Research article

Clin Ter 2020; 171 (5):e414-420. doi: 10.7417/CT.2020.2251

Muscular pattern in patients with temporomandibular joint disc displacement with reduction: an electromyographical assessment

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Abstract

Objective. Surface Electromyography of masticatory muscles (sEMG) is used as a tool to support diagnosis and treatment of Temporomandibular disorders (TMDs). The study aimed at examining jaw muscles pattern in individuals with temporomandibular joint disc displacement with reduction (TMJ/DDR). This sort of subjects was supposed to have a different muscular pattern compared to the control group.

Materials and methods. Sixty-four women with unilateral TMJ/DDR and forty TMD-free women underwent a sEMG assessment of masticatory muscles. Descriptive statistics were performed. Student T-Test assessed differences between the two groups. Statistical significance was set at $\rho < 0.05$.

Results. The t-test showed statistically significant results only in BAR and SMI scores (ρ value < 0,0001). The other measurements did not differ between the two groups. BAR index values of all healthy subjects were within the reference range. Almost the entire TMJ/DDR group had BAR index out of reference range and anteriorly placed.

Conclusions. Women with TMJ/DDR showed an altered recruitment of the jaw muscles, with significant difference between the activity of the couple of temporalis and the one of masseters, compared to the control group. A lower chewing efficiency was found in the DDR group compared to the control one. ***Clin Ter 2020; 171 (5):e414-420. doi: 10.7417/CT.2020.2251***

Key words: *Surface Electromyography, Temporomandibular disorders, disc displacement, masticatory muscles, Temporomandibular joint, muscle impairment*

Introduction

Temporomandibular disorders (TMDs) are a collective term embracing a number of clinical problems affecting the masticatory muscles, the temporomandibular joint (TMJ), and associated structures (1). The etiology and physiopathogenesis are multifactorial and not yet well known (2-4). This greatly influences the diagnostic approach and clinical management of the patient. The gold standard for the diagnosis of TMDs is: medical history, clinical examination and imaging. The diagnostic reference criteria are the Diagnostic Criteria for TMD (DC /TMD) consisting of a validated classification system also based on the biopsychosocial model of pain (5,6).

The presence of functional analysis like surface Electromyography (sEMG) of masticatory muscles is available to provide additional information in order to support the management of TMDs, but without replacing the classic diagnostic path (7). sEMG uses a painless and innocuous method which can be used to evaluate changes in the masticatory system and which it has been used in research settings for the assessment and follow-up of patients with TMDs (8,9). Several studies demonstrated different electromyographical (EMG) values in the masticatory muscles of patients with TMDs, compared to the control group. In these studies, subjects who have a diagnosis of pain related to TMD presented with an altered recruitment of the jaw muscles (10-16).

The authors of this study decided to focus their attention to a common subgroup of TMD, which is the one of the disc displacement with reduction (TMJ/DDR), that according to DC/TMD (Axis I) belongs to the category of Joint Disorders. It is defined as a disruption within the internal aspects of the TMJ, whereby the disc is displaced from its normal functional relationship with the mandibular condyle and temporal bone (6). Articular disorders are associated to arthralgia and muscle pain. Furthermore, mandibular function impairment is a common complaint among TMD patient (17). The alteration of muscle activity that may be present in the patient with joint dysfunction can be investigated through sEMG.

The study aimed at verifying the hypothesis that the patients with DDR had peculiar "muscular electromyographic patterns" when compared to healthy subjects.

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ISSN 1972-6007

Materials and methods

Study Design and Sample.

The study was approved by the Institutional Ethics Committee of Sapienza University of Rome (Protocol No 349). The study was conducted at the Department of Oral and Maxillo-facial Sciences of Policlinico Umberto I, "Sapienza" University of Rome, between March 2018 and July 2019.

The research was conducted in accordance with The Code of Ethics of World Medical Association (Declaration of Helsinki) for experiments involving humans.

Inclusion and exclusion criteria

Sixty-four females who fulfilled the following criteria were enrolled in the study: clinical diagnosis of unilateral TMJ disc displacement with reduction in accordance with DC/TMD from at least 6 months; Ortopantomography, Magnetic Resonance Imaging of TMJs. Patients were excluded from the study if they met one or more of the following exclusion criteria: other type of joint disorders (intermittent locking, disc displacement without reduction with/without limited opening, subluxation); presence of unstable medical or psychiatric illness; a positive history for a substance abuse in medical anamnesis; neurological disorders; craniofacial syndromes; history of local or general trauma; pregnancy; absence of teeth, with the exception of the third molars; fixed or removable prostheses; current orthodontic or dental treatment.

For the sake of avoiding selection bias, the sample was homogenous by gender and pathology.

Female subjects, students at the Department of Oral and Maxillo-facial Sciences, have volunteered to take part in the study, in order to allow the creation of a control group. The same exclusion criteria, appropriate to the group with DDR, were applied. Forty subjects who did not refer TMD-symptomatology, in accordance with the Symptom Questionnaire (SQ) (6) of the Diagnostic Criteria for temporomandibular disorders (DC/TMD), were included in the study. However, the absence of muscular and joint dysfunctions, according to DC/TMD-based gnathological assessment, was confirmed by a clinical examination. Those with a latent pathology or risk factors such as parafunctions or ligaments laxity (18) were excluded.

Subjects eligible for the study had provided signed informed consent, according to the World Medical Association's Declaration of Helsinki.

Sample size calculation

The number of subjects per group was considered sufficient on the basis of a minimum level required established by Ferrario et al. (19), where a sample including 21 subjects per group was sufficient to detect 5 % (SD = 4.55%) between-group differences in POC index (α=0,05 and 1-β =0,9). The enrolled subjects of both groups were comparable by age, gender and dental features. As for dental features, all subjects were characterized by a good state of dental and periodontal health and complete permanent dentition (with the exclusion of third molars).

EMG assessment

Subjects eligible for the study (DDR and control group) underwent an electromyographic assessment.

The authors of the study used a standardized protocol proposed by Ferrario (19) and widely used by Michelotti et al. (5); Santana-Mora et al (10); Tartaglia et al. (13). This protocol allows to calculate indices of jaw muscles activity by using standardized EMG signals recorded during maximum voluntary contraction in maximal intercuspation and on cotton rolls. This method reduces biological and technical noise, and allows to compare the activity of paired jaw muscles by providing indices of asymmetric jaw muscles activation during function.

The electrical activity of the right and left anterior bundle of Temporalis Muscles (AT) and right and left masseters (MM) was recorded simultaneously during standardized tasks. Silver-silver chloride bipolar surface pre-gelled electrodes (Kendall, Mansfield, MA, USA) with a diameter of 24 mm were placed on the skin along the main direction of the muscular fibres. The skin was thoroughly cleaned with an abrasive preparation gel (Everi, Spes Medica, Genova, Italy) before electrode placement in order to minimize electrode impedance. For the TA, electrodes were placed vertically over the anterior border of the muscle, on the area corresponding to the fronto-parietal suture; for the MM, the upper pole of the electrode was placed at the intersection between the tragus-labial commissure and the exocanthion-gonion (mandibular angle) lines.

Recordings were performed at least 5–6 minutes after the application of the electrode to allow the conductive gel to adequately moisten the skin surface. All subjects sat in a dental chair. The position of the seatback was fixed, while the vertical excursion of the dental chair could be adjusted by the operator. The EMG analysis was performed using a wireless EMG device (TMJOINT, BTS SpA, Garbagnate Milanese, Italy). The EMG signals were acquired at 1KHZ, amplified (gain 150) and filtered via hardware (low-pass filter 500Hz; high-pass 10Hz). A software program (Dental Contact Analyser, BTS SpA) processed the raw electrical signals and generated root mean square (RMS) values. Thereafter, RMS values were processed by an algorithm to generate indices of muscle activity and asymmetry.

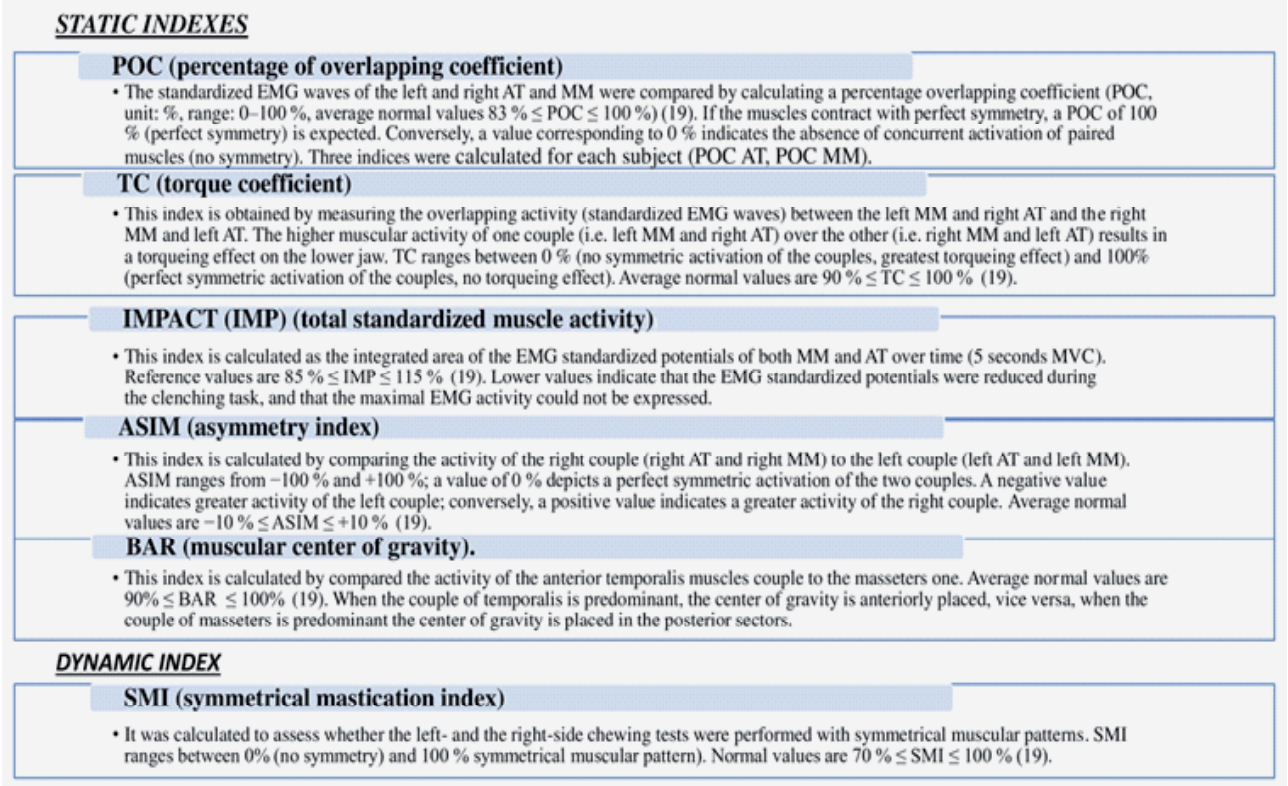
The EMG protocol included three static and two dynamic tests. The rationale was to get a more accurate measurement and values to be analyzed.

Each static and dynamic test included the protocols shown in the Table 1.

Table 1. Static and dynamic protocol

Static protocol	
1. Maximum voluntary contraction (MVC) in intercuspal position on cotton rolls (COT)	Subjects clenched as hard as possible for 5 seconds on 10 mm thick cotton rolls (positioned from the mandibular first molar to the canine on both sides).
2. Maximum voluntary contraction (MVC) in intercuspal position (CLENCH)	Subjects clenched their teeth as hard as possible for 5 seconds.
Dynamic protocol	
1. Chewing gum on the right side for 15 seconds	
2.Chewing gum on the left side for 15 seconds.	

Table 2. *Digital Static and dynamic indices.*



Between the static and the dynamic tests, participants were asked to rest for 3 minutes.

The following standardized EMG indexes were calculated via software (Table 2).

The EMG protocol and the algorithm used for the standardization of the EMG signals and the calculation of the indices have been used and described in several research studies (5,10,13,19).

A medical operator performed clinical and digital evaluations of both groups and another one processed and analyzed clinical and digital data.

Statistical Analysis

For each subject, the average value of each index of the three static and of the two dynamic tests was calculated, in order to get more reliable data. After checking the normal distribution of data with Shapiro-Wilk test, in both groups mean value, standard deviation, standard error of each index were calculated. Confidence intervals were set at 95%, to obtain a precise estimate of data. Independent Student T-Test was used to assess differences between the two groups. Statistical significance was set at $\rho < 0.05$.

All analyses were done with JASP Version 0.8.0.1, downloadable at https://jasp-stats.org/download/.

Results

The total sample included one hundred and four female subjects. Sixty-four composed the DDR group (mean age ± standard deviation 35.8 ± 15.2 years) and forty composed the control group (mean age ± standard deviation 34.1± 11.2).

In the group with TMJ/DDR, average scores of IMP, BAR, TC and SMI indexes were out of reference range respectively in the 73% (of which 26% had increased values and 74% had decreased values), 78%, 60%, 75% of patients. (Fig. 1). Almost the totality of TMJ/DDR subjects with an altered BAR Index (86%) had the center of gravity anteriorly placed.

A similar percentage trend was noticed in the control group, except for BAR average values which resulted within reference scores in all subjects and SMI average values altered in the 39% of patients (Fig. 2).

The average values of each EMG index of both the dysfunctional group and the control-one resulted out of normal range, except for BAR and SMI scores in the control group and IMP and ASIM scores in both groups, as shown below (Tables 3-4).

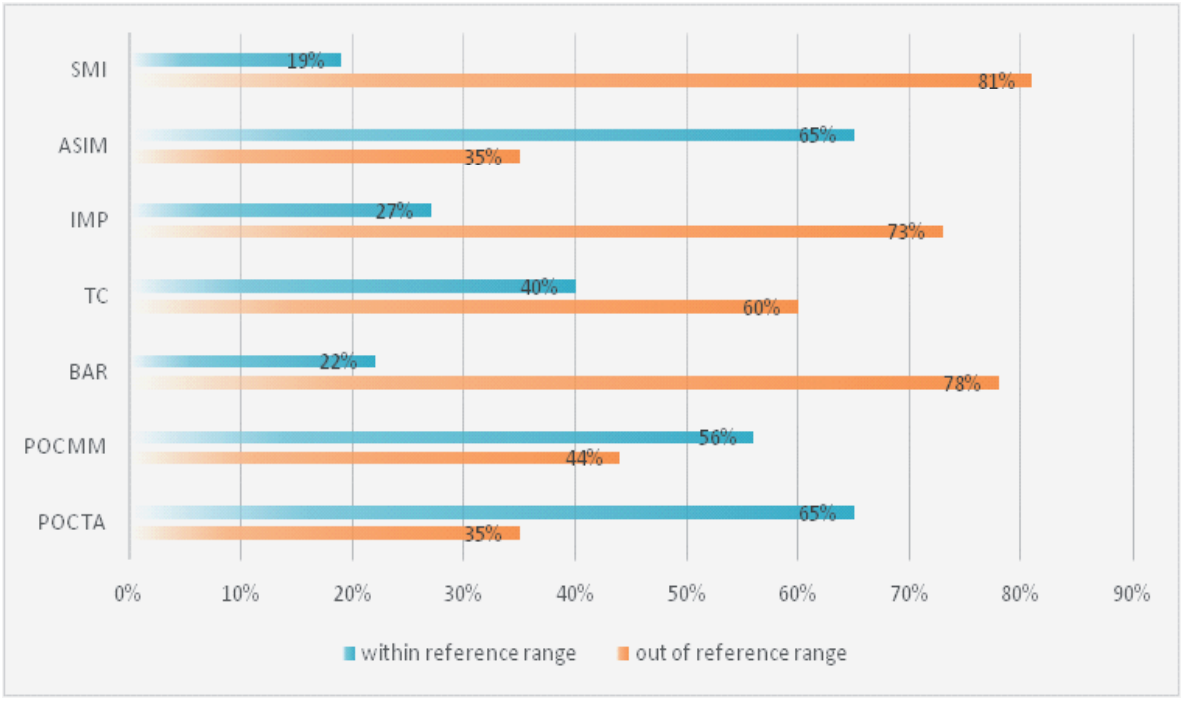


Fig. 1. Percentage (%) of DDR subjects with average values of the EMG indexes within and out of reference range.

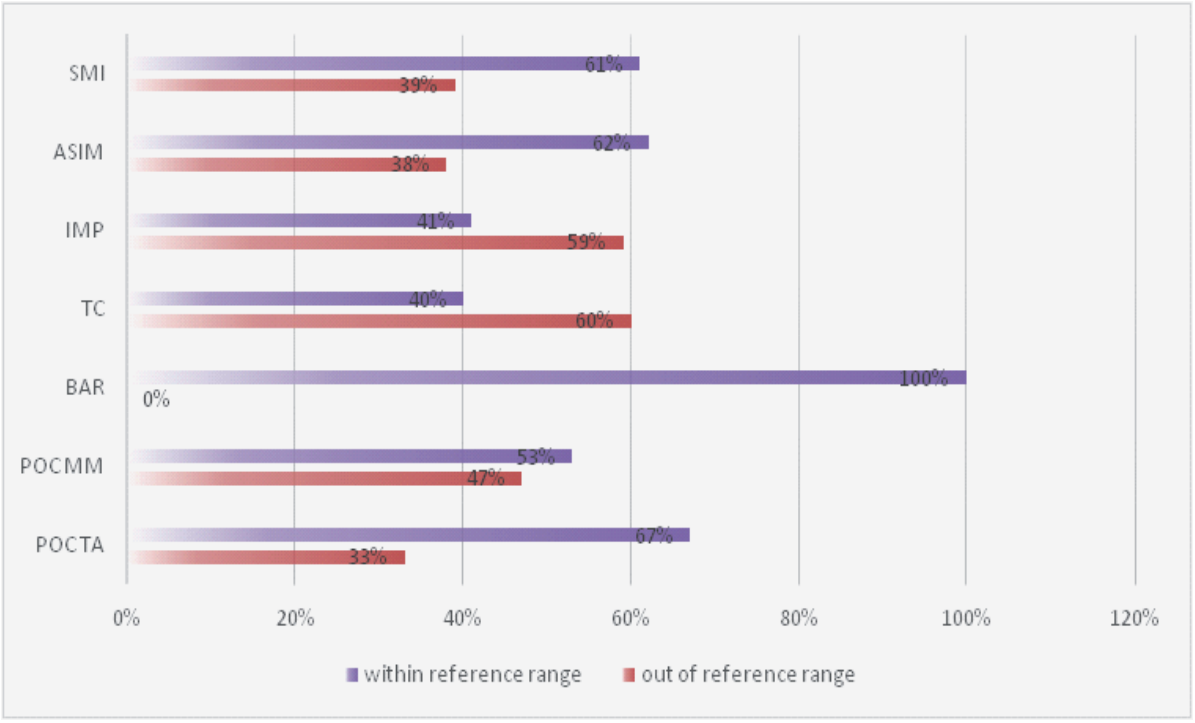


Fig. 2. Percentage (%) of control group subjects with average values of the EMG indexes within and out of reference range

Table 3. Mean value, standard deviation (ST DEV), confidence interval (CI 95%) for each EMG index in DDR subjects.

	Mean value	ST DEV	CI 95%	Normal range
POC TA	81.54	9.28	79.27 – 83.81	83 ≤ (%value) ≤ 100
POC MM	81.34	7.72	79.45 – 83.23	83 ≤ (%value) ≤ 100
BAR	77.86	9.43	75.55 – 80.17	90 ≤ (%value) ≤ 100
TC	87.2	4.74	86.04 – 88.36	90 ≤ (%value) ≤ 100
IMP	89.30	36.81	80.30- 98.31	85 ≤ (%value) ≤ 115
ASIM	|7.64|	6.92	5.95 – 9.33	-10≤ (%value)≤ +10
SMI	45.06	24.74	39.06 – 51.12	70 ≤ (%value) ≤100

Table 4. Mean value, standard deviation (ST DEV), confidence interval (CI 95%) for each EMG index in the control group.

	Mean value	ST DEV	CI 95%	Normal range
POC TA	82.47	11.00	79.07– 85.88	83 ≤ (%value) ≤ 100
POC MM	81.35	11.30	77.85– 84.85	83 ≤ (%value) ≤ 100
BAR	93.39	7.05	91.22- 95.56	90 ≤ (%value) ≤ 100
TC	87.00	8.01	84.53 – 89.47	90 ≤ (%value) ≤ 100
IMP	92.07	50.06	75.96 – 106.18	85 ≤ (%value) ≤ 115
ASIM	|8.03|	6.56	6.01 – 10.05	-10 ≤ (%value) ≤ 10
SMI	70.56	25.11	64.41 – 76.71	70 ≤ (%value) ≤100

As for the differences of mean values between the two groups, the t-test showed statistically significant results, as shown below only for what concerning BAR scores and SMI scores (ρ value < 0,0001). The other measurements did not differ between the two groups (Table 5).

Table 5. T-student test; ρ value < 0.05 is considered statistically significant. NS= not significant, S= significant

EMG Index	p value
POC TA	0.65 NS
POC MM	0.99 NS
TC	0.88 NS
IMP	0.76 NS
BAR	0.0001 S
ASIM	0.77 NS
SMI	0.0001 S

Discussion

In this in vivo study, the Authors aimed at assessing the muscular patterns in subjects with disc displacement with reduction, in order to make the diagnosis more complete and to set therapies in a more targeted and individualized way. Compared to the muscle palpation only, the sEMG evaluation could potentially add more objective and quantifiable information on the " system of muscle forces" acting in the stomatognathic apparatus.

Studies concerning the electromyographic analysis of patients affected by temporomandibular disorders are wide spreading (20-22). Technological progress led to the introduction of digital devices in TMD management. The current thought, however, is that these devices only provide clinicians with additional information and that they do not constitute real diagnostic tools (23).

The variety of methodological assessments of the studies examined does not always allow to compare research findings in a homogeneous way. Therefore, there is no unanimity in defining which indices, and their respective values, discriminate healthy subjects from TMD ones (24,25).

In this study, no substantial difference was found between the TMD group and the control group with respect to the

muscle symmetry indexes (POC and ASIM) and this result is consistent with the study of Valentino et al (26) and not with the one of Tartaglia et al (13) which showed that arthrogenous patients were significantly asymmetric compared to controls. Also the study of De Felicio (21) reported that TMD patients showed more asymmetry between right and left muscle pairs. Also TC index did not show differences between the two groups and this is consistent with other studies (13,19, 27). All these data could be explained considering the individual capacity of each patient of adaptation and, even having muscular asymmetry, a subject might never develop a pathology without other risk characteristics and vice versa, on dysfunctional patients the asymmetrical pattern may be a factor of further imbalance of the system.

As for BAR index, there were no abnormal values of the center of gravity in the control group, suggesting a possible substantial "sensitivity" of the value which could be an indicative parameter of pathology when if altered. The same does not apply to "specificity" as 29 % of the TMD group has a BAR index within the reference values. In addition, an anterior position of the center of gravity (the couple of temporalis muscles is prevailing over that of masseters) was found in almost all patients with impaired values. According to this finding, some studies reported a large asymmetry between the activity of the couple of temporalis muscles and the one of masseters in the TMD group as a consequence of increased temporalis or relatively reduced masseter activity (10, 22). This could be due to the reduced masticatory efficiency in the posterior areas of dental arches, for example, in a condition of retropositioning/ reduction of occlusal vertical dimension which are some of the most common features in patients with DDR. With the loss of a balanced center of gravity (which normally is placed in correspondence of the first molars) (28) the muscular forces move anteriorly with the predominance of temporalis muscles.

The other focal point is IMP index, which is an important controversial topic in scientific studies. On one hand, a recent study revealed that patients affected by TMDs have an average greater activity compared to the control group due to the high frequency of parafunctions (26, 29). On the other hand, other studies showed that this activity decreases in TMD patients in accordance with the pain adaptation model, which suggests that muscular activity decreases to limit movements and protect the sensory-motor system from further muscle tissue injury (10,13, 30-32). In our study there was no significant difference between the average values of IMP between the two groups. However, authors tend to think that, given the history of parafunctions reported by almost the totality of TMJ/DDR patients, the neurosensorial input was higher "in the past", with the tendency to muscle hypertonicity. Upon the appearance of joint and muscle pain, masticatory muscles had an antalgic decrease in their activity. As a consequence, this consideration embraces both the theories stated above (10,13, 26, 29-32).

As far as the dynamic test is concerned, the total masticatory efficiency (SMI) turned out to be better in the control group and this is consistent with previous studies reporting that jaw muscle activity during functional tasks is different between TMD subjects and healthy ones (10,13, 27) .

As a general remark, all comparisons are limited by the different and intrinsic characteristics of each study. For example, this study does not deal with all types of TMDs but only with a particular type of joint disorder (DDR). The reason for choosing one category of disorders at a time comes down to the fact that every type of pathology has its peculiar characteristics and the goal of an accurate survey should be to seek the features that distinguish one dysfunction from the other and from subjects without pathologies (13).

Advantages of the study. The Authors have followed standardized protocols, the total sample was homogeneous and with a more than acceptable size. The knowledge of the muscular patterns, associated to a specific temporomandibular disorder, allows to have more in-depth data also about how the individual system of each patient reacts, adapts or not, to that dysfunction. In a wider perspective, this research allows not only to know the alteration of the muscular system but also to have a measure of the dysfunction affecting the whole stomatognathic system. Despite this, further investigations are required and the comparison with the muscular patterns associated to other types of temporomandibular dysfunctions is recommended.

*Limitations of the study. s*EMG indices were calculated on the basis of the maximum voluntary contraction (MVC). The latter depends on the subject's compliance. This could represent a limitation in the reliability of the results. However, the algorithm used for the calculation of the indices, analysed the 3 seconds of the test with the highest EMG amplitude, providing a normalized estimate of MCV. Furthermore, both static and dynamic tests were repeated several times in order to minimize the interference of the patient.

Conclusions

In this research, women with disc displacement with reduction showed an altered recruitment of the jaw muscles, with significant difference between the activity of the couple of temporalis and the one of masseters, as shown in the alteration of BAR index. Moreover a lower chewing efficiency was found in the DDR group compared to control one. Asymmetric muscle pattern was found in both groups, suggesting no pathologic connotation, at least in the samples analyzed. Therefore, further studies characterized by a greater consistency as to the choice of protocols and samples are required.

Conflicts Of Interests. The authors declare that there are no conflicts of interests.

Author Disclosure Statement: No financial interests exist**.**

Funding statement:This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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