contact,[4,11-17] and an interesting correlation between body position and mandibular elevator muscle activity has been seen in healthy and affected mandibular-dysfunction and/or nocturnal-bruxism subjects.[18] During maximal voluntary clenching in healthy subjects, masseter muscular activity has been observed to decrease in a supine position, when compared to that in an upright position, although masseter activities in resting and swallowing positions are not influenced by body posture. On the other hand, in patients affected by temporomandibular dysfunction, the masseter activity at rest does not change upon variation in body position from a seated upright to supine position.[18] In agreement with previous findings,[20,21] Boyd, et al.[19] demonstrated that head-neck dorsiflexion increases the sEMG activity of the temporalis muscles, whereas ventroflexion causes an increase in the sEMG activity of the digastric muscles. Further evidence relating to this possible correlation has been reported by Goldstein, et al.[7] who showed that changes in the anterior-posterior plane in the head and neck positions has an immediate effect on the mandibular closure path in healthy subjects. Tallgren, et al.[22] noted that an altered head/neck position was often the cause of temporomandibular joint (TMJ) problems in full denture patients who were observed for one year, and investigations of individual changes showed that a marked decrease in mandibular inclination due to alveolar resorption was associated with a retroinclination of the cervical spine. Changes in mandibular posture, whether caused by occlusal, muscular, or temporomandibular disorders, can also influence neck muscles and posture.[2,9,19,23-25] Mintz[26] observed that TMJ syndromes can develop based on an orthopedic postural problem. However, several authors suggest that body posture does not influence mandibular position at initial tooth contact in healthy young adults with complete dentition, and the range of postural changes that can be compensated for is generally greater in healthy young subjects than in patients with occlusal problems.[16,27] Recently, evidence was presented for a functional and anatomic correlation between the stomatognathic system and the postural regulation system.[28,29] Moreover, the same origin of the masticatory muscles and the tympani tensore muscle, and the common innervation from the trigeminal nerve may help to explain the origin of tinnitus and vertigo that are more often present in patients with cranio-mandibular dysfunction.[30-32] Evidence that myogenic cranio-cervical-mandibular dysfunction (CMD) can be resolved by a different postural-based approach is still lacking. Hence, the aim of this study was to use surface electromyography (sEMG) to analyze and quantify the effect of a new physiotherapy machine, the Anti-Gravitary Modification of the Myotension of Asset (MAGMA) machine, on patients with CMD.

Materials and Methods

Study population.

Fifteen subjects, nine males and six females (ages 21-33 years, mean age 27.6), with CMD were chosen from patients of the Unit of Orthodontics and Gnathology of the Department of Oral Sciences of the University of Chieti and were enrolled in the study. All of them presented signs and symptoms of myogenic CMD. The following inclusion criteria were observed: 1. absence of any previously orthodontic or gnathologic treatment; 2. presence of a natural dentition and a bilateral molar support with molar and cuspid Angle class I; 3. absence of any cross-bite; 4. presence of chronic muscle pain according to the history of signs and symptoms or elicited during palpation of the muscles of the trunk, neck and stomatognathic area; 5. absence of referred pain due to myofascial trigger points; 6. absence of whiplash, neurologic, vestibular, oculomotor disorders and/or hip disymmetry; 7. absence of any particular episode of psychosocial and psychological stress profile in the last six months. Moreover, any patient positive for the diagnosis of pure articular pathology and/or symptoms caused by trauma or surgery was not included in the study population. Patients were treated by means of MAGMA therapy for one session per week over ten weeks (30 min/session). Informed consent was obtained from the patients prior to the commencement of the study, and the protocol was reviewed and approved by the Ethical Committee of the G. D'Annunzio University Medical Faculty.

MAGMA Machine

The MAGMA machine (Aereonautic Industry "La Gatta", Pomigliano d'Arco, Italy) is a structure into which the subject is placed starting in a standing position without shoes, and then the subject's heels are slightly lifted from the ground by a series of ropes and pulley straps connected to a chest support (**Figure 1**). The subject is positioned equidistantly within the space using ropes and pulleys connected to a chest support, and padded positioners by which the patient is subjected to lordotic and cifotic curves according to their physiological range (**Figure 2**). One of the positioners is placed in the back lumbar region, two below the shoulder blades, and two at the front and above the acromionclavicle region and at the upper anterior iliac spine. After the patient is positioned, a treadmill-type conveyor belt is activated. The subject, who is slightly lifted, has to walk under almost no gravity in long slow steps (**Figure 3**).

sEMG Recordings

The study was performed using a K6-I surface electromyography (K6-I System, MyoTronics, Inc., Seattle, Washington, USA) with disposable electrodes [DUO F3010 bipolar (10 mm, Ag-AgCl, lithium chloride gel, unit distance 22 mm, LTT FIAB Vicchio, Firenze, Italy]. The K6-I System is an eight channel electromyograph with a 15-430 Hz band-pass filter, containing a special 60 Hz notch filter to eliminate any of the electrical noise from the recording environment that exceeds the capabilities of the common mode rejection scheme. All monitoring was performed with the patient in a standing position.

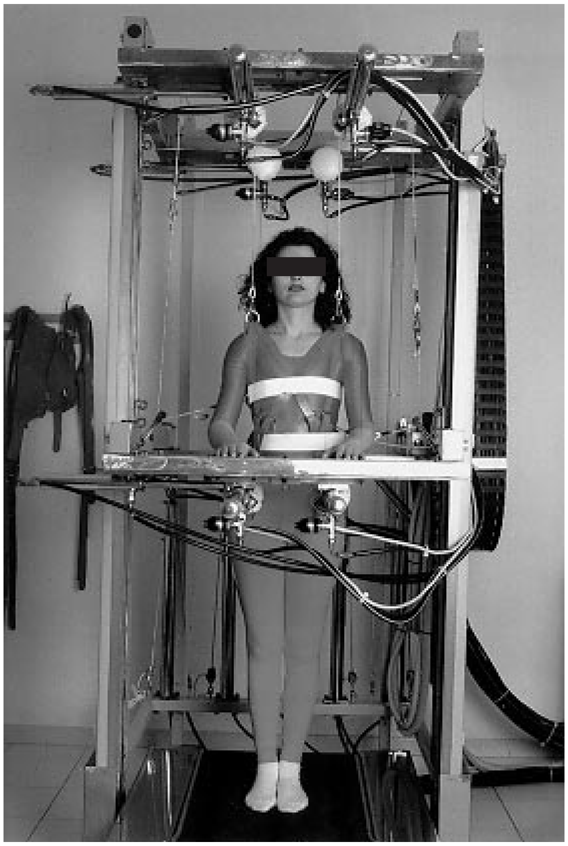

Figure 1
Photograph illustrating the use of a MAGMA machine (Aereonautic Industry "La Gatta", Pomigliano d'Arco, Italy). The subject is placed in a standing position without shoes, and then the subject's heels are slightly lifted from the ground by a series of ropes and pulley straps connected to a chest support.

The subjects were asked to make themselves comfortable, to relax their arms by their sides, and to look straight ahead and make no head or body movements during the test. The electrodes, which determine to a large extent the quality of the recordings, were placed according to the electrode atlas of Jeffrey R. Cram & Glenn S. Kasman.[33] Before the electrodes were applied, the skin was thoroughly cleaned with alcohol. The sEMG activity of eight muscles was studied bilaterally with the mandible at the rest position (scan 9, **Table 1**): the right masseter (RMM), left masseter (LMM), right anterior temporalis (RTA), left anterior temporalis (LTA), right posterior temporalis (RPT), left posterior temporalis (LPT), right digastric (RDA) and left digastric (LDA) as masticatory muscles; the right sternocleidomastoid (RSM), left sternocleidomastoid (LSM), right posterior cervicals (RPC), left posterior cervicals (LPC), right upper trapezius (RUTR), left upper trapezius (LUTR), right lower trapezius (RLTR) and left lower trapezius (LLTR) as postural muscles. The sEMG activity of two masticatory muscles (masseter and anterior temporalis) was also analyzed bilaterally during maximal voluntary clenching (MVC) in the intercuspidal position for three seconds (scan 11, **Table 2**), using cotton rolls between the dental arches. The patients were instructed to close their jaws in centric occlusion as forcefully as possible. Movement patterns were conducted for at least three repetitions to ascertain stability according to the protocol developed by Donaldson and Donaldson.[34] The first movement pattern was rejected because it was frequently dissimilar to the other two repetitions. The third movement was considered the most stable. The sEMG recording time for each analysis was at

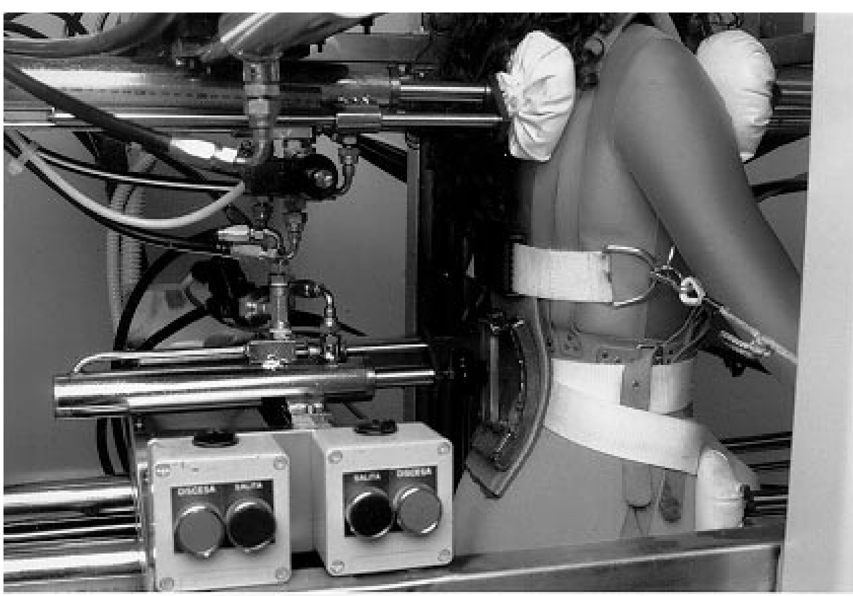

Figure 2
The subject is positioned equidistantly within the space using ropes, pulleys, and padded positioners resting comfortably against their front and back curves in their normal stance.

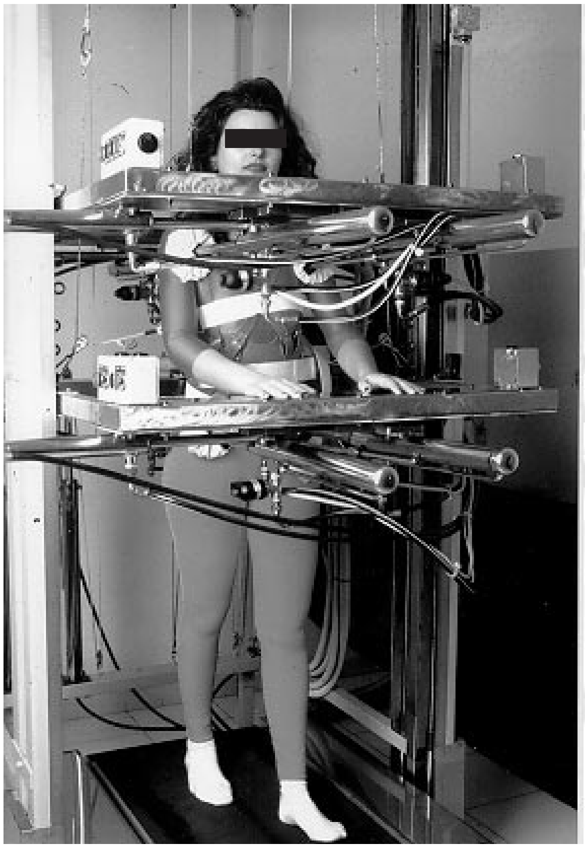

Figure 3
One of the positioners is placed in the back lumbar region, two below the shoulder blades, and two at the front and above the acromionclavicle region and at the upper anterior iliac spine. After the patient is positioned, a treadmill-type conveyor belt is activated. The subject, who is slightly lifted, has to walk under almost no gravity in long slow steps.

least 15 seconds, and the values were expressed in microvolts per second (μVolts/sec). For each subject, sEMG recordings were performed before and after therapy.

Statistical Data

The Statistical Package for Social Sciences program (SPSS, Inc., Chicago, Illinois, USA) was used to perform the data analysis on a computer. With each muscle and scan, the sEMG activity was expressed as mean (standard deviation [SD]); moreover, the corresponding mean (standard error [SE]) of the differences of the means between the two clinical sessions of monitoring was also computed. At this stage it was observed that the scan 9 data had a markedly skewed distribution; hence, a root-square transformation was required to produce a normal distribution of data within the different series. Since the root-square transformation was successful, transformed values were used in scan 9 for inferential methods. For both scans 9 (rest) and 11 (MVC), a paired student's *t* test was performed to assess the significance of the changes in sEMG activities between the clinical sessions within each muscle. Moreover, a further paired *t* test was employed to test the significance levels of differences in sEMG activity between the left and right sides, by muscle, at each time point. Finally, a probability of $p<0.05$ was accepted for rejection of the null hypothesis.

Results

The clinical results obtained in the present study are summarized in **Tables 1** and **2**. At rest, all muscles significantly decreased their sEMG activity over the study term, with the only exceptions being the LTA, RTA, LPT, and RPT, which did not show sEMG activity modification after the MAGMA therapy, as compared to the baseline (**Table 1**). Moreover, at the end of the study, in the digastrics (DAs) and posterior cervicalis (PCs), the sEMG activities were significantly different between left and right, with the latter being greater (**Table 1**). In the MVC, each monitored muscle showed a statistically significant elevation in sEMG activity after the MAGMA therapy, in comparison to the baseline levels (**Table 2**). After treatment, the masseters (MMs) showed a significantly different sEMG activity between the two lateral sides; this activity was greater on the left side (**Table 2**).

Discussion

We have performed a longitudinal study aimed at evaluating the effects of an antigravitarial body-postural approach in the resolution of myogenic CMD. Moreover, to objectively monitor the muscles' status over time, we made use of sEMG recordings.

Surface EMG is based on the extracellular recording of the motor unit action potentials by means of surface sensors, and the magnitude of energy recorded is in the millivolt range.[33] Reflecting the muscle activity, the sEMG signal is lower at rest and greater under isometric contraction; therefore, when a muscle is affected by some dysfunction, the signal at rest generally tends to increase, and the sEMG activity tends to decrease during isometric contraction.[33]

Four bilateral masticatory muscles were monitored at both the mandibular rest position and under isometric contraction. In particular, in order to avoid any occlusal interference on the maximal voluntary isometric contraction, the recordings of the MVC were made by using cotton rolls strongly tied between the dental arches. Four bilateral postural muscles were additionally monitored at rest to check evidence of any effects of the therapy on the muscles and on their possible interactions with the masti-

Table 1
sEMG Activities (µV/s) of the Different Monitored Muscles at the Mandibular Rest Position (Scan 9) (n=15)

Muscles	Baseline (mean±SD)	After treatment (mean±SD)	Mean diff. (mean±SE)	Difference
Left masseter	3.0±2.0	1.1±0.9	-1.9±0.4	p<0.01*
Right masseter	2.4±1.22	1.2±0.5	-1.2±1.9	p<0.05*
Left anterior temporal	3.3±2.8	2.4±0.9	-1.1±0.7	p>0.05†
Right anterior temporal	3.7±1.3	2.7±1.3	-0.9±0.6	p>0.1†
Left posterior temporal	5.3±3.1	4.1±2.0	-1.2±0.7	p>0.1†
Right posterior temporal	5.6±4.3	3.2±1.7	-2.5±1.2	p>0.05†
Left digastric	3.1±1.2	1.4±1.1§	-1.8±0.4	p<0.05*
Right digastric	3.0±1.3	1.8±1.2	-1.3±0.4	p<0.01*
Left sternocleidomastoid	4.5±1.8	1.6±0.9	-2.8±0.6	p<0.01*
Right sternocleidomastoid	4.4±3.0	1.7±0.8	-2.7±0.8	p<0.01*
Left posterior cervicals	4.6±1.6	1.7±0.9§	-2.9±0.6	p<0.01*
Right posterior cervicals	4.0±0.8	1.8±1.2	-1.8±0.5	p<0.01*
Left upper trapezius	4.1±1.6	2.0±2.2	-1.8±0.8	p<0.05*
Right upper trapezius	5.2±3.2	1.4±0.6	-3.8±0.9	p<0.01*
Left lower trapezius	5.0±1.0	2.7±1.7	-2.3±0.4	p<0.01*
Right lower trapezius	5.6±2.6	4.0±2.3	-1.8±0.6	p<0.05*

*Significant
†No significant difference
§Significantly different from the corresponding contralateral muscle
SD = Standard deviation
SE = Standard error
Diff. = Statistical significance of differences of sEMG activity between times within each muscle

catory muscles, as indicated by several studies. In most cases, the sEMG activity of the muscles at rest significantly decreased after therapy as compared to the baseline with the only exemptions being for the LTA, RTA, LPT, and RPT (**Table 1**). In the MVC, all masticatory muscles showed an increase in their sEMG activity after treatment, in comparison to the baseline, to a statistically significant level (**Table 2**). This suggests that the effects on the muscular tensions produced by the MAGMA therapy can also extend to some of the masticatory muscles. Since there were several significant improvements in sEMG activity of the muscles in the stomatognathic area following a modification in body posture, we may speculate on a possible clinically relevant interdependence between total body posture and occlusion. Furthermore, the mandibular muscle activities may be influenced by tonic neck and trunk muscles, as previously reported by Darnell.[34] A possible clinical correlation between the stomatognathic system and the rest of the body may be based on the body muscle chains of the neuromuscular system. In fact, when a muscle is in spasm or has a myofascial trigger point it might lead to a modification in postural position.[36] However, with regard to the sEMG activity at rest of the LTA, RTA, LPT, and RPT, the MAGMA therapy did not produce the same improvement. The different results observed in the stomatognathic area may be explained by the existence of different synaptic connections for the temporal, masseter, sternocleidomastoid, and both trapezius, as previously described.[22,28,29,37-39] It should also be noted that muscle sEMG activity can be affected by several factors, for example, psychological stress. A negative stress profile may have a specific influence on muscle activity that may be of importance for musculoskeletal disorders.[40] Ruf, et al.[41] found that the sEMG activity of the masticatory muscles during stress situations was significantly higher when compared to that of nonstress situations, and that females have significantly higher ratings than males.

In our study, even though the patients themselves said there was no particularly significant positive or negative psychophysiological stress during the time of their treatment, this could not be deemed reliable. Using sEMG

Table 2
sEMG Activities (μV/s) of the Different Monitored Muscles in the Maximal Voluntary Clenching (Scan 11) (n=15)

Muscles	Baseline (mean±SD)	After treatment (mean±SD)	Mean diff. (mean±SE)	Difference
Left masseter	125±54	216±57§	91±13	p<0.01*
Right masseter	133±67	202±52	66±15	p<0.01*
Left anterior temporal	103±32	157±36	55±8	p>0.01*
Right anterior temporal	104±36	157±40	53±7	p<0.01*

*Significant
§Significantly different from the corresponding contralateral muscle.
SD = Standard deviation
SE = Standard error
Diff. = Statistical significance of differences of sEMG activity between times within each muscle.

during experimental stress states, Jordy, et al.[42] have reported a 24-32% error in the diagnosis obtained by routine anamestic procedures following the criteria recommended by the Headache Classification Committee of the International Headache Society. Moreover, approximately 40% of all chronic pain syndromes are in the craniofacial region, with the most relevant of these being CMD and muscle-tension-type headache. This suggests that the head and neck muscles may present a special physiological sensitivity to psychological stress.[43]

Finally, it is of interest to note that in the MVC (scan 11), all the monitored muscles significantly improved their sEMG activity following therapy; therefore a different response to the postural approach in the MVC, compared to that at rest, can occur at least at this level of observation. More difficult to explain from the results of the isometric contraction are factors mentioned above, like psychophysiological stress, which may become less important in their effects upon the sEMG activity. We observed that the MAGMA therapy has in general a good impact on the monitored postural and masticatory muscles; however, the presence of possible interactions, such as psychosocial and psychological stress, may have limited the patient sEMG improvements.

The results obtained in this study warrant further investigation and demonstrate that such antigravitary therapy should be more extensively used in research in order to better understand the complex body posture system and its relation to the force of gravity.

Based on a clinical point of view, our results can be added to several other observations which indicate that a specialist in a single disicipline cannot always resolve a patient's problems and underscore the importance of a multidisciplinary approach. Dentists, physicians, osteopaths, phonoaudiologists, physiotherapists, etc., each contribute their own specific knowledge in order to reach a differential diagnosis that allows correct treatment planning. Clinical success, therefore, depends on the ability of each specialist to analyze the different aspects of the same problem. A teamwork structure may thus be the best option in order to obtain a good functional state of the stomatognathic system and the rest of the body after therapy. In this regard, a psychological approach may have a significant role in managing chronic pain. The aim of this type of approach is to bring the patient towards a functional rehabilitation process through relaxation of the muscles, awareness of the problem, reduction of drug dependency, and a daily improvement in life conditions.

Conclusion

These results indicate that MAGMA therapy can allow a patient to obtain a different postural pattern that is less affected by myogenic tensions, and therefore, we propose the use of the MAGMA machine as one of the tools for resolution of myogenic CMD. However, further investigations are required to better understand the clinical effectiveness of this MAGMA therapy in CMD patients.

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