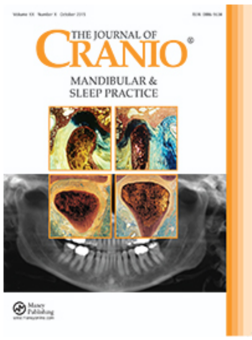

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Immediate Effects of Plantar Inputs On the Upper Half Muscles and Upright Posture: A Preliminary Study

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ABSTRACT: This purpose of this study was to investigate the immediate effects of plantar inputs on both the upper half muscle activity (anterior temporal, masseter, digastric, sternocleidomastoid, upper and lower trapezius, cervical) and the body posture, by means of electromyography (EMG) and vertical force platform, respectively. Twenty four (24) healthy adults, between the ages of 24 and 31 years (25.3±1.9), with no history of craniomandibular disorder or systemic musculoskeletal dysfunction, were randomly divided into two groups: test group (fourteen subjects) and control group (ten subjects). A first recording session (T0) measured the baseline EMG and postural patterns of both groups. After this session, the test group wore test shoes with insoles that stimulated the plantar surfaces, while the control group wore placebo shoes. After one hour, a second set of measurements (T1) were performed. Significant differences between the groups at baseline were observed in the left anterior temporal, left cervical, and left upper trapezius, as well as at T1 in the left anterior temporal and right upper trapezius ($p<0.05$). Within-test group analysis showed a significant increase of the right upper trapezius activity ($p<0.05$), whereas no changes were found by within-control group analysis. Lower risk of asymmetric muscle patterns and *postural blindness* in the test group compared to the control group was observed. Further studies are warranted to investigate the short and long-term effects of this type of insole, in patients with both craniomandibular-cervical and lower extremity disorders.

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Craniomandibular disorder (CMD) is a syndrome characterized by several clinical problems affecting the musculoskeletal structures of the stomatognathic system, of which pain is the most frequent symptom.[1] There is general agreement that CMD is associated with several local factors,[2-5] among which masticatory parafunctions, particularly bruxism, seem to be the most important in the determination of temporomandibular dysfunction (TMD).[6]

Besides the relationships between these local factors and CMD, in the last decade several researchers have investigated the possible correlation between occlusion, TMD, and body posture.[7-10] Recently a clinical trial performed by D'Attilio, et al.[11] showed a significant modification of the masticatory muscle electromyography pattern following ascending inputs produced by antigravity therapy. With regard to these ascending inputs, the plantar district plays an important role in balance control. In diabetic patients, falls due to ulceration were reported in a recent study.[11,12] In older subjects, the effects of aging

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seem to be associated with impaired postural control and increased risk of falls, both of which are due to a reduction in plantar-sensitive function.[13] In human experimental models that have employed rotating platforms, foot-sensitivity has been confirmed as one of the significant factors for body posture control.[14]

Although the role of plantar sensitivity on balance is quite clear[12-14] and its effect on the muscles of the lower half of the body are documented,[14] knowledge regarding its influence on the upper half of the body is scarce. Considering that plantar-sensitivity function has repercussions on body posture, which in turn is associated with both neck-muscle electromyographic (EMG) changes[7] and head sway,[15] the purpose of this study was to investigate the immediate effects of plantar stimulation on the head, neck, and shoulder muscles using surface EMG, as well as on body posture using a force-measuring platform.

Materials and Methods

Twenty four (24) healthy adults (four females and 20 males), between the ages of 24 and 31 years (25.3±1.9), with no history of CMD or systemic musculoskeletal dysfunctions participated in this experiment. Informed consent was obtained from all subjects, who were enrolled at the School of Dentistry, University "G. d' Annunzio", Chieti, Italy. The shoes (continental size 41.5) were judged comfortable by all subjects. Two pairs of hard shoes (**Figure 1**) were made to perform this investigation. Shape, weight and size were identical for both pairs, the only difference being the insoles used. The control shoes containedanormalanatomicsole(Dr.Scholl's,Manchester, UK), while the test shoes had a foot-bed with an insole one mm thick (Dr. Scholl's, Manchester, UK). The test-shoe insole incorporated three raised inserts in the anterior area of the foot, positioned precisely between the second and the third metatarsus and five mm from the metatarsal heads. These inserts were present even in the middle-heel area. All inserts were four mm in diameter, of the same height, and positioned 15 mm apart. Inserts were made from semi-rigid poly-amynic material to obtain reasonable stimulation of the plantar surface in proportion to body weight.

Figure 1
Photo of two pairs of shoes used in the study.

Electromyography (EMG)

We used a methodology based on surface EMG to determine head and neck muscular activity while static[16] (muscle-tone). All measurements were made using an EmgWin 2.0 electromyograph (Biotronic-S. Benedetto del Tronto, Italy). The pre-gelled electrodes (Duotrode, Novaxa, Milan, Italy) were placed at various, critical points on the subject after deep cleaning with an alcohol-soaked pad to control skin impedance.[17] Withdrawal sites were those stated by anatomical reference-book for the electrode placements[16] (**Figures 2** and **3**), respecting the six rules to improve the accuracy of EMG recordings.[18] The muscular sites used were the following: left and right anterior temporal, left and right masseter, left and right digastric, left and right sternocleidomastoid, left and right cervical, left and right upper trapezius, left and right lower trapezius. Hardware was calibrated at 10^4 Ohm Input Impedance, the sampled frequency, and the filter, at 10^3 Hz. All EMG values were expressed in Root Mean Square (RMS) micro volts per second (μVolts/sec) and were automatically calculated by the electrodiagnostic system during the sessions.

During EMG withdrawal, ten seconds for each recording, participants were asked to maintain a Romberg standing stance,[19] looking straight ahead in a quiet room in front of a mirror three meters away, with the mandible at rest (teeth apart) and eyes open. To standardize foot position, the subjects were placed on two platforms, with two black reference lines marked (**Figure 4**). The medial longer line was used to fix the second toe extremity and the center of the outer limit of the heel, while the lateral shorter line, starting from the center point, was used to position the center of the malleolus. The longer medial black lines were separated by an angle of 30 degrees.

Postural Pattern Measurements

Postural sway patterns were withdrawn to record postural parameters during the Romberg stance as stated previously. Measure-ments were made using a Vertical Force Platform (Lizard, Lizard SZ, Como, Italy) on which the feet were positioned on the reference lines shown in **Figure 4** using the stated methodology. These platforms were made of carbon fiber and Kevlar (E. I. du Pont de Nemours and Co.) and contained miniaturized load cells (BC 300, OS Europe, Milan, Italy) correspond-

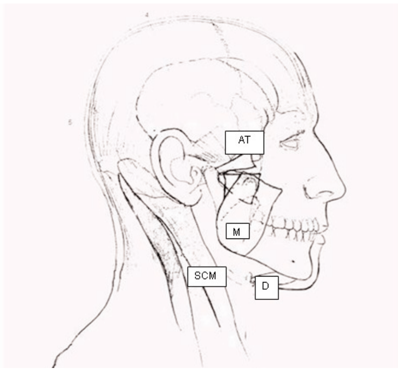

Figure 2 (above)
Representative drawing of the facial and anterior neck sites where electrodes were placed, **SCM**: sternocleidomastoid; **M**: masseter; **AT**: anterior temporal.

Figure 3 (below)
Representative drawing of the posterior neck sites were electrodes were placed, **C**: cervical; **LUT**: left upper trapezius; **RUT**: right upper trapezius; **LT**: lower trapezius.

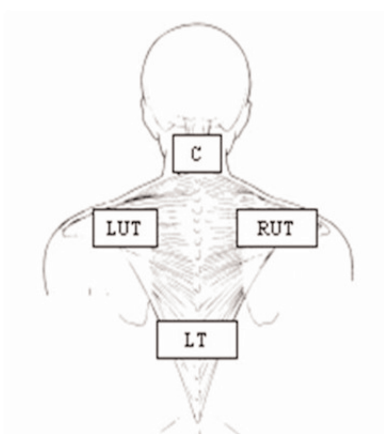

Figure 4
Platform used for feet placement.

ing to the first and fifth metatarsus and to the heel, in order to have three points to measure variations in the center of gravity placement for each foot. Load cells worked as calibrated springs. A Wheatstone bridge with a strain gauge measured the mechanical flexion, transmitting a proportional electrical signal that was amplified and translated into body weight. Consequently, body weight recording described the body-weight distribution on the plantar surface and the body sway pattern.

Postural parameters were expressed as sway length in mm, which was automatically calculated by the electrodiagnostic system during the sessions. The postural pattern recording was performed in the Romberg stance with eyes open and then closed.[20] Recordings lasted 50 seconds for each condition.

To minimize procedural bias, a pilot study tested the reliability of EMG and postural pattern measurements, finding no significant differences between the two related samples. Using a randomized method, subjects were divided into two groups: test group (fourteen subjects, 58.3%; M:F, 4.6:1) and control group (ten subject, 41.6%; M:F, 10:1). A single operator performed all measurements and double-blinding was used. Moreover, in order to reduce the influences from usual footwear, all subjects were asked to walk barefoot for five minutes in the laboratory before undergoing baseline recordings, At the end of this familiarizing time, the initial EMG and postural pattern measurements (T0) were recorded. Immediately after T0, test group subjects wore test shoes and control group subjects wore placebos. Each subject adjusted to the shoes by walking for one hour, and at the end of the period, final EMG and postural pattern measurements were made (T1).

Statistics

The EMG and postural variables were given as mean and standard deviation (SD). RMS amplitudes were used to calculate Symmetry Percentage[21] (SP) for each muscle pair. SP between two homologous muscles was calculated using the following formula:

$$SP = \frac{\text{greater RMS } (\mu\text{Volts/sec}) - \text{smaller RMS } (\mu\text{Volts/sec})}{\text{greater RMS } (\mu\text{Volts/sec})}$$

Pairs of muscles with SP>20% were considered to be asymmetric[21] (AM; asymmetric muscle). Postural recordings were used to calculate Length Romberg Index (LRI)[20] using the following formula:

$$LRI = \frac{\text{sway length (eyes closed-mm) x100.}}{\text{sway length (eyes open-mm)}}$$

Subjects that had LRI< 100 were considered to be "postural blindness patients"[20] (PBP).

Collected data were tested using the Kolmogorov-Smirnov test. EMG and postural values did not display normal distribution. Subsequently, differences in EMG and postural data were evaluated using nonparametric statistics, so that comparisons within-group were made using the Sign two-tailed test for two related samples, while inter-group differences were examined using the Kolmogorov-Smirnov two-tailed test for two independent samples.[22] Statistical significance was defined as two-sided p-value less than 0.05. All analyses were carried out using SPSS statistical software (SPSS for Windows, version 8.0, Chicago, IL).

The Reduction in Risk (RR) of increase in number of homologous muscles with SP>20% (MNI_{AM}) and subjects affected by postural blindness (PBP) due to plantar stimulation was also calculated using the following formulas:

RR_{SP}=(MNI_{AM} control group-MNI_{AM} test group)/MNI_{AM} control group;
RR_{LRI}=(%PBP control group-%PBP test group)/%PBP control group.

The 95% Confidence Interval (CI) was collected for the percentages used to calculate RR.

Results

Within-group and inter-group descriptive results of the EMG and postural variables are given in **Tables 1** and **2**, respectively, whereas within-group and inter-group comparison results are presented in **Figures 5**, **6**, and **7**. Differences between groups were observed at base line in the left anterior temporal, left cervical and left upper trapezius (p<0.05). In the test group, the first and second showed lower EMG activity, whereas the third showed higher activity (**Figure 5a**). Furthermore, at T1 we found differences between the groups in the left anterior temporal muscle and right upper trapezius (p<0.05). In the test group, the left anterior temporal muscle showed lower RMS amplitude, whereas the right upper trapezius showed a higher amplitude (**Figure 5b**). Within-control group analysis found no differences from T0 to T1 (**Figure 5c**), whereas within-test group analysis showed a significant increase in the right upper trapezius postural activity (p<0.05). This muscle went from an initial RMS value of almost 5 µVolts/sec to T1 value of eight µVolts/sec (**Figure 5d**).

The symmetry percentage, sway length and Length Romberg Index comparisons showed no significant differences in both within-group and inter-group analysis (**Figures 6** and **7**).

Table 1

Pre- and Post-Plantar Stimulation Values of the Electromyographic Measurements of Each Group

Parameters				LAT	RAT	LM	RM	LD	RD	LSCM	RSCM	LUT	RUT	LLT	RLT	LC	RC
RMS	Test group	T0	Mean	4.4	4.8	2.1	3.3	4.9	3.5	2.99	3.52	4.8	4.4	5.2	4.4	5.6	5.2
			SD	1.5	1.5	0.5	2.2	2.0	1.8	0.83	1.76	0.9	1.4	2.7	2.2	1.5	1.9
		T1	Mean	4.6	4.7	4.4	3.5	4.5	3.4	3.69	3.20	8.0	9.1	5.2	4.4	4.7	4.7
			SD	1.7	1.5	2.9	2.2	1.8	2.3	1.46	0.96	5.7	5.9	1.6	2.6	2.0	3.0
	Control group	T0	Mean	6.3	6.1	2.9	3.4	4.5	4.5	4.84	4.79	3.6	3.2	5.2	4.7	6.6	5.6
			SD	2.0	1.2	1.0	1.2	1.3	2.5	1.19	2.31	0.9	1.2	1.8	1.6	1.8	1.0
		T1	Mean	6.4	5.8	3.4	3.5	4.3	3.5	4.72	3.04	3.9	3.3	5.6	6.0	5.9	6.0
			SD	0.7	0.8	1.0	1.4	0.6	1.1	0.85	0.90	0.6	0.6	2.1	2.0	1.7	1.3

Parameters				AT	M	D	SCM	UT	LT	C
Symmetry % (x 100)	Test group	T0	Mean	0.2	0.3	0.3	0.3	0.2	0.3	0.3
			SD	0.1	0.2	0.2	0.2	0.2	0.2	0.2
		T1	Mean	0.2	0.3	0.4	0.2	0.3	0.2	0.2
			SD	0.1	0.2	0.2	0.2	0.2	0.2	0.1
	Control group	T0	Mean	0.1	0.2	0.2	0.2	0.2	0.2	0.2
			SD	0.2	0.2	0.2	0.3	0.2	0.1	0.2
		T1	Mean	0.2	0.2	0.2	0.4	0.1	0.2	0.2
			SD	0.1	0.2	0.2	0.2	0.1	0.2	0.1

Muscles: LAT: left anterior temporal; RAT: right anterior temporal; LM: left masseter; RM: right masseter; LD: left digastric; RD: right digastric; LSCM: left sternocleidomastoid; RSCM: right sternocleidomastoid; LUT left upper trapezius; RUT: right upper trapezius; LLT: left lower trapezius; RLT: right lower trapezius; LC: left cervical; RC: right cervical; AT, M, D, SCM, UT, LT, C are the pairs of the muscles.

Table 2
Pre- and Post-Plantar Stimulation Values of the Postural Pattern Measurements of Each Group

		Test group				Control Group			
		T0		T1		T0		T1	
Parameters		RS	EC	RS	EC	RS	EC	RS	EC
Sway	Mean	269.50	338.40	260.90	358.10	284.20	342.30	286.20	409.10
Length (mm)	SD	73.70	124.20	81.12	110.80	101.70	154.50	91.17	186.10
		T0		T1		T0		T1	
Length Romberg	Mean	125		137		123		138	
Index (%)	SD	28		22		40		36	

RS: Romberg Stance with eyes open
EC: Romberg Stance with eyes closed

Risk Analysis

Descriptive results are given in **Figure 8**. In general, lower risk of asymmetric muscles and postural blindness was observed in the test group compared to the control group. Thus, in the control and test groups, MNI_{AM} was 50% (IC; 10-90%) and 33% (IC; 5-65%), respectively, with RR of 33%. PBP percentage was 50% (IC; 5-90%) in the control group and 0% (IC; 0-50%) in the test group with RR of 100% (**Figure 8**).

Discussion

The limitations of this study must first be considered. The small size of the two groups reduced the power to detect significant differences. Further, despite the strict inclusion criteria, the two groups were not representative of the whole sample. All individuals were clinically healthy, but not evenly distributed for our purposes. Control and test groups showed baseline differences in muscular tone for three of the fourteen investigated muscles (left anterior temporal, left upper trapezius and left cervical). Despite these different EMG patterns, the RMS amplitudes of all muscles ranged from 2-6 μVolts/sec (**Figure 5a**), considered to be normal range of normality.[23] However, in the EMG measurements taken using standard procedures, a between-subject variability was accepted as the source of diagnostic data[16] and these differences could be due to a varying use of the monitored muscles.[24]

With these caveats, this randomized controlled trial provides information for the first time on the ascending effects of plantar inputs on the head and neck muscles, as well as on the postural stance. Our main findings were: as regards the EMG pattern of each muscle: 1. the right upper trapezius increased following plantar inputs, showing significant changes compared to its baseline and compared to the control group EMG activity; 2. the left anterior temporal muscle activity was lower in the test group compared to the control group, and the plantar inputs did not induce significant variations in EMG symmetry percentages and balance parameters; 3. the test group showed a lower risk of increase in both muscle asymmetry and postural blindness.

Recently, the effects of ascending input on the stomatognathic system and neck postural muscles through antigravity therapy have been reported in an uncontrolled clinical trial.[11] The authors suggested that both postural and masticatory muscles responded to gravity reduction, decreasing the RMS amplitude at rest and increasing the EMG activity during maximal voluntary clenching.

Similarly, our results showed a significant response in upper half muscles through plantar surface stimulation. We introduced the plantar inputs during the Romberg standing stance, through experimental shoes designed according to the previous criteria. Robbins & Gouw[25] reported that surface irregularities should be added to the insoles to gain correct sensory input, and Burgess, et al.[26] suggested that small inserts placed in a hard sole, proximal to the metatarsal heads and between the second and third, produced a pressure peak shifting from the medial to lateral forefoot and a simultaneous reduction in plantar pressure.

The mechanisms that link body posture to the stomatognathic system, as well as those linking plantar-sensitive function and upper half postural muscles are yet unclear. One possibility is that plantar stimulus induced a balance reflex and, therefore, a postural muscular response, as observed in the current study upon the

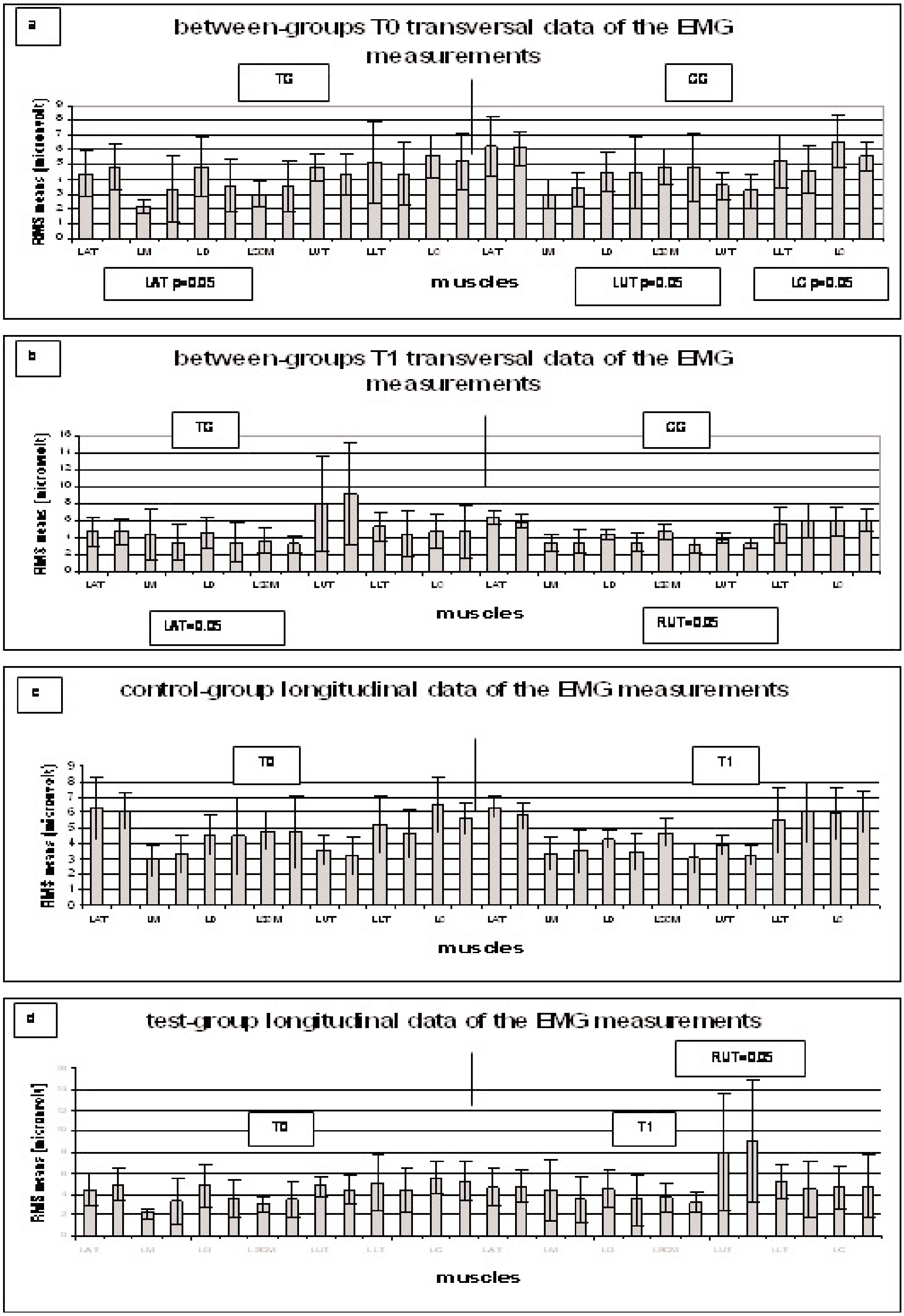

Figure 5
Inter-group and within-group comparisons of EMG activity for each muscle, **a**: baseline comparison between groups; **b**: T1 comparison between groups; **c**: within-control group comparison; **d**: within-test group comparison.
Muscles: **LAT**: left anterior temporal; **RAT**: right anterior temporal; **LM**: left masseter; **RM**: right masseter; **LD**: left digastric; **RD**: right digastric; **LSCM**: left sternocleidomastoid; **RSCM**: right sternocleidomastoid; **LUT** left upper trapezius; **RUT**: right upper trapezius; **LLT**: left lower trapezius; **RLT**: right lower trapezius; **LC**: left cervical; **RC**: right cervical.

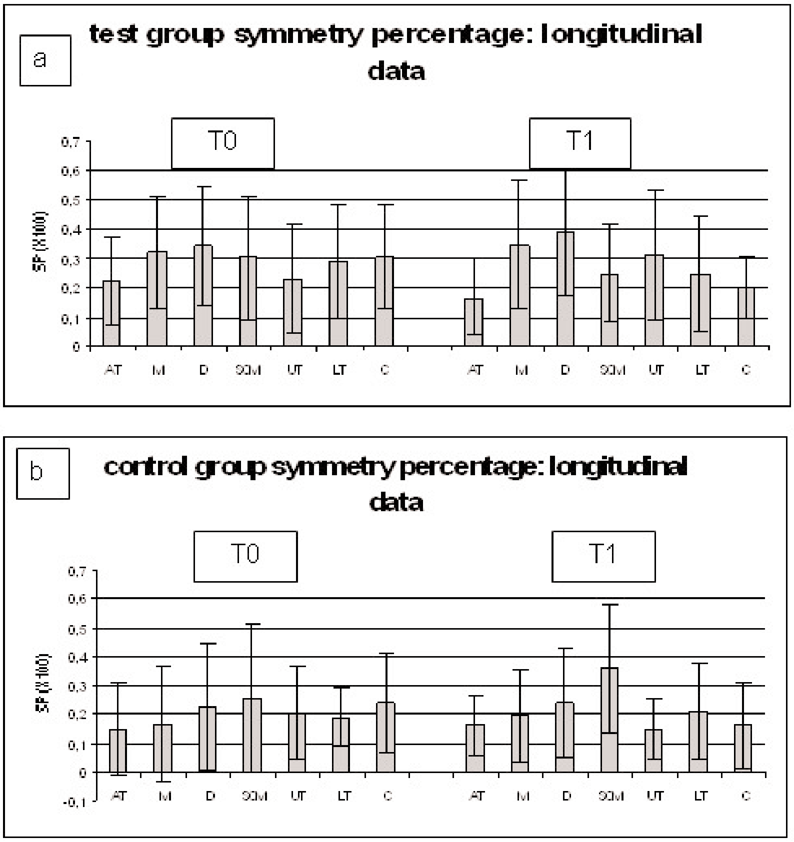

Figure 6
Symmetry percentages: **a**: within-test group comparison; **b**: within-control group comparison.
Muscles:
LAT: left anterior temporal;
RAT: right anterior temporal;
LM: left masseter;
RM: right masseter
LD: left digastric;
RD: right digastric;
LSCM: left sternocleidomastoid;
RSCM: right sternocleidomastoid;
LUT left upper trapezius;
RUT: right upper trapezius;
LLT: left lower trapezius;
RLT: right lower trapezius
LC: left cervical;
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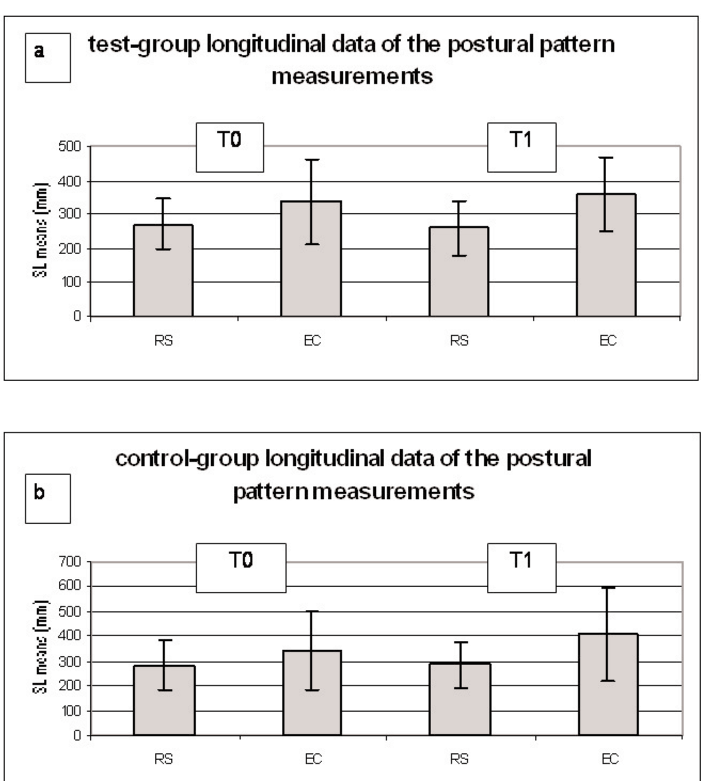

Figure 7
Within-group comparisons of postural parameters: a: within-test group comparison; b: within-control group comparison.
RS: Romberg Stance with eyes open
EC: Romberg Stance with eyes closed

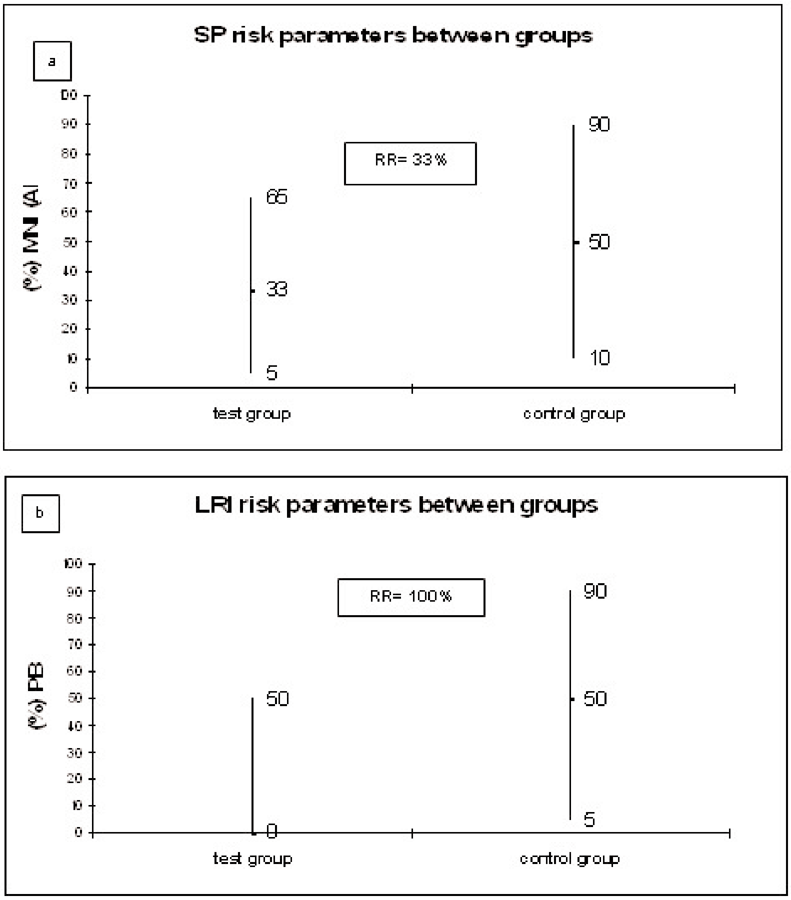

Figure 8
Graph showing the relative risk values with their confidences limits. MNI: muscle number increasing; SP: symmetry percentage; RR: relative risk reduction.

trapezius muscle. This theory was reported in a study performed by Valentino, et al.,[27] in which the neurological mechanisms leading to a peri-cranial muscle response, following plantar stimulation, were described. They applied "plastiline" to the medial margin of the right plantar arch and observed EMG changes on the monitored paravertebral, masseter, and temporalis muscles.

Besides studies undertaken to comprehend the effects of plantar stimulations on the head and neck muscle-pattern, another study was aimed at correlating body posture (intended as body position) with EMG activity of the sternocleidomastoid and masseter muscles in patients with myogenic cranio-cervical-mandibular dysfunction.[7] The authors suggested that parafunctional habits and body position were closely related to the discomfort in these muscles.[7] Zonnenberg, et al.[9] investigated whether body posture was an etiological factor in patients with TMD and found a significant correlation between shoulder-line and pelvis-line not found in healthy subjects. It emerges that body position variations, as well as ascending inputs, may influence the muscular pattern of the upper part of the body, particularly upper postural muscle activity (sternocleidomastoid, trapezius, and paravertebral muscles). It is obvious that postural stimulus is closely related to the responses of these muscles, being anatomically and functionally involved in balance reflexes. This could explain the behavior of the trapezius muscles observed in our study (**Figure 5**). In **Figure 5** (**a**, **b**, **c**, and **d**), it is seen that both left and right upper trapezius (although the left muscle was not significantly affected) reached eight µVolts/sec, while the others in all sessions never reached six µVolts/sec, suggesting an evident response in these muscles.

Besides the relationships cited above between the lower and upper parts of the body, those investigated in the head and neck areas are worth noting. In several studies, morphological interaction between the various structural variables was found.[28-33] In a recent study undertaken by Festa, et al.,[28] correlations between craniofacial morphology, head posture and cervical lordosis variables were reported. They analyzed lateral cephalograms taken from 70 Caucasian females and observed, in particular, a significant negative association between the mandibular length and the cervical lordosis angle. Since the 1970s, several researchers studied the relationship between craniofacial morphology and head posture,[29,30] approaching the issues from different directions, i.e., studying patients with TMD,[31] craniofacial development[32] and the influence of the respiratory pattern on the cranio-cervical posture.[33] Other researchers studied the functional relationship between musculoskeletal structures of the neck and head, suggesting the existence of a craniomandibular-cervical masticatory system.[34] Al-Abbasi, et al.[34] found that isometric strength of the cervical muscles was affected by bite position and vertical-occlusion dimension. In this light, Kibana, et al.[35] recently reported that occlusal support influenced the sternocleidomastoid EMG activity.

These structural and biomechanical interactions are based upon the complex anatomy of the head and neck musculoskeletal system,[36] as well as upon the neurological convergences existing in this area.[37] Chains of interconnecting muscles, tendons, ligaments, and fascia in the head and neck regions give evidence of several interconnections (from the skull to the suboccipital muscles, to the cervical spine, and to the anterior and posterior cervical muscles; from the facial muscles and their ligaments to the hyoid bone; from hyoid bone to infra-hyoid structures),[36] Moreover, sensory convergences, documented in the V-brain stem system and coming from the C l-C3 and trigeminal afferents, supported the findings in the TMJ pain experimental models, in which an increase in EMG activity in the mandible elevator and depressor muscles occurred following induced pain in the C I-C3 inter-vertebral receptors.[37] It is reasonable to assume that the function of a part of this anatomical functional system might have repercussions on another, so that, for example, the changes observed in the trapezius muscles could trigger changes in associated, linked structures involving the myofascial layers as far as the top of the head (temporal muscles).

Our findings regarding the differences between test and control groups in the left anterior temporal muscle are generally consistent with those from the previous studies, but unfortunately, the small number of subjects prevented meaningful comparison with baseline measurements for the test group. In addition, the decision to perform recordings during standing might have limited plantar sensitivity, leading to the lack of significant changes in both balance parameters and symmetry percentage (**Figures 6** and **7**). This is in accordance with Komiyama, et al.,[38] who recently suggested that the standing posture may lead to a reduction in sensitivity due to the absence of "human cutaneous reflexes."

Risk analysis was performed to investigate whether or not the random administration of an experimental insole, which stimulated the plantar surfaces, produced some impairment of or improvement in postural and EMG variables, compared to a placebo insole. Surprisingly the proportion of subjects, that suffered both an increase in muscle asymmetry and the presence of postural blindness, was higher in the control group than in the test group (**Figure 8**), suggesting that these shoes prevented postural and muscular symmetry impairment.

It is well known that foot orthoses may provide relief of plantar pressure for the treatment of ulcerations in diabetic patients,[19] and that small inserts, placed in the sole of a shoe, may contribute to control the areas affected by this pressure.[26] Unfortunately, the previous researches investigated neither the overall posture nor the upper muscular patterns, and similarly we did not measure the plantar pressure distribution. In other words, we were unable to assess the impact of this shoe on the plantar peak pressure, having limited the measurements to upper half EMG pattern and the balance parameters. It is difficult to compare our risk analysis results on the possible therapeutic effects of these shoes with other studies. A future study would allow for a more definitive assessment of the plantar pressure effects.

The current study had two main strengths, including randomized clinical trial design and recordings taken in standing posture that avoided movement and, therefore, the artifacts. We believe that the results of this study are consistent with the available literature and that could have clinical implications. If plantar sensitive function influences the postural activity of the upper trapezius, then the lower parts of the legs should be investigated in patients with TMD, because they frequently claim symptoms in the neck area.[1] It is not unusual for the greater occipital nerve, which passes through the semispinalis capitis and the upper trapezius muscle fibers, to suffer compression entrapment deriving from the trigger-point bands, showing tingling, numbness, hypoesthesia and, sometimes, hyperesthesia.[40] In addition, upper trapezius trigger points are the major source of tension neck ache and contribute to tension-type headaches.[40] It is worth noting that the trapezius muscles play an important role in the maintenance of head posture, which in turn, especially in forward stance, can be correlated with class II occlusion and craniomandibular dysfunction.[31] Therefore, monitoring of this muscle is fundamental in both the diagnosis and treatment of head and neck pain. For this reason, the control of all factors that can influence upper trapezius activity is needed and plantar sensitivity seems to be one of them.

The management of patients with head and neck area dysfunction must be performed not only from a local point of view, but also with systemic, multidisciplinary approach, which takes into account the ascending inputs coming from the lower extremities. Although this study helps to clarify our understanding of the functional relationship between several distinct areas of the body, further studies are warranted to clarify the short and long-term effects of this type of insole, on patients with both craniomandibular-cervical and lower extremity disorders.

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