UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

MEIRE ALVES DE SOUSA
Cirurgiã-Dentista

ANÁLISE ELETROMIOGRÁFICA DOS MÚSCULOS MASSÉTER, TEMPORAL E ORBICULAR DA BOCA EM JOVENS COM MALOCLUSÃO CLASSE II, 1ª DIVISÃO DENTÁRIA, APÓS O USO DE APARELHO EXTRABUCAL DE TRAÇÃO OCCIPITAL.

Tese apresentada à Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas, como parte dos requisitos para a obtenção do título de Doutor em Radiologia Odontológica, área de concentração em Ortodontia.

Orientadora: Profª Drª Vânia Célia Vieira de Siqueira.

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Dedico este trabalho

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"A mente que se abre a uma nova idéia jamais volta ao seu tamanho original".

(Albert Einstein).

RESUMO

A eletromiografia de superfície representa um importante instrumento de avaliação da função muscular. No entanto, apresenta limitações, devido à grande variabilidade que ocorre na amplitude do sinal eletromiográfico obtido. Com o intuito de diminuir essa variabilidade, sugere-se a normalização dos dados coletados, que consiste na divisão do sinal eletromiográfico bruto registrado por um valor de referência, expresso em porcentagem, derivado da própria medida do sinal eletromiográfico. Objetivou-se neste estudo avaliar, por meio da eletromiografia, a ocorrência de alterações na atividade eletromiográfica da porção superficial do músculo masséter, da porção anterior do músculo temporal e dos segmentos superior e inferior do músculo orbicular da boca, bilateralmente, em 25 jovens, entre 8 e 10 anos de idade, com maloclusão Classe II, 1ª divisão dentária, após se submeterem ao tratamento ortodôntico com o aparelho extrabucal, comparando-os com um grupo de 25 jovens com oclusão normal, com idade similar. Além de avaliar se o procedimento de normalização dos dados obtidos influencia no resultado final. Para a captação dos sinais eletromiográficos dos músculos masséter e temporal utilizou-se eletrodos de superfície ativos diferenciais simples, e para o músculo orbicular da boca, eletrodos de superfície passivos de Ag/AgCl. Realizou-se a coleta do sinal na situação de repouso, na contração isométrica e na contração isotônica, antes e após o tratamento ortodôntico no grupo com maloclusão e em períodos similares no grupo com oclusão normal. Por meio de software específico, determinou-se o valor da Root Mean Square (RMS) de cada movimento realizado. Submeteu-se os dados iniciais coletados à normalização, comparando-os com os dados iniciais originais, por meio da análise de variância (ANOVA) para parcelas subdivididas Os resultados demonstraram que o procedimento de normalização influenciou a interpretação dos dados ao suprimir as diferenças existentes entre os grupos, reforçando a idéia de que os resultados originais permitiram conclusões mais adequadas do que os dados normalizados. Com base nesses resultados, optou-se pela utilização dos dados originais para avaliar o efeito do tratamento ortodôntico no grupo com maloclusão. Nesta etapa utilizou-se a ANOVA para medidas repetidas com modelos mistos e o teste de Tukey (α=0,05). Observou-se que ocorreu uma diminuição na atividade eletromiográfica de todos os músculos do grupo com maloclusão e com oclusão normal, entretanto esta diferença não apresentou-se estatisticamente significante para o músculo temporal direito e orbicular da boca, segmento superior. Na fase inicial do estudo o grupo com maloclusão apresentou maior atividade elétrica em todos os músculos do que o com oclusão normal, no entanto, essa diferença não apresentou-se significante para o músculo masséter. Não ocorreram diferenças significativas entre os grupos na fase final do experimento. Concluiu-se que o tratamento com o aparelho extrabucal possibilitou a melhora do padrão muscular das jovens com maloclusão Classe II, 1ª divisão dentária.

Palavras-chave: eletromiografia, ortodontia, aparelhos ortodônticos, ortodontia interceptora.

ABSTRACT

The surface electromyography is an excellent way to evaluate the muscle function. However, it presents limitations, because the great variability in the amplitude of the electromyographic signal obtained. To reduce this variability, has been proposed the normalization of the electromyographic signal. The process consist of dividing the raw electromyographic recorder signal by a reference value expressed as a percentage, derived from measure of the electromyographic signal itself. The purpose of this study was to evaluate electromyographically the action potential of the superficial masseter muscle, the anterior temporal muscle, the orbicularis oris muscle, upper and lower segment, bilaterally, in 25 young females, aged ranging from 8 to 10 years old, with Class II division 1 malocclusion after the treatment with extraoral appliances and to compare them with 25 young females with normal occlusion, with similar aged. And to evaluate if the experiment final results can be influenced by the normalization of electromyographic data. The electromyographic signals of the masseter and temporal muscles were adquired by active single differential surface electrodes, and of the orbicularis oris muscle by passive surface electrodes of the Ag/AgCl. Muscle activity was recorded in resting position, in isometric contraction and in isotonic contraction, before and after orthodontic treatment in the malocclusion group and similar periods in the normal occlusion group. Through of specific software was determined the Root Mean Square (RMS) values of each movement. The initial data collected were submitted to the normalization procedure and were compared with the initial raw data, through of statistical analyses of variance. The results showed that the normalization procedure was able to affect the electromyographic data, suppressing the difference between the groups. This support the idea that the raw data were able to produce better conclusions than normalized data. Thus, the orthodontic treatment of the malocclusion group was evaluated using the raw data, through of statistical analyses of variance and Tukey test (α=0,05). The results showed that there was decrease of the electromyographic activity in all the muscles, in both groups difference between the groups, but that difference was not statistically significant for the right temporal muscle and the orbicularis oris muscle upper segment The muscle activity was higher in the malocclusion group than normal occlusion group in the initial phase, but that difference was not statistically significant for the masseter muscle. In the final phase there was not significant difference between the groups. It was concluding that the treatment with extraoral appliances was able to improve the muscular pattern of the young females with Class II division 1 malocclusion.

Key-words: electromyography, orthodontics, orthodontic appliances, orthodontics interceptive.

SUMÁRIO

LISTA DE ABREVIATURAS E SIGLAS

A/D	- Analógico/digital
AEB	- Aparelho extrabucal
Ag	- Prata
AgCl	- Cloreto de prata
ANB	- Ângulo formado pela intersecção das linhas NA e NB.
ANOVA	- Análise de variância
Bpm	- Batimentos por minuto
CMRR	- Relação de rejeição em modo comum
CV	- Coeficiente de variação
dB	- Decibéis
EMG	- Eletromiografia
FMA	- Ângulo formado pela intersecção dos planos horizontal de Frankfurt e mandibular
GL	- Grau de liberdade
GΩ	- Giga Ohms
IHG	- Interlandi Head Gear
Hz	- Hertz
KHG	- Kloehn Head Gear
Log	- Logarítmo
MD	- Músculo masseter direito
ME	- Músculo masseter esquerdo
OI	- Músculo orbicular da boca, segmento inferior
OS	- Músculo orbicular da boca, segmento superior
RMS	- "Root Mean Square" (raiz quadrada da média)
R^2	- Coeficiente de determinação
SAS	- "Statistical Analysis System" (sistema de análise estatística)
SNA	- Ângulo formado pela intersecção das linha SN e NA

SNB	- Ângulo formado pela intersecção das linhas SN e NB
SNGoGn	- Ângulo formado pela intersecção das linhas SN e GoGn
TD	- Músculo temporal direito
TE	- Músculo temporal esquerdo
μV	- Microvolt

INTRODUÇÃO GERAL

A maloclusão Classe II, de Angle caracteriza-se por uma discrepância maxilo-mandibular dentária e/ou esquelética no sentido ântero-posterior, resultando de alterações dos componentes dentoalveolares, de uma protrusão maxilar, de uma retrusão mandibular ou uma combinação desses fatores (Moyers, 1991).

O tratamento da maloclusão Classe II torna-se um grande desafio para o ortodontista. Seu grau de dificuldade sofre diversas influências, como: as alterações esqueléticas, os fatores hereditários, os fatores ambientais, as tendências de crescimento facial e as possíveis combinações entre estes fatores. Em virtude desta complexidade, existem várias maneiras para se tratar esta maloclusão e o aparelho extrabucal representa uma das terapias mais recomendadas nos casos de Classe II com protrusão maxilar e/ou dentoalveolar (Henriques *et al*, 1999 e 2000; Carvalho *et al*, 2009). Esse dispositivo terapêutico produz movimentos ortodônticos e alterações ortopédicas na maxila e/ou mandíbula e quando o plano de tratamento estabelece ou requer distalização do molar, apresenta uma eficiência ímpar (Barros, 1999; Carvalho *et al*, 2009).

Os objetivos de um tratamento ortodôntico incluem a obtenção da estética e da harmonia facial, oclusão funcional satisfatória, função mastigatória eficiente, saúde dos dentes e das estruturas adjacentes e estabilidade em longo prazo (Vaden, 1996). Esta estabilidade encontra-se fortemente influenciada pelo comportamento dos músculos circunjacentes. Os efeitos dessa atividade muscular representam a razão ou o resultado das maloclusões. Assim, uma cuidadosa avaliação da atividade muscular antes, durante e após o tratamento orienta o profissional no diagnóstico, no planejamento ortodôntico e na eleição adequada da contenção, minimizando recidivas. E neste contexto, a análise eletromiográfica dos músculos da mastigação representa um importante instrumento de exame complementar (Sousa, 2004; Siqueira *et al*, in press).

Define-se eletromiografia (EMG) como a coleta de informações sobre a atividade elétrica muscular, por meio de eletrodos conectados a equipamentos para amplificação e registro dos sinais (Lehmkuhl & Smith, 1989).

Os primeiros relatos descrevendo o uso da EMG na Odontologia ocorreram por volta dos anos 50.

Moyers, em 1949, introduziu a EMG na pesquisa odontológica. Realizou um extenso estudo eletromiográfico sobre os músculos da mastigação, utilizando eletrodos de superfície, em pacientes com maloclusão Classe II, 1ª divisão, de Angle, comparando-os com um grupo similar de pacientes com oclusão normal. Observou que ocorreu atividade eletromiográfica diferente entre os grupos e que o tratamento ortodôntico pode alterar o potencial de ação desses músculos.

Outros autores também demonstraram que o padrão de atividade dos músculos mastigatórios observado nos casos de maloclusão difere daqueles com oclusão normal (Pruzansky, 1952; Perry, 1955; Quirch, 1965; Moss, 1975; Freeland, 1979; Deguchi *et al*, 1994; Palomari *et al*, 2002; Sousa, 2004; Siqueira *et al*, in press) e que, após o tratamento ortodôntico, evidenciam-se alterações nas características do sinal eletromiográfico desses músculos (Thilander & Filipsson, 1966; Moss, 1975; Simpson, 1977; Freeland, 1979; Störmer & Pancherz, 1999; Uner *et al*, 1999; Leung & Hagg, 2001; Hiyanna *et al*, 2005; Arat *et al*, 2008).

Apesar de se constituir numa técnica que permite o acesso a processos bioquímicos e fisiológicos dos músculos esqueléticos sem procedimentos invasivos, a EMG de superfície apresenta limitações (De Luca, 1997). No entanto, a melhora e a padronização de instrumentos, eletrodos e técnicas observadas atualmente permitem uma avaliação estatística dos dados registrados, favorecendo, assim, a comparação e a evolução dos estudos e dos resultados das pesquisas. A EMG de superfície mostra-se como uma ferramenta útil na investigação dos músculos mastigatórios, proporcionando uma boa acurácia e reprodutibilidade dos dados, contanto que se siga um protocolo adequado (Ferrario *et al*, 1993).

Entretanto, a grande variabilidade observada nos registros eletromiográficos dificulta a interpretação dos dados. Assim, vários autores ((Soderberg & Cook,1984; Basmajian & De Luca, 1985; Portney, 1993; Turker, 1993; Knutson *et al*,1994; Mathiassen *et al*, 1995; De Luca, 1997; Ervilha *et al*, 1998; Morris *et al*, 1998; Lehman & McGill, 1999) descreveram a necessidade da normalização da amplitude do sinal eletromiográfico ao se comparar dados obtidos de diferentes pacientes ou de um mesmo paciente em diferentes dias ou ainda em diferentes músculos, com o intuito de reduzir essa variabilidade. No entanto, a normalização remove do sinal todas as características brutas da amplitude e, com isso, perdem-se muitos dados importantes, o que impossibilita uma melhor compreensão do evento fisiológico estudado (Semeghini, 2000).

Acredita-se que a disfunção dos músculos masseter, temporal e orbicular da boca representa um dos possíveis fatores etiológicos de maloclusões e de recidiva após tratamento ortodôntico (Ingervall & Thilander, 1974; Lowe *et a*l, 1983; Takada *et al*, 1984). Embora o uso da EMG de superfície encontre-se bem estabelecido na literatura como método confiável, se adequadamente utilizado, no âmbito da prática baseada em evidência, não se encontrou na literatura consultada estudos eletromiográficos que avaliassem a resposta muscular ao uso do aparelho extrabucal no tratamento da maloclusão Classe II, 1ª divisão.

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PROPOSIÇÃO

a) Avaliar se o procedimento de normalização dos dados eletromiográficos obtidos em jovens com Classe II, 1ª divisão dentária e com oclusão normal, sob condições padronizadas, pode influenciar no resultado final.

b) Avaliar a existência de alterações na atividade eletromiográfica da porção superficial do músculo masseter, da porção anterior do músculo temporal e dos segmentos superior e inferior do músculo orbicular da boca em jovens com Classe II, 1ª divisão dentária, após se submeterem ao tratamento ortodôntico com o aparelho extrabucal, comparando-os com um grupo de jovens com oclusão normal.

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CAPÍTULOS

CAPÍTULO 1 :

Surface electromyography in the evaluation of young people with Class II, division 1 malocclusion and with normal occlusion: the effect of normalization*.

Abstract

Introduction: The objective of this study was to evaluate whether normalization of electromyographic data obtained from patients with Class II, division 1 malocclusion and from patients with normal occlusion can influence the interpretation of results. **Methods:** The sample consisted of 25 young people with Class II, division 1 malocclusion and 25 with normal occlusion, all of them female and aged between 8 and 10 years, who never underwent orthodontic treatment. The electromyographic activity of the masseter, temporal and orbicularis oris muscles was analyzed at rest, at the isometric contraction and at the isotonic contraction. The collected data was subjected to normalization and compared with the original data through analysis of variance for subdivided parcels. **Results and conclusions:** It was found that the normalization procedure influenced interpretation of the data by reducing the differences between groups, reinforcing the idea that the original data allowed more appropriate conclusions than the normalized data.

Introduction and literature review

Electromyography (EMG) is a generic term that describes recording of the electrical activity of a muscle during a contraction. It presents numerous applications in diagnosis of neuromuscular disease or trauma, in rehabilitation, and as a tool for the study of muscle function in specific activities[1,2,3]. The introduction of electromyography to odontological research occurred in 1949 when Moyers[4] conducted an extensive

* De acordo com as normas do periódico American Journal of Orthodontics and Dentofacial Orthopedics

electromyographic study on the mastication muscles, in which he demonstrated the existence of differences in electromyographic activity in patients with malocclusion and patients with normal occlusion. Since then, several papers have been published in the field, analyzing muscle behavior and contributing to the diagnosis and prognosis of patients with some type of dysfunction.

Although computerized electromyographic equipment with appropriate software that enables objective study of the electrical behavior of muscles now exists, it is important to understand that the relationship between the EMG signal and the force produced by a muscle is very complex. In order to register an electromyogram, a system of electrodes is needed to capture electrical potentials of the muscle in contraction, as well as an amplifier that processes the electrical signal and a decoder that allows graphical display and/or hearing of sounds emitted[1,3,5]. Monitoring of the myoelectric signal utilizes surface or needle electrodes. The choice of electrodes depends on the muscle to be studied. Surface electrodes are indicated in the study of large muscles or groups of superficial muscles, for testing of nerve conduction and in kinesiologic investigations. Needle electrodes are advised for the study of small and deep muscles[1, 5].

To facilitate the quantification of raw data, the electromyographic signal is electronically compiled. Determination of the root mean square (RMS) is the best method of signal manipulation, since it considers physiological changes in the electromyographic signal and reflects the number, shot frequency and the form of action potentials of active motor units while still allowing analysis of the electromyographic signal amplitude[6].

The surface EMG is an excellent way to evaluate physiological processes of skeletal muscles without invasive procedures[7]. However, despite the apparent ease of technical and instrumental use, the surface EMG presents limitations as a measurement instrument. These reflect the complexity of the process, which includes electrode placement, the physiological, anatomical and biochemical characteristics of the studied muscle, the type of activated muscle fiber, the amount of tissue between the muscle surface and the electrode, skin transpiration, method of computational analysis, and other factors[7-

[13]. These factors can generate great variability in the amplitude of the EMG signals obtained intra- and/or inter-patients, as well as intra- and/or inter-muscles. Hence, standardization of procedures is important in order to avoid errors and distortions in the results [1,5,7,14,15,16].

Several authors[1,5,7,15,17-20] described the need for normalization of the electromyographic signal to create a common framework for different electromyographic data and reduce inter-patient variability. Normalization is defined as the attempt to reduce the differences between records of the same patient or from different patients in order to make the interpretation of data reproducible. The process consists of dividing the raw EMG recorded signal by a reference value expressed as a percentage, derived from measure of the EMG signal itself, allowing comparison between the obtained values[1,15,20].

Several normalization procedures have been proposed in the literature[17,21], but none is able to eliminate all the variables of the EMG signal. Use of the percentage of the EMG signal acquired in a maximum voluntary contraction has been suggested as one of the best strategies for normalization in healthy people[15]. However, normalization provides similar data for different patients, tending to eliminate distinctions in the data associated with abnormal or pathological cases[7] and, in some cases, obscuring differences in amplitude between groups[22-25]. Therefore, the need for normalization of myographic data has become a controversial issue in the scientific literature.

It is proposed in this article to evaluate whether normalization of EMG data obtained under standardized conditions from patients with Class II, division 1 malocclusion and from patients with normal occlusion, can influence the interpretation of results.

Materials and Methods

This research project was previously submitted to review and approval of the Ethics Committee in Research of the Piracicaba Faculty of Dentistry, State University of Campinas (FOP-UNICAMP) under the protocol number 147/2002.

With due legal authorization, under an informed free consent agreement, we selected 50 students from public schools in the city of Piracicaba, all of them female, Caucasian and between 8 and 10 years of age, with no history of prior orthodontic treatment. The students were divided into two groups: an experimental group, consisting of 25 young people with Angle Class II, division 1 malocclusion and a control group, consisting of 25 young people with normal occlusion. In order to appropriately diagnose these groups, each child was subjected to initial clinical examination and complementary tests that consisted of panoramic radiographs, lateral cephalometric radiographs, plaster casts and intra- and extra-oral pictures.

Electromyographic analysis

For electromyographic recording, the Signal Conditioner Myosystem - I ® (Data Hominis Tecnologia Ltda.) signal acquisition system was used. The system contains 12 channels with 12 bit dynamic range resolution, a Butterworth-type filter with 500 Hz low-pass and 20 Hz high-pass filters, 100X gain, analog to digital (A/D) converting board with a capacity of 2000 to 4000 Hz, Myosystem - I software version 2.12 for simultaneous signal presentation of the 12 channels and signal processing (RMS value, average, minimum, maximum and standard deviation) with sampling frequency of 2000 Hz.

To capture the action potential of the masseter and temporal muscles, simple active differential surface electrodes by Lynx Technologia Electronica Ltda. were used. These consisted of two pure silver (Ag) parallel rectangular bars (10x1 mm), spaced by 10 mm and fixed in an acrylic capsule of 20x41x5 mm, with input impedance greater than 10 GΩ, minimum CMRR of 84 dB and 20X gain. To capture the action potential of the orbicularis oris muscle, passive surface electrodes of Ag/AgCl from Data Hominis Tecnologia Ltda were used. We also used a reference electrode (ground), consisting of a stainless steel metal plate.

Realization of electromyographic records was performed in the Laboratory of Electromyography, Department of Morphology, Piracicaba Faculty of Dentistry-

UNICAMP, according to the protocol adopted by the same[26]. The volunteer remained seated in the most comfortable position possible in a chair with supported back, with her head positioned in the Frankfurt plane parallel to the ground, eyes open, feet flat on the floor and arms resting on the lower limbs. Electrodes were fixed bilaterally at the anterior portion of the temporal muscle, at the superficial portion of the masseter muscle and at the upper and lower segments of the orbicularis oris muscle by means of Stampa adhesives and tape, after previous cleaning of the skin with a 70% alcohol solution, using the following procedure:

- *Anterior portion of the temporal muscle*: It was asked that the volunteer perform maximal forced intercuspation, as proof of function. The electrode fixation was about 2 to 3 cm superior-posterior to the lateral corner of the eyes in the region of greatest evident muscle mass, devoid of hair. The electrodes remained parallel to the muscle fibers, but with their detection surface oriented perpendicular to the fibers.

- *Superficial portion of the masseter muscle*: It was asked that the volunteer perform maximal forced intercuspation to prove function; by palpation, the electrodes were placed about 1 to 2 cm above the gonial angle of the jaw in the muscular venter in the area of greatest evident muscular mass, parallel to the muscle fibers with their detection surface perpendicular to the fibers.

- *Upper and lower segments of the orbicularis oris muscle*: A pair of electrodes previously smeared with electroconductive gel was placed at the middle portion of the upper lip, 2 mm above the free edge and 1 cm from each other; the same procedure was adopted for the lower lip, with electrodes fixed 2 mm below its free edge.

The reference electrode (ground), connected to the electrode surface and previously smeared with electroconductive gel, was fixed on the right wrist of each volunteer using a Velcro strip.

Before collection of electromyographic signals, all volunteers received information regarding the characteristics of the equipment and training on the movements that should be performed. Electromyographic recordings began with assessment at rest, followed by isometric contraction and then isotonic contraction. For each of the above situations, three measurements were taken over 10 seconds with two minute intervals between them, in order not to induce fatigue in the muscles studied[7].

For registration of the rest situation, each volunteer remained with the facial and masticatory muscles relaxed and lips in their habitual posture, while being given the following command: relax, relax, relax ... Then, to record isometric contraction performed in the maximum intercuspation position, the volunteer bilaterally placed a piece of parafilm between the superior and inferior posterior teeth (this material offers the smallest variability in electromyographic records[27]). To obtain the dimension of a bubble gum, the parafilm was cut and folded into five equal parts and refolded in half the total length[27]. This was established using the following verbal command: bite, bite, bite… maintained for 10 seconds. For registration of isotonic contraction (unusual mastication activity), we used the parafilm with the same method as for the previous movement; the chewing cycle was determined by means of a metronome with frequency of 60 beats per minute. We instructed the volunteer to bite the parafilm when she heard the sound of the metronome, during 10 seconds. After collection, the signals were processed using the Myosystem – I software, which determined the RMS value of each movement performed. Next, we obtained the mean RMS values of the three samples taken for each situation evaluated.

We subjected the data to the normalization process: the mean RMS values obtained at rest and isotonic conditions were expressed as a percentage of mean isometric values (maximum voluntary contraction), always observing their respective muscle groups. In other words, the average RMS value at rest and for the isotonic condition was divided by the average RMS value for the isometric condition of each muscle group, multiplied by one hundred. The original and normalized data were then subjected to analysis of variance with the appropriate model for experiments in divided parcels. Transformation to the optimal power was adopted as recommended by Box-Cox, which guarantees the use of each model at its maximal verisimilitude. No tests were applied for multiple comparisons of means, because the objective of this analysis was not to compare levels of the factors, but only to compare the adequacy of models. The analyses were processed by SAS[1].

Results

In Table 1, it can be seen that the coefficient of variation (CV) of the original and normalized data presented similar results, showing that for the statistical analysis there was no advantage in normalization or in non-normalization. The coefficient of determination (R^2) was also similar, which did not allow affirmation that normalization resulted in a better model. Data transformation also yielded similar powers, indicating that there is no great difference in the distribution of the data.

Table 1. Coefficient of variation (CV), coefficient of determination (R^2) and optimum power suggested by the Box-Cox technique for transformation of original and normalized EMG data for the right masseter (RM), left masseter (LM), right temporal (RT), left temporal (LT), orbicularis oris superior (OS) and inferior orbicularis (OI) muscles.

		Muscle					
Statistics	EMG	RM	LM	RT	LT	OS	OI
CV	Original	8.43	16.35	13.02	14.28	11.07	20.37
	Normalized	9.30	8.57	13.08	10.29	8.71	11.80
R^2	Original	94.83	92.99	95.69	93.07	77.36	69.21
	Normalized	93.82	94.20	96.01	95.76	83.54	68.17
Power	Original	-0.2	log ()	log ()	0.1	-0.3	log ()
	Normalized	0.2	0.2	log ()	0.3	log ()	log ()

[1] SAS Institute Inc. The SAS System, release 9.1.3 – SP 4. SAS Institute Inc., Cary: NC, 2002.

The results for distinct topics are presented below in relation to each of the variables.

Right masseter (RM): In comparing the results of the original data analysis with the normalized data (Table 2), strong evidence is observed ($p < 0.01$) for differences in real average levels of the situation factor and for differences in the real average of the group factor ($p < 0.05$), while for the non-normalized data, no significant effects of the group factor were observed ($p = 0.29$). Thus, use of normalized data does not allow the conclusion that differences exist between the real averages of groups, a reasonable conclusion when using the original data. In terms of adjustment (Table 1), the models appear to be quite similar, with coefficients of variation (CV) below 10% and coefficients of determination (R^2) greater than 90%.

Left masseter (LM): In the analysis of results for this muscle (Table 2), there was full compatibility of results obtained using the normalized data and the original data. In both cases, we observed strong indications ($p < 0.01$) of differences between real average levels of the situation factor, but found no evidence of differences between group real averages or in interaction between group and situation. It is likely that in this case, similar conclusions would be reached whether the original data or the normalized data was analyzed. The only analytical indicator that denoted a difference between the normalized and the original data was the coefficient of variation; it indicated a greater variability in the original data than in the normalized data, >15% compared to <10% (Table 1).

Right Temporal (RT): The data referent to this muscle show the same behavior described for the RM (Table 2), i.e., in the original data, strong indicators of differences in the group and situation factors are observed, while in the normalized data no significant effects of the group factor are seen.

Left temporal (LT): The analysis of the data showed a behavior similar to that previously described for the LM (Table 2). There was compatibility between the original and normalized data, with both showing strong evidence for differences in the situation factor, and no statistical indication of differences in group factor or in interaction between group and situation.

Orbicular Oris, the superior (OS) and inferior (OI) segments: These data show the same behavior previously described for the variables RM and RT (Table 2). Again, the use of normalized data would not allow the conclusion that differences exist between the real averages of groups, though such differences are evident when the original data is used. Indicators of model adjustment indicate a better adjustment of the normalized data, since the coefficient of variation is lower and the coefficient of determination greater (Table 1).

Table 2. P-values for comparison of the real averages of original and normalized EMG data for the different groups and situations calculated using an appropriate model for experiments in subdivided parcels.

		MD	ME	TD	TE	OS	OI
Original	Group	0.0129	0.8026	0.0003	0.3013	0.0012	0.0272
	Situation	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Group*Situation	0.0946	0.2831	0.1779	0.9033	0.3316	0.9220
Normalized	Group	0.2928	0.4816	0.5156	0.2010	0.4049	0.7042
	Situation	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Group*Situation	0.7321	0.3124	0.1677	0.6894	0.7397	0.9158

Discussion

The concept of normal occlusion includes the relationships of teeth with each other, with the bone support structures and the surrounding muscles. Consequently, the analysis of neuromuscular function is crucial to orthodontic diagnosis[28]. Several studies in the literature have reported differences in electromyographic activity between patients with malocclusion and those with normal occlusion[4,29-34]. To Moyers[28], abnormal muscle function is an important aspect of Class II, division 1 malocclusion; it occurs because of great overget, which requires the tongue and facial muscles to adopt abnormal contraction patterns. Other authors[35-38] also observed the presence of muscle imbalance in patients with Class II, division 1 malocclusion.

In this study, we sought to evaluate a group of female children between 8 and 10 years of age with Class II, division 1 malocclusion and to compare them with a similar group with normal occlusion. There is a great demand for malocclusion treatment in everyday clinical practice and it is believed that intervention to correct malocclusion is more efficient in this age group due to greater tissue visco-elasticity. The selection of females was based on the objective of avoiding variables due to inherent differences in development between the sexes that could affect the results. The results showed differences between the original and the normalized data. The original data showed statistically significant differences in electromyographic activity between groups (malocclusion and normal occlusion) for all muscles except the LM and LT and between situations (rest, isometric and isotonic), while the normalized data showed no differences between groups. The persistence of significant differences in the situation factor after normalization is due to the fact that this factor showed strong indications of differences ($p<0.001$) in the original data; in such cases, the results will be obvious, regardless of normalization. Utilization of the analysis of variance model yielded comparable results with the original data and with the normalized data; the parameters CV, R^2 and optimum power, which measure the quality of the model, showed no evidence of any benefit of normalization for technical data analysis, since they presented similar results.

Other authors, including Oliveira[22], Semeghini[23], Biasotto[24] and Gadotti[25], when comparing data from individuals with muscular disorders with that from clinically normal volunteers, also found that the normalization procedure did not demonstrate differences in amplitude between groups. According to De Luca[7], one of the disadvantages of normalization is its tendency to provide similar data for different subjects, which may suppress distinctions in data associated with pathological or abnormal cases.

Although several authors[1,5,7,15,17-20], due to the great variability that is seen in the amplitude of the electromyographic signal, advocate normalization of the signal from collection through data analysis, it has become important to identify the situations in which such methodology can be correctly used. Its recommendation for utilization when comparing data obtained from different patients, or from the same patient on different days or in different muscles[2,6,14,17-19], appears to be very ample.

Due to the characteristic variability of surface electromyography, methodological factors become extremely important for fidelity in signal detection. One alternative to minimize interference is the adoption of an adequate protocol. The lack of a standardized methodology represents a challenge when comparing many electromyographic studies. We had great difficulty in comparing our primary data with that reported in the literature. In the vast majority of studies related to orthodontics, the authors do not use normalization for data analysis. In other studies, the authors performed normalization but did not make comparisons among groups, only among normalization types[17,19-21]. However, Semeghini[23], when considering the possible existence of a modified cranium-cervical muscle pattern in volunteers with occlusal parafunction and comparing them with normal occlusion volunteers, observed that the normalization process did not reveal statistically significant differences between groups. By using non-normalized data, the differences between the groups were evident. Therefore, that author chose to use non-normalized data. Ferla et al.[39] and De Rossi et al.[40] used normalization for data analysis, but did not compare its impact in the results.

The results obtained in this study indicate that normalization removes all the gross features of amplitude from the signal; with this, much important data is lost, preventing a better understanding of the physiological event in study[23]. The improper use of normalization can thus lead to inappropriate conclusions by the researcher. It is therefore suggested that further studies be performed to better clarify the methodology and achieved results.

Conclusions

The results of this study allow for conclusion that, in the experimental conditions applied:

- The process of normalization of the electromyographic signal percentage values obtained in maximal voluntary isometric contractions of the temporalis, masseter and orbicularis oris muscles showed no statistically significant differences for the group factor, but such differences were evident for the situation factor.

- With the use of original data, the differences for the group factor were significant, except for the variables LM and LT. Differences in the situation factor were significant for all variables.

- The statistical analysis did not justify the need for data normalization.

- The normalization process influenced the interpretation of electromyographic data.

- Given these facts, this study reinforces the idea that the original data allows more conclusions than does the normalized data.

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CAPÍTULO 2:

Electromyographic analysis of the masseter, temporal and orbicularis oris muscles in young people with Class II, division 1 malocclusion treated with extraoral appliance of occipital traction [*].

Abstract

Introduction: The objective of this study was to evaluate the occurrence of changes in electromyigraphic activity in the masseter, temporal and orbicularis oris muscles in young people with Class II, division 1 malocclusion who had undergone orthodontic treatment with the extraoral appliance and to compare them with a group of young people with normal occlusion. **Methods:** The sample consisted of 25 young people between 8 and 10 years of age, with dental Class II, division 1 malocclusion and of 25 people of similar age with normal occlusion. The signal was recorded at rest and during isometric and isotonic contraction, before and after orthodontic treatment in the group with malocclusion and in similar periods in the group with normal occlusion. Variance analysis for repeated measures with mixed models and Tukey's test ($\alpha = 0.05$) were used for data analysis. **Results and conclusions:** It was found that there was a reduction in electromyigraphic activity of all muscles in the group with malocclusion after orthodontic treatment. We conclude that treatment with the extraoral appliance resulted in improvement of muscular patterns in the girls with dental Class II, division 1 malocclusion.

Introduction and literature review

The correction of malocclusion Class II represents a major challenge for orthodontists because of the numerous etiologic factors that interact contributing to its development; these factors result in functional morphological characteristics as varied and individual as the people who exhibit it[1]. Such patients are characterized by a distal relationship of the mandible relative to the maxilla and/or of the mandibular alveolar

[*] De acordo com as normas do periódico American Journal of Orthodontics and Dentofacial Orthopedics

process in relation to the jaw, resulting in maxillary protrusion, mandibular retrusion or both (skeletal factor) and/or a distal positioning of the inferior teeth in relation to the superior ones (dental factor).

Class II, division 1 malocclusion is defined by the presence of a relatively poor mesiodistal relationship of dental arches, with all lower teeth occluding distally to the normal; this produces an accentuated disharmony in the maxillary region and in facial lines. In this malocclusion, the superior arch is presented atresic and the superior incisors protruded[2]. The excessive overget requires facial muscles and the tongue to adapt to abnormal contraction patterns[3].

There is a great demand for treatment of this type of malocclusion in everyday practice. Its incidence varies from 35% to 42% of malocclusion, and it may reach 50% in cases treated at the orthodontic clinic[4]. In the Brazilian population, its prevalence is high; it occurs with a frequency of 42% in children of 7 to 11 years of age. Of these, 24.05% present as dental Class II, division 1 malocclusion [5].

When the condition is characterized by maxillary and/or dental-alveolar protrusion, one of the most commonly used treatments is the extraoral appliance, a mechanical system generator of forces outside the oral cavity directed to the cervical, occipital and parietal regions that has the objective of stabilizing or moving dental elements or of redirecting craniofacial growth[6]. The choice of the direction of traction is directly related to the growth and muscle patterns of the patient. Parietal traction ("High Pull") is used in more accentuated dolichofacial patients, occipital traction (Interlandi Head Gear - IHG) in the mesofacial or suave dolichofacial and cervical traction (Kloehn Head Gear - KHG) in brachyfacial. Other factors to consider relate to the stage of craniofacial growth and development, the intensity of the applied forces and the patient's cooperation[7-11].

According to Graber[12], Class II, division 1 malocclusion is correctable by the use of extraoral force. A noticeable improvement of the basal relationship, overget and overbite can be obtained. However, the presence or absence of growth during the treatment period strongly influences the results. We obtain a better prognosis when the treatment is coordinated with the pubertal growth surge.

One of the goals of early treatment of dental Class II, division 1 malocclusion is to obtain harmonic molar and incisal relations and to establish normal occlusal function before the eruption of canines, premolars and second permanent molars. It is believed that the correction of dental anomalies allows the restoration of balanced muscle function[3].

If balanced muscular function is not restored after orthodontic therapy, the stability of the treatment will be threatened, because altered patterns of orofacial muscle contractions can result in distorted growth of facial bones or in abnormal teeth positions[3]. Hence, careful evaluation of muscular activity by the orthodontist is extremely important. Electromyography thus represents a useful tool in documenting changes in muscle function before and after therapeutic interventions, as evidence of the therapy success.

The objective of this study was to evaluate the existence of electromyographic changes in action potentials in the temporalis, masseter and orbicularis oris muscles in young girls with dental Class II, division 1 malocclusion after these patients received orthodontic treatment with the extraoral appliance.

Materials and Methods

This research project was approved by the Ethics Committee in Research of the Piracicaba Faculty of Dentistry, State University of Campinas - UNICAMP, under the protocol number 147/2002.

The sample consisted of 50 girls, Caucasian, aged between 8 and 10 years with no history of previous orthodontic treatment, distributed in two groups: an experimental group containing 25 young people with dental Class II, division 1 malocclusion and a control group containing 25 people with normal occlusion.

Through an Informed Consent Form, we obtained the permission of the parents or the legal guardian of each young girl for her participation in the study. The girls underwent clinical examination and initial laboratory tests that consisted of panoramic radiographs, lateral cephalometric radiographs, plaster casts and intra- and extra-oral pictures. All girls were free from abnormal functional habits or clinical signs of temporomandibular joint disorders.The following characteristics were used to classify patients as dental Class II, division 1 malocclusion:

- *Clinically:* lower permanent first molars and lower canines distally positioned relative to the upper permanent first molar and upper canine, respectively; overget larger than 3 mm.

- *Cephalometrically*[13]: SNA > 82°, ANB between 3° and 5°, SNGoGn between 30° and 37° (average of 35°) and FMA between 24° and 32° (average of 27°).

The following characteristics were used to categorize patients with normal occlusion:

- *Clinically*: permanent first molars in occlusion key, i.e., the mesiobuccal cusp of the upper permanent first molar occluding in the vestibular canal of lower permanent first molar, permanent canines and/or deciduous teeth in Class I, i.e., the edge of the vestibular cusp of the upper canine occluding in the vestibular battlement between the lower canine and lower deciduous first molar and/or lower first premolar; overbite and overget at approximately 2.5 mm; absence of bad dental positions and absence of dental crowding.

- *Cephalometrically*[13]: SNA = 80° to 82°, SNB = 78° to 80°, ANB = 0° to 3°.

Following appropriate diagnosis, the experimental group underwent orthodontic treatment using the extraoral appliance with occipital traction (IHG). The line of force, applied by rubber bands, was directed to pass through the center of resistance of the upper molars, the trifurcation of the roots. The treatment began with light force of 250 g on each side, with daily use from 14 to 18 hours. After the first month, the force was gradually increased to 350 g on each side. There were monthly controls of the appliance and the young girls were instructed about the proper cleaning of the teeth, the daily change of the rubber bands and the non-use of the appliance during sport activities. After obtaining overcorrection of the molar relation, we decreased the force gradually to 250 g and the use of the appliance was restricted to nighttime during sleep for 3 months, characterizing the phase of retention. The average duration of treatment corresponded to one year and nine months. After completion of treatment, there was further orthodontic documentation, consisting of panoramic radiographs, lateral cephalometric radiographs plaster casts and intra- and extra-oral pictures.

Electromyographic analysis

Electromyographic analysis of the experimental group was performed before and after orthodontic treatment and in the control group in similar periods.

For electromyographic recording, the Signal Conditioner Myosystem - I ® (Data Hominis Tecnologia Ltda.) signal acquisition system was used. The system contains 12 channels with 12 bit dynamic range resolution, a Butterworth-type filter with 500 Hz low-pass and 20 Hz high-pass filters, 100X gain, analog to digital (A/D) converting board with a capacity of 2000 to 4000 Hz, Myosystem - I software version 2.12 for simultaneous signal presentation of the 12 channels and signal processing (RMS value, average, minimum, maximum and standard deviation) with sampling frequency of 2000 Hz.

To capture the action potential of the masseter and temporal muscles, simple active differential surface electrodes by Lynx Technologia Electronica Ltda. were used. These consisted of two pure silver (Ag) parallel rectangular bars (10x1 mm), spaced by 10 mm and fixed in an acrylic capsule of 20x41x5 mm, with input impedance greater than 10 GΩ, minimum CMRR of 84 dB and 20X gain. To capture the action potential of the orbicularis oris muscle, passive surface electrodes of Ag/AgCl from Data Hominis Tecnologia Ltda were used. We also used a reference electrode (ground), consisting of a stainless steel metal plate.

Realization of electromyographic records was performed in the Laboratory of Electromyography, Department of Morphology, Piracicaba Faculty of Dentistry-UNICAMP, according to the protocol adopted by the same[14]. The volunteer remained seated in the most comfortable position possible in a chair with supported back, with her head positioned in the Frankfurt plane parallel to the ground, eyes open, feet flat on the floor and arms resting on the lower limbs. Electrodes were fixed bilaterally at the anterior portion of the temporal muscle, at the superficial portion of the masseter muscle and at the upper and lower segments of the orbicularis oris muscle by means of Stampa adhesives and tape, after previous cleaning of the skin with a 70% alcohol solution, using the following procedure:

- *Anterior portion of the temporal muscle*: It was asked that the volunteer perform maximal forced intercuspation, as proof of function. The electrode fixation was about 2 to 3 cm superior-posterior to the lateral córner of the eyes in the region of greatest evident muscle , devoid of hair. The electrodes remained parallel to the muscle fibers, but with their detection surface oriented perpendicular to the fibers.

- *Superficial portion of the masseter muscle*: It was asked that the volunteer perform maximal forced intercuspation to prove function; by palpation, the electrodes were placed about 1 to 2 cm above the gonial angle of the jaw in the muscular venter in the area of greatest evident muscular mass, parallel to the muscle fibers with their detection surface perpendicular to the fibers.

- *Upper and lower segments of the orbicularis oris muscle*: A pair of electrodes previously smeared with electroconductive gel was placed at the middle portion of the upper lip, 2 mm above the free edge and 1 cm from each other; the same procedure was adopted for the lower lip, with electrodes fixed 2 mm below its free edge.

The reference electrode (ground), connected to the electrode surface and previously smeared with electroconductive gel, was fixed on the right wrist of each volunteer using a Velcro strip.

Before collection of electromyographic signals, all volunteers received information regarding the characteristics of the equipment and training on the movements that should be performed. Electromyographic recordings began with assessment at rest, followed by isometric contraction and then isotonic contraction. For each of the above situations, three measurements were taken over 10 seconds with two minute intervals between them, in order not to induce fatigue in the muscles studied[15].

For registration of the rest situation, each volunteer remained with the facial and masticatory muscles relaxed and lips in their habitual posture, while being given the following command: relax, relax, relax ... Then, to record isometric contraction performed in the maximum intercuspation position, the volunteer bilaterally placed a piece of parafilm between the superior and inferior posterior teeth (this material offers the smallest variability in electromyographic records[16]). To obtain the dimension of a bubble gum, the parafilm was cut and folded into five equal parts and refolded in half the total length[16]. This was established using the following verbal command: bite, bite, bite… maintained for 10 seconds. For registration of isotonic contraction (unusual mastication activity), we used the parafilm with the same method as for the previous movement; the chewing cycle was determined by means of a metronome with frequency of 60 beats per minute. We instructed the volunteer to bite the parafilm when she heard the sound of the metronome, during 10 seconds. After collection, the signals were processed using the Myosystem – I software, which determined the RMS value of each movement performed. Next, we obtained the mean RMS values of the three samples taken for each situation evaluated.

The data for the masseter, temporal and orbicular oris muscles obtained in the experimental group before and after orthodontic treatment with the traction device were compared in order to verify whether orthodontic treatment changed the behavior of these muscles, comparing them with the control group.

Statistical analysis

The data analysis used the MIXED procedure of SAS[2] statistical program (Statistical Analysis System). We adopted the technique of analysis of variance (ANOVA) for repeated measurements, with mixed models and Tukey's test ($\alpha = 0.05$).

Results

Right masseter muscle (RM) and left masseter muscle(LM) → Tables of analysis of variance (Tables 1 and 4) showed strong evidence ($p < 0.01$) of differences between the real average for the different levels of situation and phase factors. Tukey’s test showed the average RMS to be significantly higher in isometry, followed by isotonia, which presented significantly higher than the at rest average (Tables 2 and 5 and Figures 1 and 3). In addition to the significant effect of the situation factor, there was also a significant effect of the phase factor (Tables 3 and 6 and Figures 2 and 4). The real average value of the RMS was shown to be significantly higher in the initial phase than in the final phase.

Table 1. Table of analysis of variance of the original electromyographic data of the RM muscle, according to the appropriate model for analysis of variance with repeated measurements.

Effect	DF numerator	DF denominator	F-value	P-value
Group	1	48	1.99	0.1644
Situation	2	96	102.45	<0.0001
Phase	1	34	10.47	0.0027
Group*Situation	2	96	0.78	0.4612
Group*Phase	1	34	1.71	0.2003
Situation*Phase	2	68	1.12	0.3310
Group*Situation*Phase	2	68	0.87	0.4225

[2] SAS Institute Inc. The SAS System, release 9.1.3 – SP 4. SAS Institute Inc., Cary: NC, 2002.

Table 2. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RM muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Situation	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups
			Superior	Inferior	(α=0.05)
Isometry	163.026	90.859	182.506	143.545	A
Isotonia	112.358	64.909	126.275	98.442	B
Rest	4.805	1.966	5.226	4.383	C

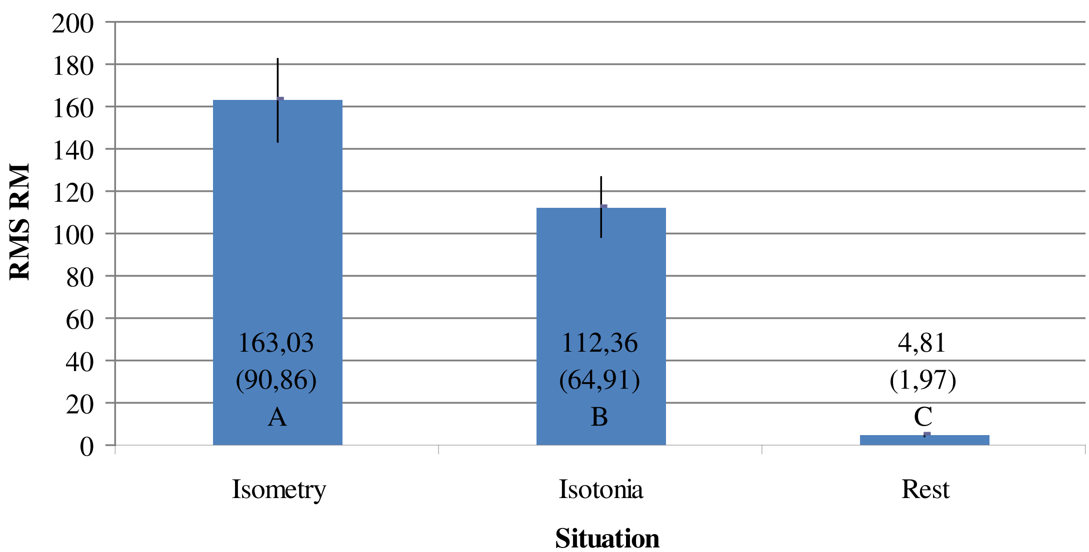

Figure 1. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RM muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 3. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RM muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence interval of the mean (95%)		Tukey's Groups
Phase	Mean	Standard deviation	Superior	Inferior	(α=0.05)
Final	88.818	86.467	105.312	72.324	A
Initial	96.693	96.207	112.215	81.171	B

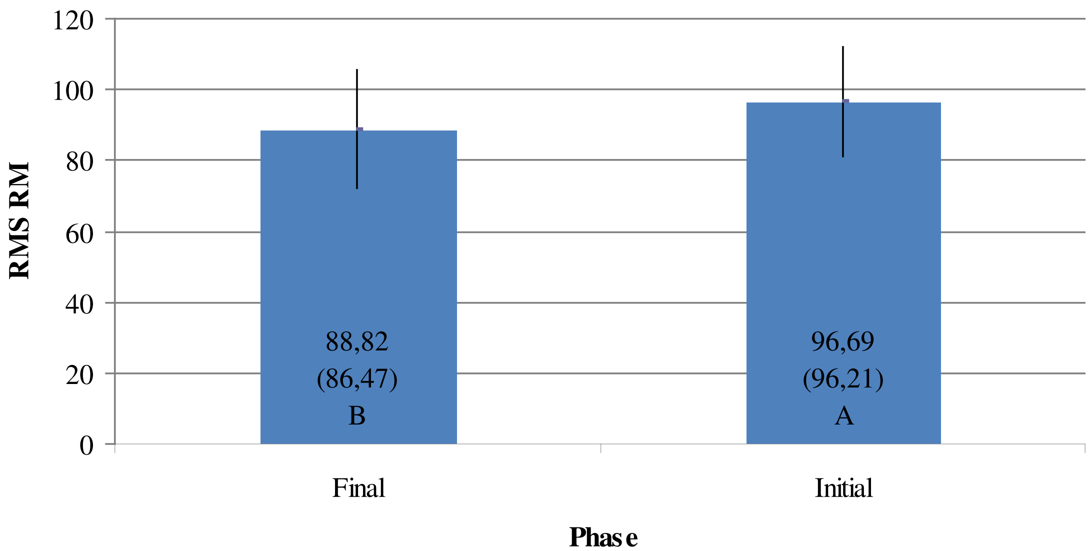

Figure 1. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RM muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 1. Table of analysis of variance of the original electromyographic data of the LM muscle, according to the appropriate model for analysis of variance with repeated measurements.

Effect	DF numerator	DF denominator	F-value	P-value
Group	1	48	0,04	0,8429
Situation	2	96	128,39	<0,0001
Phase	1	34	14,12	0,0006
Group*Situation	2	96	0,02	0,9804
Group*Phase	1	34	0,08	0,7763
Situation*Fase	2	68	1,28	0,2835
Group*Situation*Phase	2	68	0,05	0,9474

Table 2. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LM muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence intervalo f the mean(95%)		Tukey's Groups
Situation	Mean	Standard Deviation	superior	inferior	(α=0.05)
Isometry	144,335	68,430	159,006	129,663	A
Isotonia	100,509	53,684	112,019	88,999	B
Rest	5,326	2,804	5,927	4,724	C

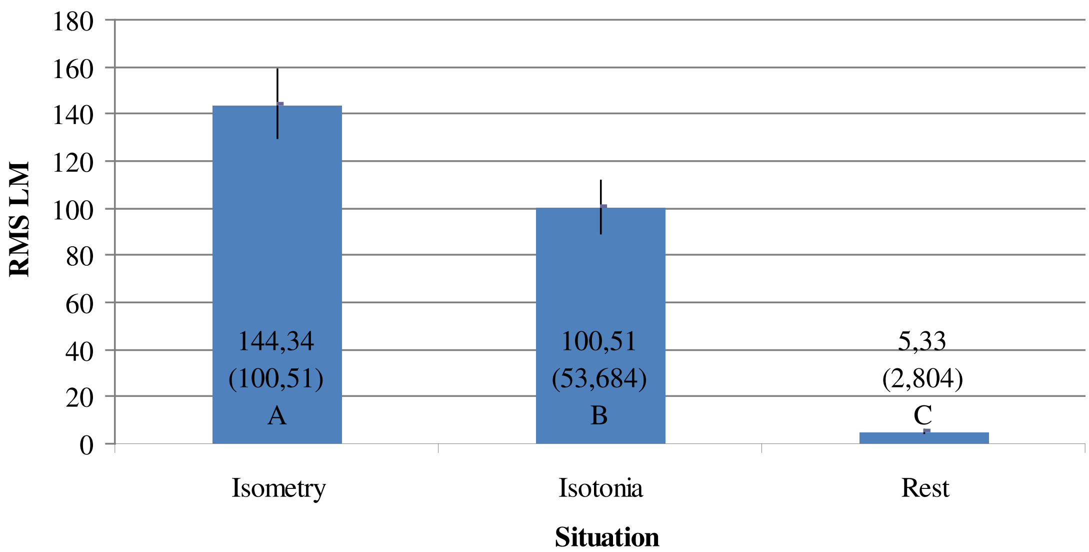

Figura 2. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LM muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 3. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LM muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence intervalo f the mean(95%)		Tukey's Groups
Phase	Mean	Standard Deviation	superior	inferior	(α=0.05)
Final	77,151	67,268	89,983	64,319	B
Initial	87,882	82,779	101,238	74,526	A

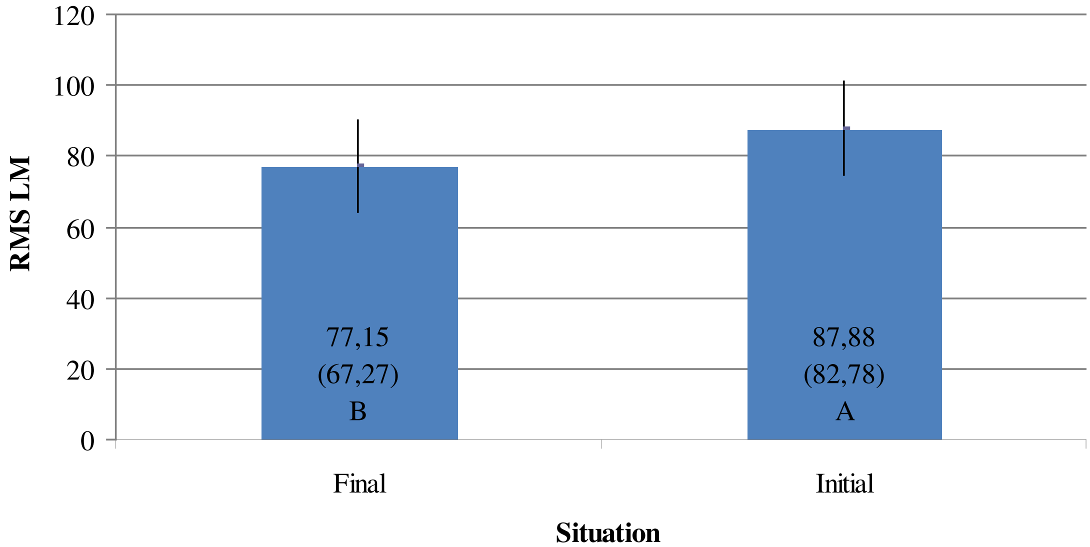

Figure 3. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LM muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Right temporal muscle (RT) → The table of analysis of variance (Table 7) showed strong evidence ($p < 0.01$) of differences between the real average for the different levels of group and situation factors; it also showed significant effects of group/phase interaction and of group/phase/situation triple interaction. Evidence for differences between the real mean of myoelectrical activity in early and late phases was found only in the group with malocclusion in the isotonia situation, with a reduction of the mean in the late phase, as shown in Table 8 and Figure 5. In other conditions, there were no indications of significant differences between the groups using Tukey's test at the specified level of significance.

Table 4. Table of analysis of variance of the original electromyographic data of the RT muscle, according to the appropriate model for analysis of variance with repeated measurements.

Effect	DF of numerator	DF of denominator	F-value	P-value
Group	1	48	8,40	0,0056
Situation	2	96	166,75	<0,0001
Phase	1	34	3,99	0,0539
Group*Situation	2	96	2,89	0,0603
Group*Phase	1	34	17,70	0,0002
Situation*Phase	2	68	0,40	0,6695
Group*Situation*Phase	2	68	3,31	0,0425

Table 5. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RT muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Group	Situation	Phase	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups
					Superior	Inferior	(α=0,05)
Malocclusion	Isometry	Final	134,100	65,736	166,790	101,410	A
		Initial	156,572	72,966	186,691	126,453	A
	Isotonia	Final	87,661	46,865	110,967	64,355	B
		Initial	118,220	63,192	144,304	92,136	A
	Rest	Final	4,683	1,603	5,480	3,886	A
		Initial	6,408	2,875	7,595	5,221	A
Normal Oclusion	Isometry	Final	118,100	35,687	135,847	100,353	A
		Initial	101,628	30,704	114,302	88,954	A
	Isotonia	Final	89,289	24,860	101,651	76,927	A
		Initial	70,580	23,683	80,356	60,804	A
	Rest	Final	3,967	1,872	4,898	3,036	A
		Initial	3,720	1,116	4,181	3,259	A

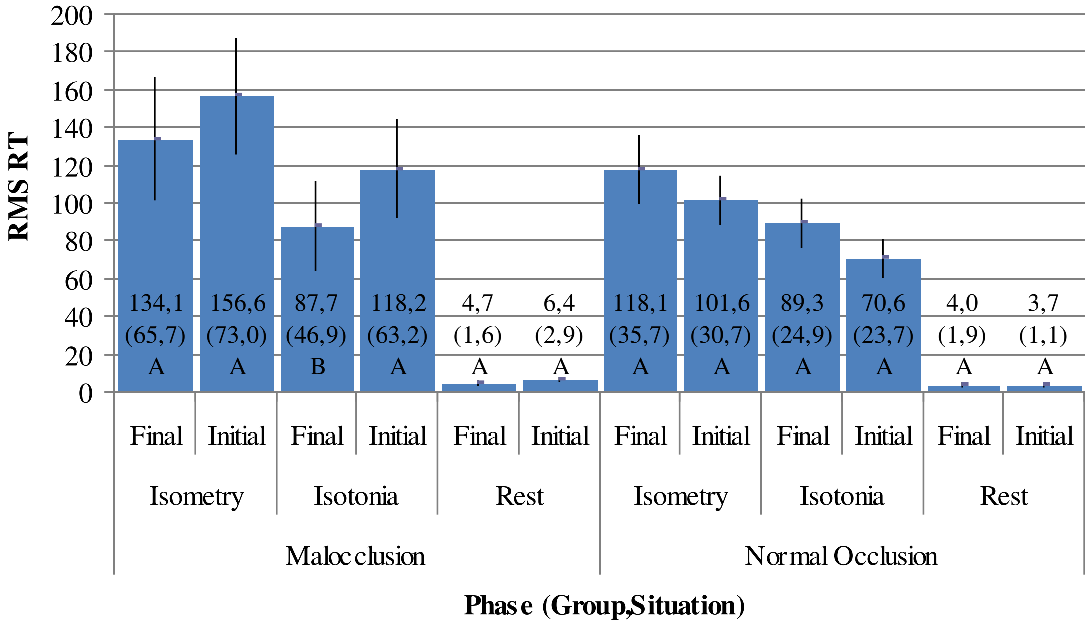

Figure 4. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RT muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

When comparing situations within the levels of group and phase factors, quite different results were seen, especially for the group with malocclusion. In this group, there were differences between the isometry and isotonia situations, as well as between each of these and the rest situation, while in the group with normal occlusion there was evidence only of differences between rest and other situations, with no significant differences between isometry and isotonia. These data are shown in Table 9 and Figure 6.

Table 9. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of MD muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Group	Phase	Situation	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups (α=0.05)
					Superior	Inferior	
Malocclusion	Final	Isometry	134.100	65.736	166.790	101.410	A
		Isotonia	87.661	46.865	110.967	64.355	B
		Rest	4.683	1.603	5.480	3.886	C
	Initial	Isometry	156.572	72.966	186.691	126.453	A
		Isotonia	118.220	63.192	144.304	92.136	B
		Rest	6.408	2.875	7.595	5.221	C
Normal Occlusion	Final	Isometry	118.100	35.687	135.847	100.353	A
		Isotonia	89.289	24.860	101.651	76.927	A
		Rest	3.967	1.872	4.898	3.036	B
	Initial	Isometry	101.628	30.704	114.302	88.954	A
		Isotonia	70.580	23.683	80.356	60.804	A
		Rest	3.720	1.116	4.181	3.259	B

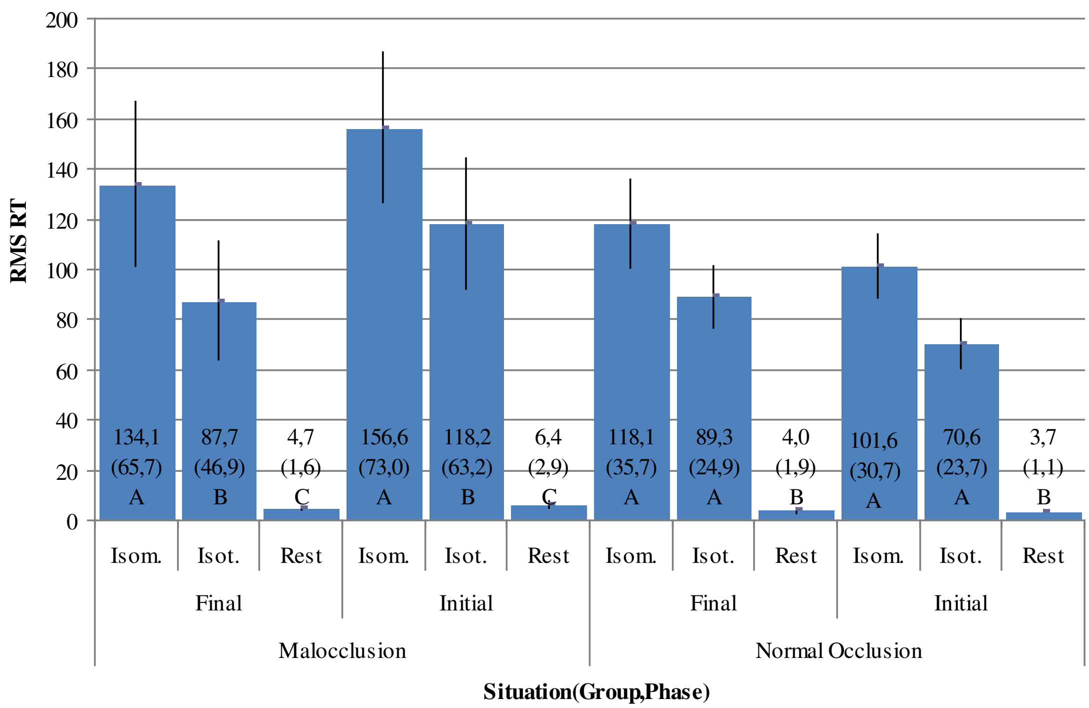

Figure 5. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RT muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

In order to extend the comparison of the means to triple interactions, it became necessary to compare groups, keeping fixed the situation and phase factors. We detected evidence of differences between the means of groups with normal occlusion and malocclusion in the initial phase; there is no evidence for differences at rest and no indication of differences in the final phase. This is shown in Table 10 and Figure 7.

Table 6. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RT muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Phase	Situation	Group	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups (α=0,05)
					Superior	Inferior	
Isometry	Final	Malocclusion	134,100	65,736	166,790	101,410	A
		Normal Occlusion	118,100	35,687	135,847	100,353	A
	Initial	Malocclusion	156,572	72,966	186,691	126,453	A
		Normal Occlusion	101,628	30,704	114,302	88,954	B
Isotonia	Final	Malocclusion	87,661	46,865	110,967	64,355	A
		Normal Occlusion	89,289	24,860	101,651	76,927	A
	Initial	Malocclusion	118,220	63,192	144,304	92,136	A
		Normal Occlusion	70,580	23,683	80,356	60,804	B
Rest	Final	Malocclusion	4,683	1,603	5,480	3,886	A
		Normal Occlusion	3,967	1,872	4,898	3,036	A
	Initial	Malocclusion	6,408	2,875	7,595	5,221	A
		Normal Occlusion l	3,720	1,116	4,181	3,259	A

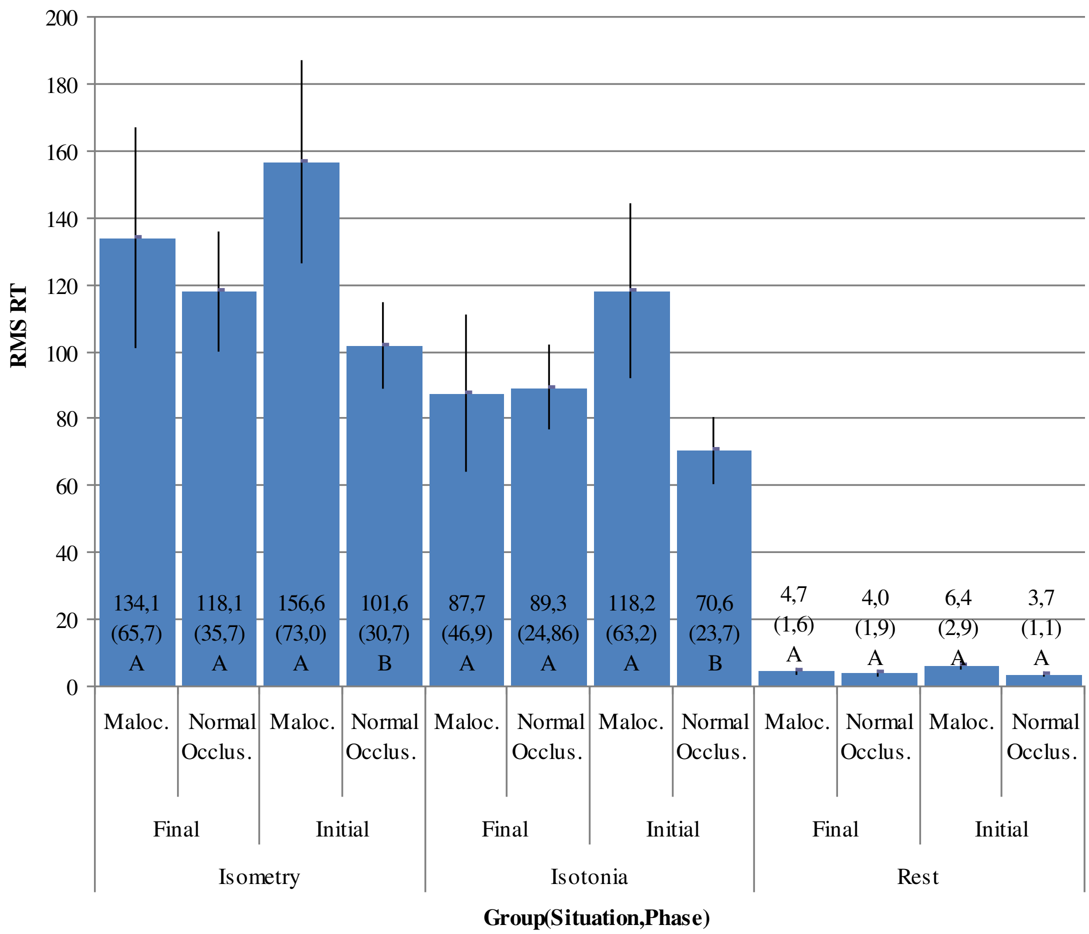

Figure 6. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of RT muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Left temporal muscle (LT) → In the data analysis, there was evidence ($p<0.05$) of differences between the real average observed in levels of the group factor and strong evidence ($p <0.01$) of differences between real average observed in different levels of the situation and phase factors (Table 11).

According to Tukey's test, the following was observed:

- The average RMS was shown to be significantly higher in the malocclusion group than in the normal occlusion group (Table 12 and Figure 8);

- The average RMS was shown to be significantly higher in isometry, followed by isotonia, both of which presented a higher mean value than the rest average (Table 13 and Figure 9);

- The average RMS was shown to be significantly higher in initial phase than in the final phase of the experiment (Table 14 and Figure 10).

Table 7. Table of analysis of variance of the original electromyographic data of the LT muscle, according to the appropriate model for analysis of variance with repeated measurements.

Effect	DF of numerator	DF of denominator	F-value	P-value
Group	1	48	4,74	0,0345
Situation	2	96	172,15	<0,0001
Phase	1	34	12,69	0,0011
Group*Situation	2	96	1,60	0,2074
Group*Phase	1	34	3,12	0,0862
Situation*Phase	2	68	1,33	0,2702
Group*Situation*Phase	2	68	0,83	0,4421

Table 8. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LT muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence interval of the mean (95%)		Tukey's Groups
Group	Mean	Standard Deviation	superior	inferior	(α=0.05)
Malocclusion	93,935	82,745	108,350	79,520	A
Normal Occlusion	75,688	62,370	86,554	64,823	B

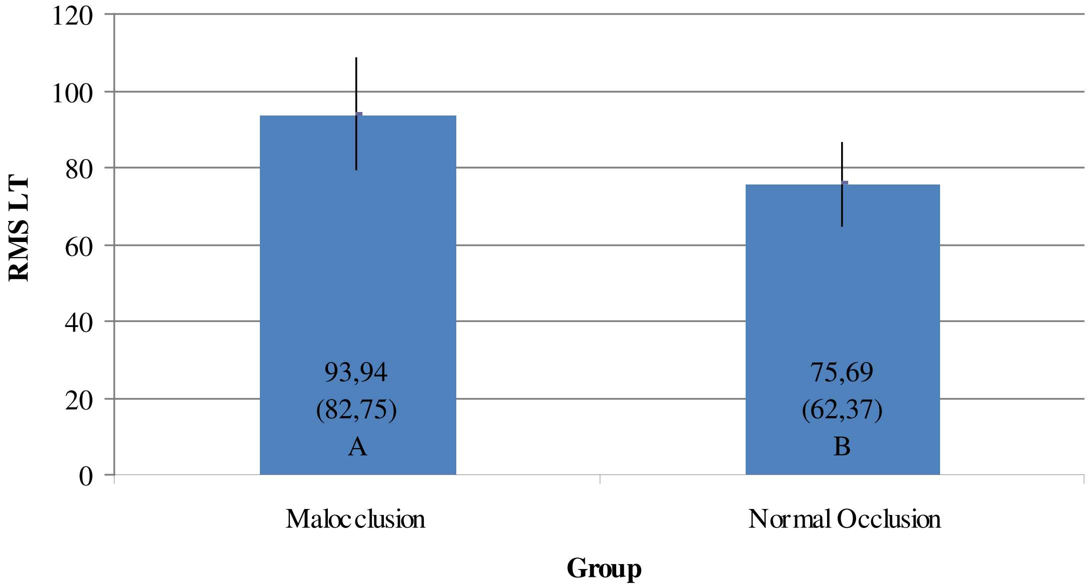

Figure 7. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LT muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 9. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LT muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Effect	Mean	Standard deviation	Limits of the confidence interval of the mean (95%) superior	inferior	Tukey's Groups (α=0.05)
Isometry	144,917	61,860	158,180	131,655	A
Isotonia	103,358	48,087	113,668	93,048	B
Rest	6,159	4,440	7,111	5,207	C

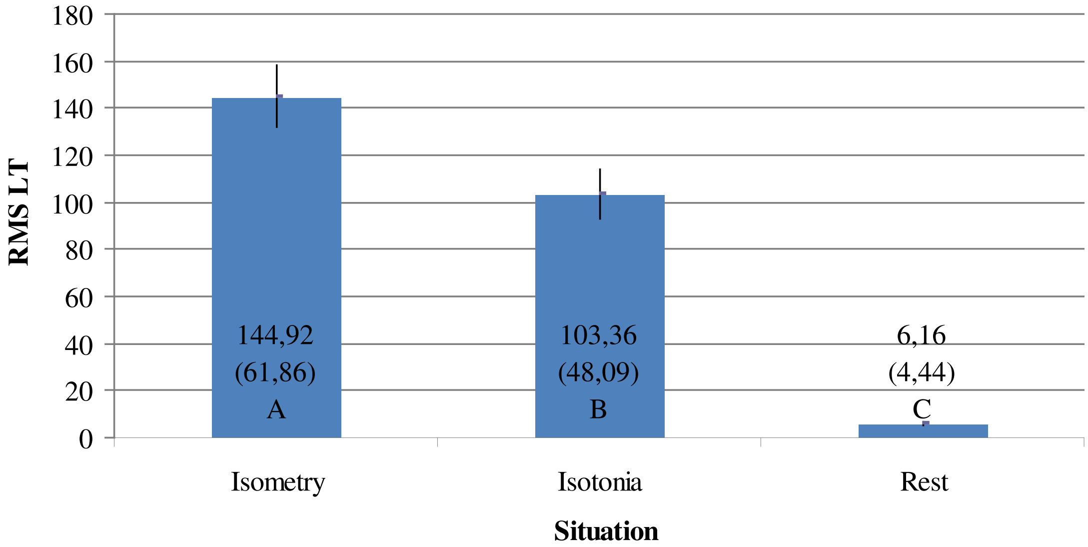

Figure 8. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LT muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 10. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LT muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence interval of the mean (95%)		Tukey's Groups
Effect	Mean	Standard Deviation	superior	inferior	(α=0.05)
Final	80,649	70,765	94,148	67,150	B
Initial	87,809	75,828	100,043	75,575	A

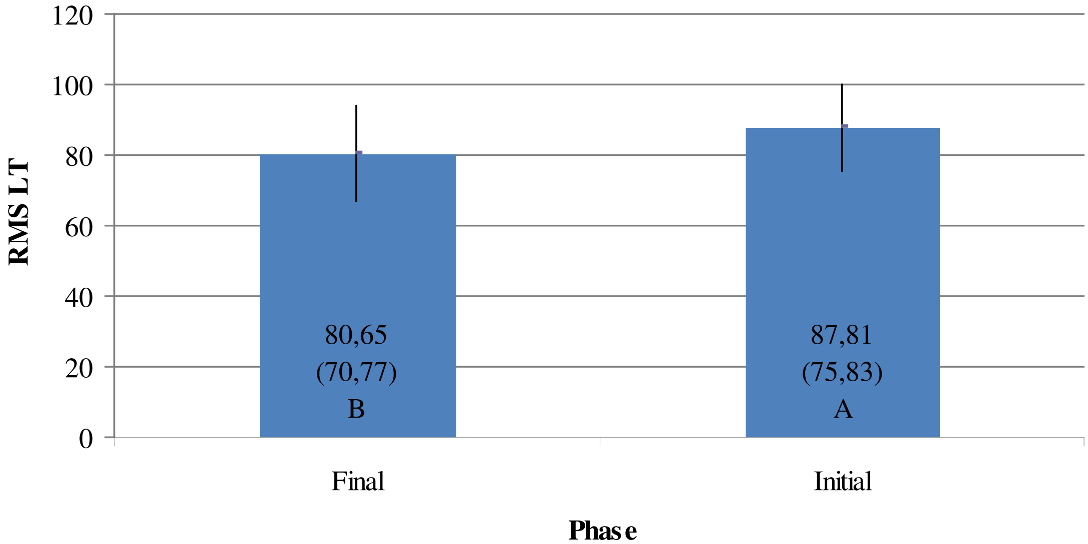

Figure 9. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of LT muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Orbicular Oris muscle, the superior segment (OS) → The table of analysis of variance (Table 15) presented strong evidence ($p < 0.01$) of differences between real average for the different levels of group and situation factors. According to Tukey's test, it is observed that:

- The malocclusion group presented significantly higher average RMS than the normal occlusion group (table 16 and figure 11);

- The average RMS was shown to be significantly higher in isometry and isotonia than at rest, but there were no indications of differences between the real average of isometry and isotonia (table 17 and figure 12).

Table 11. Table of analysis of variance of the original electromyographic data of the OS muscle, according to the appropriate model for analysis of variance with repeated measurements.

Effect	DF of numerator	DF of denominator	F-value	P-value
Group	1	48	13,76	0,0005
Situation	2	96	37,56	<,0001
Phase	1	34	2,44	0,1276
Group*Situation	2	96	0,61	0,5477
Group*Phase	1	34	1,53	0,2240
Situation*Phase	2	68	0,43	0,6544
Group*Situation*Phase	2	68	0,43	0,6501

Table 12. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OS muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Group	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups
			superior	inferior	(α=0.05)
Malocclusion	17,657	16,008	20,445	14,868	A
Normal Occlusion	12,253	7,980	13,643	10,863	B

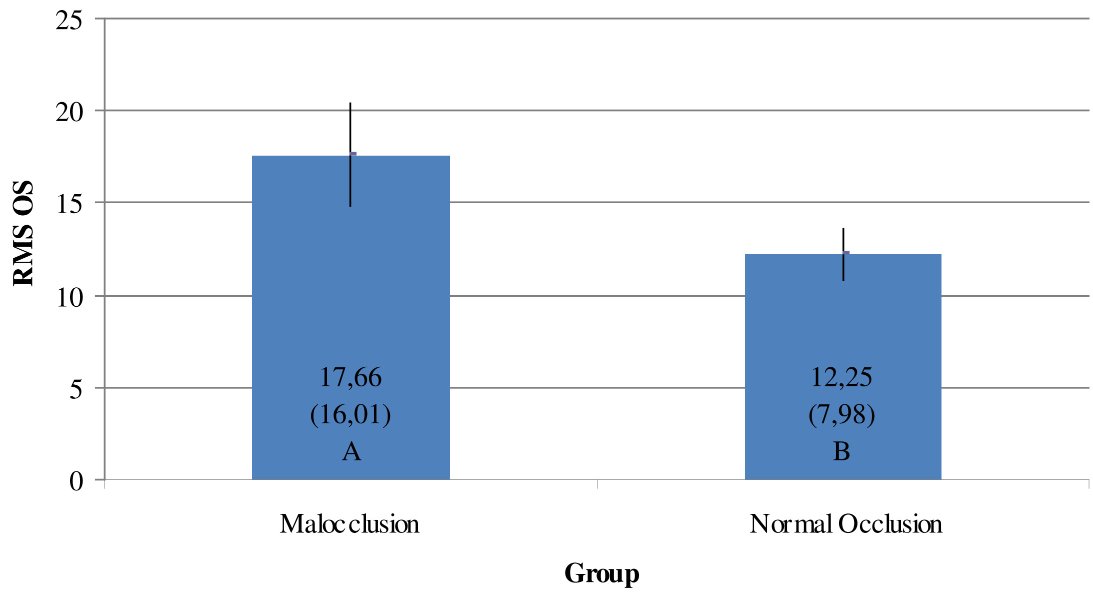

Figure 10. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OS muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 13. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OS muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence interval of the mean (95%)		Tukey's Groups
Effect	Mean	Standard Deviation	superior	inferior	(α=0.05)
Isometry	21,076	15,314	24,359	17,792	A
Isotonia	17,072	11,396	19,515	14,629	A
Rest	6,716	5,332	7,859	5,573	B

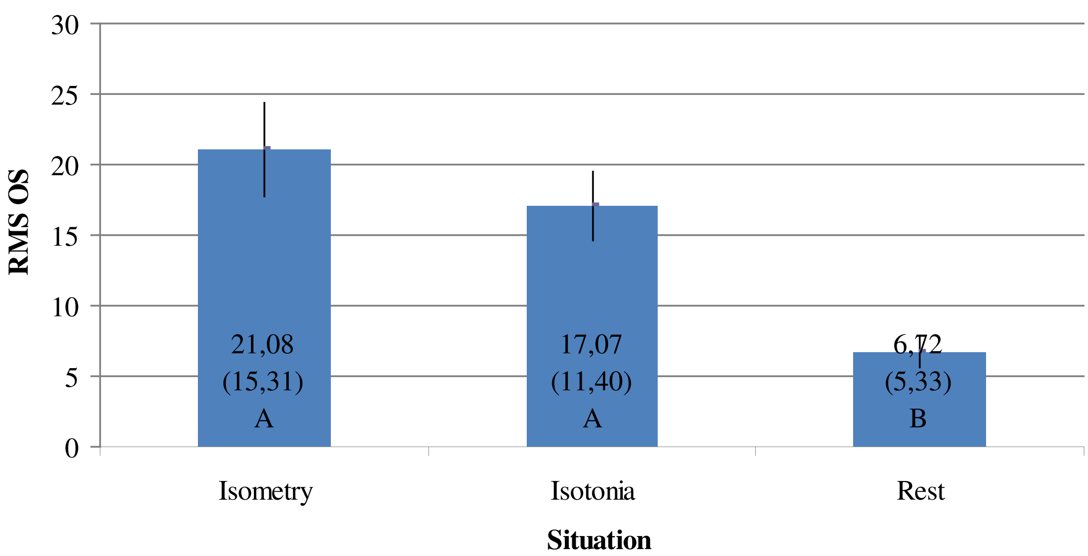

Figure 11. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OS muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Orbicular Oris muscle, inferior segment (OI) → Table of analysis of variance (Table 18) presented strong evidence (p <0.01) of differences between real average for different levels of group, situation and phase factors. There was also evidence (p <0.05) of a significant group/phase interaction. According to the Tukey test, it was observed that:

- The average RMS was shown to be significantly higher in isometry and isotonia than at rest, but there were no indications of differences between the real average of isometry and isotonia (Table 19 and Figure 13);

- Noteworthy evidence of differences between the phase average occurs only in the group with malocclusion; there is no detectable difference in the averageRMS of the initial and final phases in the group with normal occlusion (Table 20 and Figure 14);

- In the group with malocclusion, the average RMS was significantly higher in the initial phase than in the final phase (Figure 14);

- Although no evidence of differences in the final phase between real average of RMS in the malocclusion and control groups was found, in the initial phase a higher average was observed in the group with malocclusion (Table 21 and Figure 15).

Table 14. Table of analysis of variance of the original electromyographic data of the OI muscle, according to the appropriate model for analysis of variance with repeated measurements.

Effect	DF of numerator	DF of denominator	F-value	P-value
Group	1	48	9,17	0,0039
Situation	2	96	38,75	<,0001
Phase	1	34	7,56	0,0095
Group*Situation	2	96	0,09	0,9115
Group*Phase	1	34	5,89	0,0207
Situation*Phase	2	68	0,02	0,9819
Group*Situation*Phase	2	68	1,74	0,1841

Table 15. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OI muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

			Limits of the confidence interval of the mean (95%)		Tukey's Groups
Effect	Mean	Standard Deviation	superior	inferior	(α=0.05)
Isometry	23,688	11,242	26,099	21,278	A
Isotonia	21,552	13,453	24,437	18,668	A
Rest	8,992	7,356	10,569	7,415	B

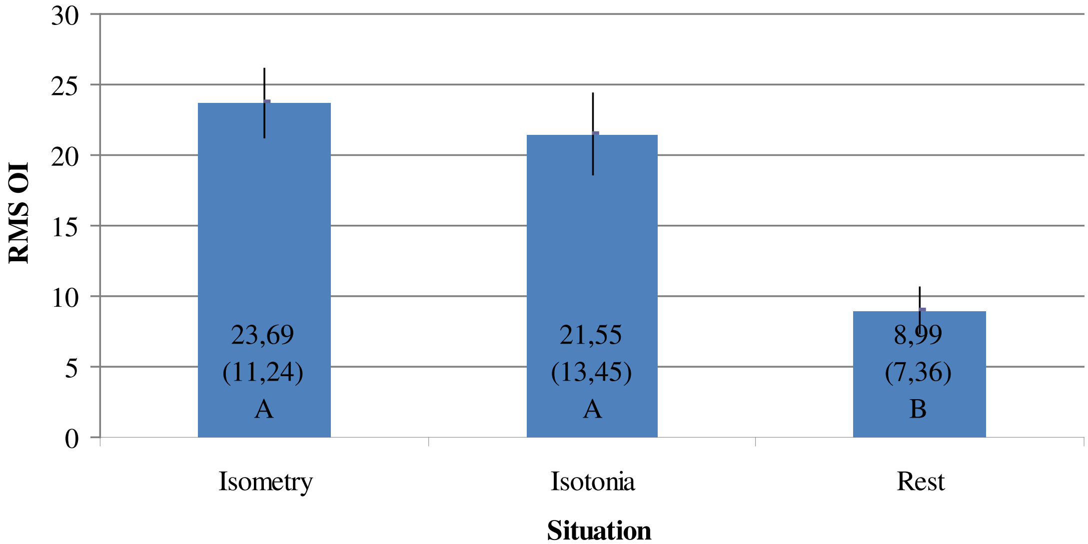

Figure 12. Means, standard deviation, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OI muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 16. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OI muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Group	Phase	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups
				Superior	Inferior	(α=0,05)
Malocclusion	Final	16,285	11,123	19,321	13,249	B
	Initial	23,573	14,381	26,882	20,265	A
Normal Occlusion	Final	15,365	9,193	17,874	12,856	A
	Initial	15,825	12,741	18,757	12,894	A

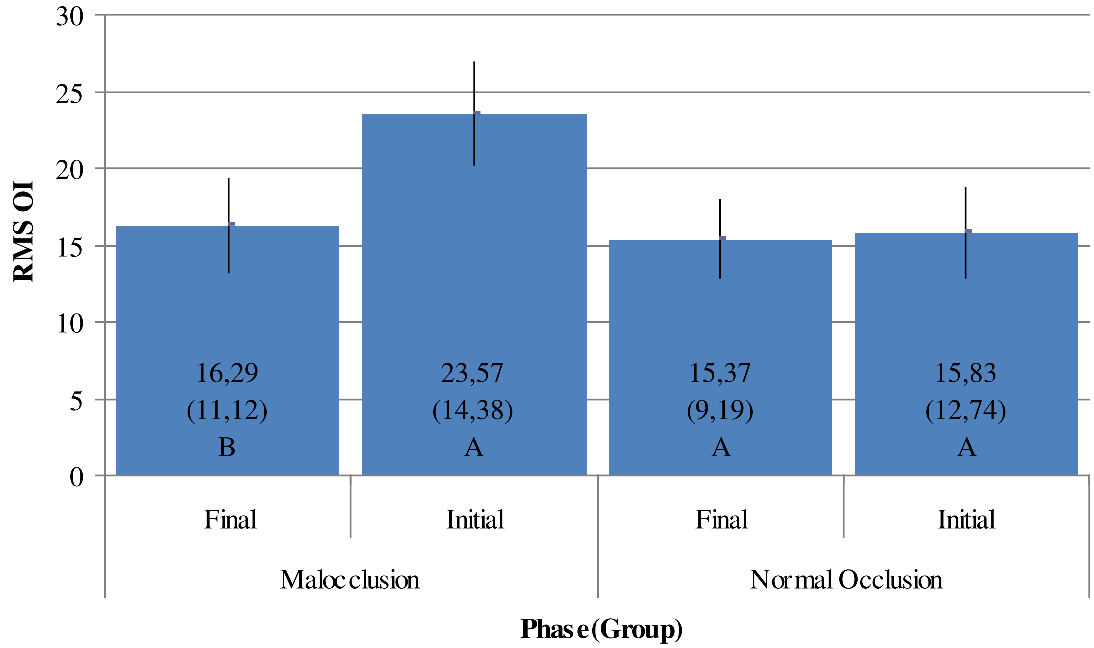

Figure 13. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test with significance level of 5% for comparison of phase means in level of group factor, of the OI muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Table 17. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test of OI muscle RMS. Means with distinct letters differ among themselves in the level of significance of 5%.

Phase	Group	Mean	Standard Deviation	Limits of the confidence interval of the mean (95%)		Tukey's Groups (α=0,05)
				Superior	Inferior	
Final	Malocclusion	16,285	11,123	19,321	13,249	A
	Normal Occlusion	15,365	9,193	17,874	12,856	A
Initial	Malocclusion	23,573	14,381	26,882	20,265	A
	Normal Occlusion	15,825	12,741	18,757	12,894	B

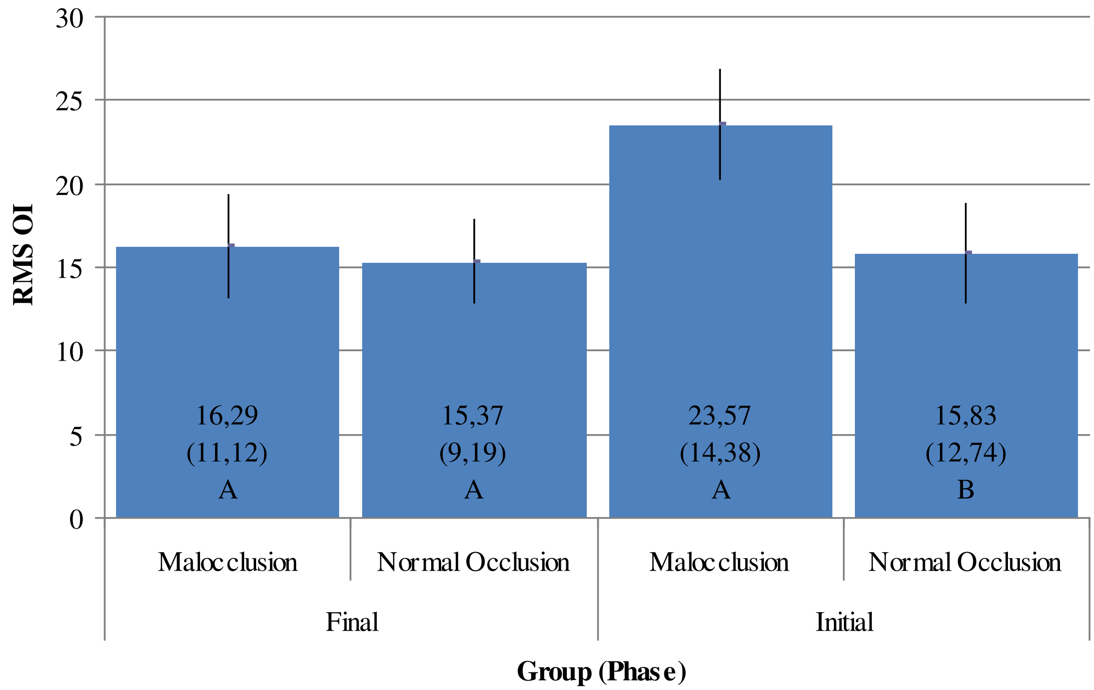

Figure 14. Means, standard deviations, limits of the confidence interval of the mean (95%) and groups formed by the Tukey's test with significance level of 5% for comparison of phase means in level of group factor, of the OI muscle RMS. Bars with distinct letters differ among themselves in the level of significance of 5%.

Discussion

Imbalanced muscle function is a frequent and important aspect of Class II malocclusion and is usually a prominent etiological factor in its development[3]. According to previous studies[17-22], patients with Class II, division 1 malocclusion require greater effort of perioral and masticatory muscles to make several movements than patients with normal occlusion. This is probably related to the characteristic flaring of the superior incisors in this malocclusion, a condition that is associated with the disharmony of the maxillaries in the anteroposterior direction and that hinders the performance of these muscles in their basic functions.

The treatment of dental Class II, division 1 malocclusion using the extraoral appliance is characterized as a first phase of orthodontic treatment; its goal is to obtain normal molar relations and a repositioning of anterosuperior teeth in relation to their basal bone, thereby seeking the establishment of normal muscle function as early as possible. According to Moyers[3], the correction of dental anomalies of this malocclusion enables almost complete restoration of normal muscle function.

This study evaluated the effect of treatment with the extraoral appliance on the masseter, temporal and orbicularis oris muscles in young people with dental Class II, division 1 malocclusion, comparing them with a control group with normal occlusion. The lack of published studies concerning muscular response after the use of the extraoral appliance led us to discuss the results virtually without comparing them with those of other authors.

The young girls analyzed presented pattern growth mesofacial, with tendency dolichofacial, with maxilla and jaws well positioned in relation to the middle portion of the skull base, effective size near the standard value, disharmony of the apical bases, anterior inferior facial height slightly increased and upper molar mesialized[13]. These data indicated an interceptor treatment with extraoral appliance supported by the Interlandi Head Gear, with the aim of distalizing the upper molar, reshaping the maxilla, improving the relationship of the apical bases, gaining vertical control and reducing the antero-inferior facial height[13].

The results showed a difference in electromyographic activity between young people with malocclusion and normal occlusion in the initial phase of the experiment, with increased electrical activity of the masseter, temporal and orbicularis oris muscles in the group with malocclusion. This difference was not significant for the masseter muscle. After treatment, there were no significant differences between groups, but both showed a reduction of electromyographic activity. However, this reduction was not significant for the right temporal or for the orbicularis oris, superior segment. The results suggest that correction of Class II, division 1malocclusion resulted in better muscle balance. Ahlgren[23] and Ingerval & Thilander[24], assessing people with normal occlusion similar in age to those in the present study, also found a decrease in electromyographic activity with increasing age. Hiyama et al.[25] observed that the characteristics of the EMG signal of masticatory muscles in several jaw movements changed after patients underwent orthodontic treatment and that these changes occurred with improvement of the craniofacial structure and occlusal relationships, especially when inharmonious functions were eliminated. Other authors have made similar observations [17,21,26-37]. According to Moss[38], the lack of change in muscle contraction pattern indicates a failure of tegumentary tissues to adapt to the new position of the teeth. Normalization of the electromyographic contraction pattern of the masticatory muscles after orthodontic treatment was also detected in other previous studies[38-40]. However, Störmer & Pancherz[33], when comparing the electromyographic activity of masticatory and perioral muscles in patients who underwent orthodontic treatment for correction of anterior open bite, found that there was no normalization of swallowing and that this lack of normalization generated a high possibility of recurrence. According to Moyers[17], it is important to differentiate whether the muscle dysfunction is presented as an etiological factor or as a malocclusion result. Electromyographic analysis before and after orthodontic treatment can provide us with this information, assisting us in choosing the appropriate retention.

In the rest situation, minimum muscle activity in both phases, with the 2nd phase presenting lower activity, was observed in both groups. According to Pinho et al.[41], patients with dysfunction of the stomatognathic system have increased electromyographic activity of masticatory muscles during rest. According to Sgobbi de Faria & Bérzin[42], the mandibular rest position is effectively maintained by the viscoelastic properties of muscles and tendons, which oppose the force of gravity. According to Quirch[18] and Ferrario et al.[43], the muscle activity at rest is minimal under normal conditions. The activity detected in this study was probably due to some anxiety generated by the examination, making it difficult for the girls to achieve an appropriate degree of relaxation. Yemm and Berry[44] also suggested that the rest position is largely governed by the balance of elastic forces when patients are fully relaxed and that the electrical activity seen in the rest position is the result of the patient's emotional reaction to the experimental situation. However, according to Latif[45], the presence of temporal muscle activity at rest indicates that this muscle participates actively in the maintenance of mandibular posture.

Comparing the situations evaluated, we observed an increased activity of all muscles in isometry, with the exception of the orbicularis oris muscle, upper and lower segment, which did not differ between the isometric and isotonic. In isotonic contraction (unusual masticatory activity), higher electromyographic activity was seen than with the muscle at rest. According to Ahlgren et al.[46] and Bakke et al.[47] there is a positive correlation between bite force and muscle activity. The greater the bite force, the greater the electromyographic activity. The movements adopted in the isotonic contraction allowed the observation of the masticatory cycles, with speed and direction control of the motion; these variables are difficult to control in other dynamic conditions, such as usual masticatory activity.

As a general rule, it is accepted that the masseter is a power muscle, while the temporal is a positioner muscle. In this study, during isometric contraction as during isotonic contraction, there was moderate activity of these two muscles. This confirms that these muscles participated in these movements without predominance of one over the other. Pancherz[48] also found that young people showed similar activities of the masseter and temporal muscles during maximum intercuspal position. According to Ferrario et al.[43], females exhibit similar levels of activity of the temporal and masseter muscles during isometric contraction, whereas in males masseter activity is dominant.

In relation to the orbicularis oris muscle, superior and inferior segment, the high activity observed in the initial phase in the group with Class II, division 1 malocclusion is probably related to malpositioning of the incisors, which creates adaptation needs[22]. After treatment with the extraoral appliance, it was found that there was an effective distalization of the upper permanent first molars and that the incisors showed positive change in axial tilt and positioning at their apical bases[13]; this could contribute to explain the observed reduction in the electromyographic activity.

In the literature, there are many reports emphasizing the importance of perioral muscles as an etiological factor in malocclusion; however, it is noteworthy that there is great difficulty in measuring the real participation of these muscles in the determination of teeth position. Simpson[28] did not find the correlation between the shape of the upper arch and the activity of perioral muscles. Lowe & Takada[49] suggested a possible impact of the activity of the orbicularis oris muscle in the final position of teeth in dental arches, especially in Class II, division 1 and division 2. According to Jung et al.[50], the orbicularis oris muscle influences the angle of the superior incisors; however, it is not influenced by the degree of maxillary protrusion.

The large standard deviation observed before and after treatment is typical of electromyographic studies[37,43,51] and is possibly due to the large biological variability inherent to the patients, which does not invalidate the methodology. This study was carefully designed to minimize this variability, with a careful selection of the sample regarding age, sex, skeletal pattern, vertical growth pattern, dental characteristics, and no previous orthodontic treatment. For the collection and analysis of the EMG signal, we used a careful and accurate protocol and methodology of data collection, adopted and established in extensive prior research[16, 19,20,22,42].

According to results obtained in this study, patients with dental Class II, division 1 malocclusion show a pattern of masticatory and perioral muscle activity that differs from that in individuals with normal occlusion; such patients require greater employment of muscle fibers to perform several functions. Treatment with the extraoral appliance, when appropriately used, results in an improvement of this muscle pattern.

Conclusions

Through analysis of data obtained in this study, considering the characteristics of the sample used and the methodology employed, it is concluded that:

- There were changes in action potentials of the anterior portion of the temporal muscle, the superficial portion of the masseter muscle and the superior and inferior segments of the orbicularis oris muscle in young people with dental Class II, division 1 malocclusion after orthodontic treatment with extraoral appliance.

- Young girls with dental Class II, division 1 malocclusion had less electrical activity in all muscles studied after the orthodontic treatment; however, this difference was not statistically significant for the right temporal muscle and the orbicularis oris muscle, superior segment.

- There was a difference in electromyographic activity between young girls with malocclusion and normal occlusion in the initial phase of the experiment, with greater electrical activity of muscles in the group with malocclusion. However, this difference was not significant for the masseter muscle.

- In the final phase of the experiment, young girls with normal occlusion also showed a reduction in electromyographic activity in all muscles studied; this difference was not statistically significant for the right temporal muscle and the orbicularis oris muscle, superior segment.

- There were no significant differences between groups in the final stage of the experiment.

- Treatment with the extraoral appliance made it possible to improve the muscular patterns of the girls with dental Class II, division 1 malocclusion.

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CONSIDERAÇÕES FINAIS

A prática da Ortodontia contemporânea envolve a compreensão e a aplicação de vários princípios biomecânicos para se alcançar os resultados almejados. O desenvolvimento de várias técnicas baseadas nestes princípios possibilita aos ortodontistas efetuar alterações favoráveis tanto no complexo craniofacial quanto no posicionamento dos dentes. No entanto, o planejamento ortodôntico não se baseia simplesmente em considerações biomecânicas, requer também um adequado conhecimento de todo o "meio-ambiente" onde os ossos e dentes encontram-se inseridos. Os músculos desempenham um papel de suma importância na etiologia e no tratamento das maloclusões, bem como na estabilidade pós-tratamento. Assim, a análise da função neuromuscular torna-se crucial para o ortodontista.

Observa-se, na clínica diária, uma grande demanda para o tratamento da maloclusão Classe II, 1ª divisão, provavelmente devido ao grande comprometimento estético a ela associado. E quando essa maloclusão apresenta-se como dentária, a atuação precoce por parte do ortodontista, em um período onde o complexo dento-esquelético e dento-alveolar encontra-se em crescimento, favorece a obtenção de movimentos dentários, remodelações alveolares e das bases apicais, possibilitando alcançar uma oclusão e uma estética mais satisfatória e uma maior estabilidade do caso (Proffit & Tulloch, 2002). Acredita-se que essa maior eficiência do tratamento precoce se relaciona com a maior viscoelasticidade tecidual, característica das pessoas mais jovens.

Ao se utilizar o aparelho extrabucal (AEB) para a correção da Classe II, deve-se considerar algumas premissas: a escolha da direção da tração (alta ou parietal, média ou occipital e baixa ou cervical), o estágio de crescimento e desenvolvimento da face e dos dentes, a intensidade das forças a serem aplicadas, a inclinação e o comprimento do arco externo do AEB, a linha de ação de força e a cooperação do paciente. A escolha da direção da tração encontra-se diretamente relacionada ao padrão de crescimento craniofacial do paciente. Obtêm-se um melhor prognóstico quando se coordena o tratamento com o surto de crescimento puberal (Proffit & Fields Jr, 1995). Para produzir movimentação ortodôntica, utilizam-se forças leves ou ideais (180 a 350 g) e para gerar alterações ortopédicas, utilizam-se forças pesadas (>500 g). Quaisquer movimentos de rotação, inclinação ou translação dos dentes, bem como rotação horária ou anti-horária da maxila e da mandíbula apresentam-se controláveis quando se conhece os mecanismos que os produzem. A cooperação do paciente representa um fator importante para estabelecer os resultados do tratamento. Mas, de acordo com Proffit & Fields Jr, em 1995, experiências clínicas sugerem fortemente que só a cooperação não explica a variabilidade nos resultados. Parece provável que as melhores respostas se alcançam nos jovens que tendem a crescer mais favoravelmente.

Uma vez que a função muscular desequilibrada apresenta-se como uma característica da maloclusão Classe II, o estabelecimento de uma função muscular harmônica o mais cedo possível torna-se um dos primeiros objetivos do tratamento precoce.

Esse estudo investigou as mudanças musculares ocorridas no pós-tratamento da maloclusão Classe II, 1ª divisão dentária com o aparelho extrabucal, onde a eletromiografia de superfície mostrou-se um instrumento útil na documentação dessas mudanças.

Todo músculo, quando ativado, sofre uma série de transformações mecânicas, estruturais, químicas e elétricas. As descargas elétricas que originam a contração muscular ocorrem devido às mudanças na polarização da membrana que envolve a fibra muscular. O conjunto de descargas elétricas das diferentes fibras que compõem uma unidade motora constitui o potencial de ação. O eletromiógrafo capta, amplifica e registra esse potencial elétrico (Quirch,1965).

Observou-se neste estudo que as jovens com maloclusão Classe II, 1ª divisão apresentaram uma maior atividade elétrica dos músculos temporal, masseter e orbicular da boca do que as jovens com oclusão normal. Mas, após se submeterem ao tratamento ortodôntico com o AEB, com a conseqüente melhora da oclusão, essa atividade muscular diminuiu, apresentando-se similar às jovens com oclusão normal. Tal fato evidenciou a efetividade do tratamento realizado, sugerindo que a disfunção muscular inicial apresentou-se como conseqüência da maloclusão. O maior equilíbrio muscular alcançado com o tratamento provavelmente diminuiu as chances de recidiva.

Enfocou-se também neste estudo, a complexidade da interpretação dos dados eletromiográficos, em virtude da grande variabilidade dos resultados, conseqüente da grande variabilidade individual, inerente aos pacientes. Nesta situação específica avaliada, a normalização, processo pelo qual se submetem os dados EMG para a redução desta variabilidade, mostrou-se contra-indicada, uma vez que suprimiu as diferenças entre os grupos. Com isso, questionou-se a orientação presente na literatura de se normalizar os dados ao se comparar diferentes pacientes, ou mesmos pacientes em diferentes dias ou diferentes músculos. Apresenta-se necessária a realização de outros estudos para identificar, com maior embasamento científico, quais as situações onde a normalização deveria ou não ser indicada.

Os resultados desse estudo enfatizam a importância do comportamento da musculatura mastigatória e peribucal para a estabilidade pós-tratamento dos pacientes com maloclusão Classe II, 1ª divisão, uma vez que forma e função apresentam-se relacionadas. Torna-se crucial para o ortodontista avaliar se a mecanoterapia empregada produziu as alterações morfológicas e funcionais desejadas. Em alguns casos, a utilização de terapia miofuncional apresenta-se imprescindível.

Ao se utilizar a EMG para a avaliação da função muscular, torna-se necessário um rigoroso controle sobre a metodologia empregada. Além disso, mostra-se preponderante para a interpretação do eletromiograma um bom conhecimento da dinâmica muscular, como também um meticuloso estudo clínico do paciente, a fim de se estabelecer as correlações respectivas. Finalmente, enfatiza-se que a EMG representa um valioso instrumento auxiliar na clínica, mas a sua utilização, sem uma detalhada observação clínica prévia, carece de seriedade e validade científica.

CONCLUSÃO GERAL

Diante dos resultados obtidos conclui-se que:

- O procedimento de normalização dos dados pela porcentagem do valor do sinal eletromiográfico adquirido em uma contração isométrica voluntária máxima dos músculos temporal, masseter e orbicular da boca, influenciou a interpretação dos resultados desse estudo, ao suprimir as diferenças existentes entre o grupo com maloclusão Classe II, 1ª divisão dentária e o grupo com oclusão normal. Diante desse fato, reforçou-se a idéia de que os resultados originais permitiram conclusões mais adequadas do que os dados normalizados.

- Com os dados originais ocorreu uma diminuição na atividade eletromiográfica da porção anterior do músculo temporal, da porção superficial do músculo masséter e dos segmentos superior e inferior do músculo orbicular da boca, nas jovens com maloclusão Classe II, 1ª divisão dentária, após se submeterem ao tratamento ortodôntico com o aparelho extrabucal. Entretanto esta diferença não apresentou-se estatisticamente significante para o músculo temporal direito e orbicular da boca, segmento superior. Tais resultados sugeriram que o tratamento com o aparelho extrabucal possibilitou a melhora do padrão muscular das jovens com maloclusão Classe II, 1ª divisão dentária.

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* De acordo com a norma da UNICAMP/FOP, baseadas na norma do International Committee of Medical Journal Editors - Grupo Vancouver. Abreviatura dos periódicos em conformidade com o Medline.

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APÊNDICE

1- Figuras referentes à coleta do sinal eletromiográfico:

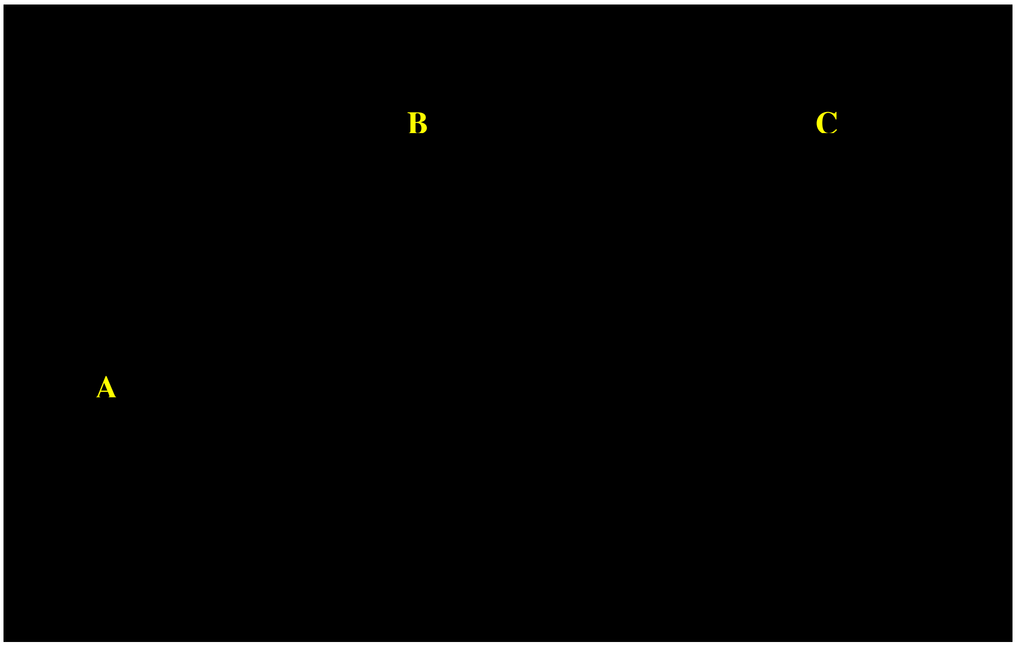

Figura 1- Eletromiógrafo (A), microcomputador com placa conversora A/D instalada (B) e tela do monitor mostrando a aquisição do sinal eletromiográfico por meio do software (C).

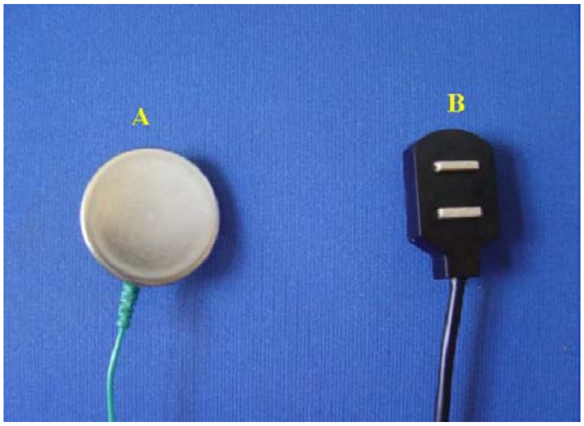

Figura 2 – Eletrodos terra (A) e de superfície ativo diferencial simples(B)

Figura 3 – Eletrodos de superfície passivos

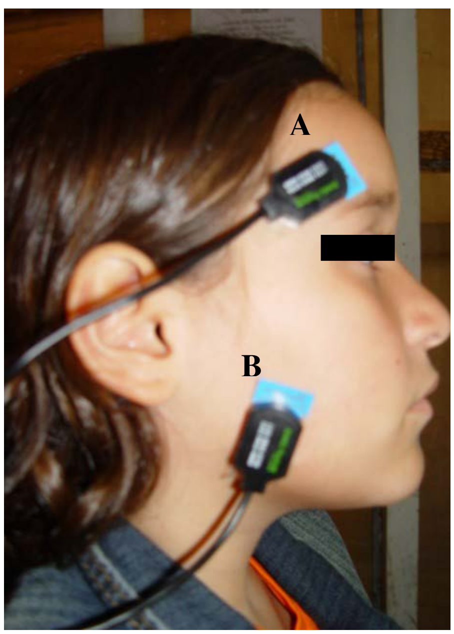

Figura 4 – Eletrodos ativos posicionados: temporal (A) e masseter (B).

Figura 5 – Eletrodos passivos posicionados

Figura 6- Material parafilme

Figura 7 – Metrônomo

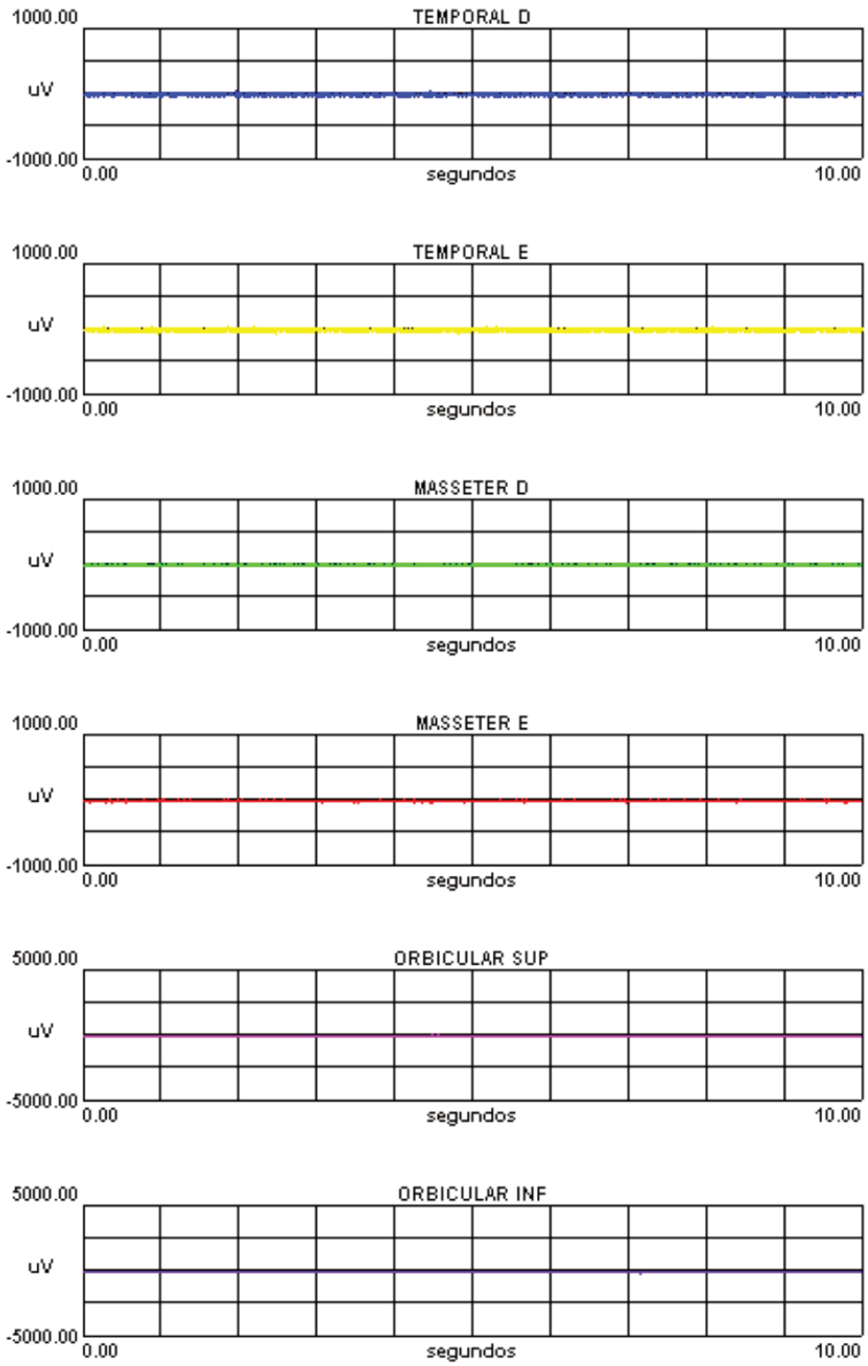

Figura 8- Exemplo do sinal eletromiográfico dos músculos temporal direito e esquerdo, masséter direito e esquerdo, e orbicular da boca, segmento superior e inferior, durante a situação de repouso, de uma jovem com maloclusão.

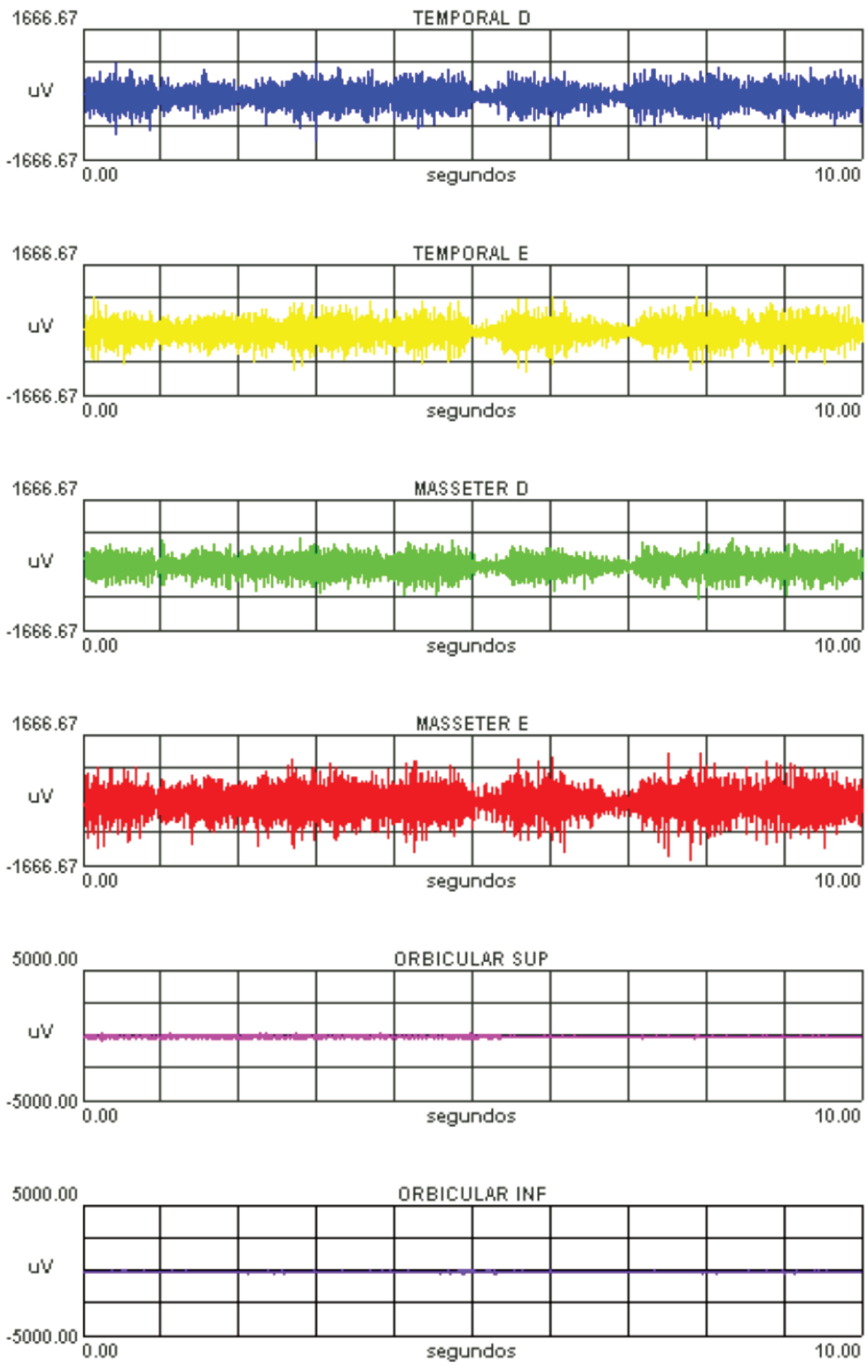

Figura 9- Exemplo do sinal eletromiográfico dos músculos temporal direito e esquerdo, masséter direito e esquerdo, e orbicular da boca, segmento superior e inferior, durante uma contração isométrica, de uma jovem com maloclusão.

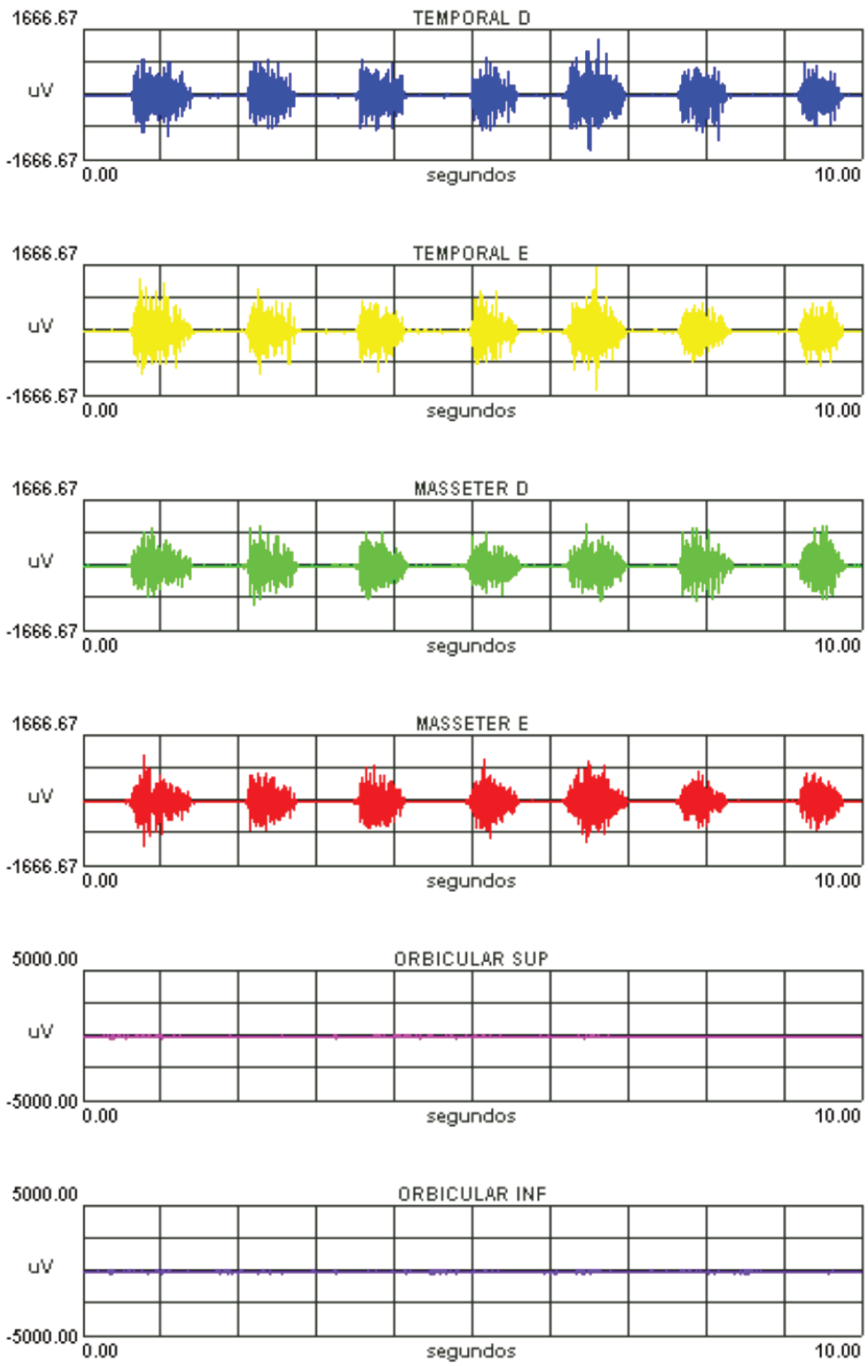

Figura 10- Exemplo do sinal eletromiográfico dos músculos temporal direito e esquerdo, masséter direito e esquerdo, e orbicular da boca, segmento superior e inferior, durante uma contração isotônica, de uma jovem com maloclusão.

2- Figuras referentes ao tratamento ortodôntico com AEB:

Figura 11- AEB de tração occipital, vista frontal.

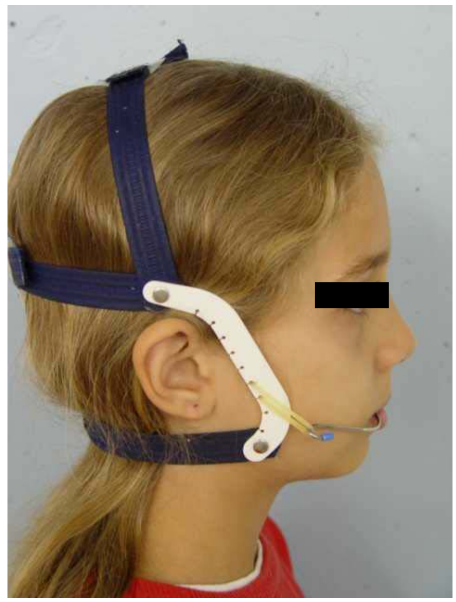

Figura 12- AEB de tração occipital, vista lateral.

ANEXOS

ANEXO 1

Certificado do Comitê de Ética em Pesquisa da FOP/UNICAMP

UNICAMP

COMITÊ DE ÉTICA EM PESQUISA

UNIVERSIDADE ESTADUAL DE CAMPINAS

FACULDADE DE ODONTOLOGIA DE PIRACICABA

CERTIFICADO

Certificamos que o Projeto de pesquisa intitulado "Estudo eletromiográfico dos músculos masséter, temporal, suprahioideo e orbicular dos lábios em jovens com maloclusão Classe II, 1ª divisão, dentária, antes e após tratamento ortodôntico", sob o protocolo nº **147/2002**, da Pesquisadora ***Meire Alves de Sousa***, sob a responsabilidade da Profa. Dra. **Vânia Célia Vieira de Siqueira**, está de acordo com a Resolução 196/96 do Conselho Nacional de Saúde/MS, de 10/10/96, tendo sido aprovado pelo Comitê de Ética em Pesquisa – FOP.

Piracicaba, 10 de março de 2003

We certify that the research project with title "Electromyographic study of the masseter, temporal, suprahyoid and orbicular oris muscles in young people with Class II, Division 1 dental malocclusion, before and after orthodontic treatment", protocol nº **147/2002**, by Researcher ***Meire Alves de Sousa***, responsibility by Prof. Dr. **Vânia Célia Vieira de Siqueira**, is in agreement with the Resolution 196/96 from National Committee of Health/Health Department (BR) and was approved by the Ethical Committee in Research at the Piracicaba Dentistry School/UNICAMP (State University of Campinas).

Piracicaba, SP, Brazil, March 10 2003

Prof. Dr. Pedro Luiz Rosalen
Secretário
CEP/FOP/UNICAMP

Prof. Dr. Antonio Bento Alves de Moraes
Coordenador
CEP/FOP/UNICAMP

ANEXO 2

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Nome do voluntário: ....

Nome do responsável: ....

Endereço: ....

Telefone: ....

Cidade: .... Estado: .... CEP: ....

As informações contidas neste prontuário foram fornecidas pela cirurgiã-dentista ***Meire Alves de Sousa*** (mestranda em ortodontia da FOP-UNICAMP) e Prof^a ***Dr^a Vânia Célia Vieira de Siqueira*** (orientadora), objetivando firmar acordo escrito mediante o qual, o responsável pelo voluntário da pesquisa autoriza sua participação com pleno conhecimento da natureza dos procedimentos a que se submeterá, com a capacidade de livre arbítrio e sem qualquer coação.

1- ***Título do experimento:*** ESTUDO ELETROMIOGRÁFICO DOS MÚSCULOS MASSÉTER, TEMPORAL E ORBICULAR DA BOCA EM JOVENS COM MALOCLUSÃO CLASSE II, 1ª DIVISÃO, DENTÁRIA, ANTES E APÓS TRATAMENTO ORTODÔNTICO.

2- ***Objetivo:*** Estudar clinicamente o comportamento dos músculos da mastigação em jovens com maloclusão Classe II, 1ª divisão, dentária, antes e após tratamento ortodôntico, comparando-os aos jovens com oclusão normal.

3- ***Justificativa:*** Tendo em vista a necessidade de melhorar a compreensão da função muscular no tratamento das maloclusões, propomos este estudo.

4- ***Descrição dos procedimentos:*** serão selecionadas 50 jovens voluntárias da rede pública de ensino da cidade de Piracicaba, sendo 25 com oclusão normal e 25 com maloclusão Classe II, 1ª divisão dentária. Inicialmente será registrada a atividade eletromiográfica dos músculos masséter, temporal e orbicular da boca, de todas as jovens, através de eletrodos superficiais colocados sobre a pele. A seguir, as jovens com maloclusão serão tratadas com aparelho extra-bucal removível e submetidas a novo registro eletromiográfico dos mesmos músculos.

5- ***Desconforto ou riscos esperados:*** Para o registro eletromiográfico serão utilizados eletrodos de superfície, colocados sobre a pele, o que não causa nenhum desconforto. Para o tratamento das maloclusões, será utilizada terapia rotineira em ortodontia. Esta pesquisa não envolve nenhum risco ao paciente.

6- ***Benefícios esperados:*** Melhor compreensão da dinâmica dos músculos da mastigação, o que poderá nos auxiliar no tratamento das maloclusões. As jovens selecionadas com maloclusão terão acesso a tratamento ortodôntico gratuito e de qualidade; as jovens com oclusão normal terão garantidas o controle de seu crescimento craniofacial na FOP-UNICAMP.

7- ***Forma de acompanhamento e assistência:*** Todos os procedimentos descritos serão realizados pelos pesquisadores, assim como a supervisão da saúde bucal dos voluntários. Assegura-se aos mesmos, encaminhamento para tratamento na FOP-UNICAMP, em caso de possíveis lesões de cáries ou qualquer outro tipo de lesões bucais.

Os voluntários deverão sempre vir acompanhados por um responsável maior de 18 anos de idade. Caso ocorra necessidade de esclarecimentos, os pais ou responsáveis poderão entrar em contato com a pesquisadora e/ou orientadora do estudo, através do telefone deixado no final deste termo.

8- ***Informações:*** O voluntário e/ou seu responsável tem garantia que receberá respostas a qualquer pergunta ou esclarecimento de qualquer dúvida quanto aos assuntos relacionados à pesquisa. Também os pesquisadores supracitados assumem o compromisso de proporcionar informações atualizadas obtidas durante o estudo.

9- ***Retirada do consentimento***: O responsável pelo menor tem a liberdade de retirar o seu consentimento a qualquer momento e deixar de participar do estudo, sem penalização alguma e sem prejuízo a seu cuidado.

10- ***Confidencialidade:*** Os voluntários terão direito a privacidade. A identidade do participante não será divulgada. Porém os responsáveis assinarão o termo de consentimento para que os resultados obtidos possam ser apresentados em congressos ou em publicações.

11- ***Formas de ressarcimento:*** As despesas com o tratamento ortodôntico, inclusive a confecção dos aparelhos ortodônticos, assim como as despesas com transporte dos voluntários e acompanhantes, serão de responsabilidade dos pesquisadores.

13- ***Quanto à indenização:*** Não existem danos previsíveis decorrentes desta pesquisa. Entretanto os pesquisadores se responsabilizam por qualquer dano físico ou moral que os voluntários venham a ter decorrentes da participação na mesma, garantindo assim que qualquer prejuízo será arcado pelos pesquisadores e a indenização se fará na forma da lei.

Local da pesquisa: FOP-UNICAMP, localizada à Av. Limeira, 901, bairro Areião – CEP: 13.441-900 – Piracicaba – SP. Fone: (19) 3412 5288.

Eu____

responsável pelo menor ____, certifico que, tendo lido as informações acima e suficientemente esclarecido (a) de todos os itens, estou plenamente de acordo com a realização do experimento. Assim, eu autorizo a execução do trabalho de pesquisa exposto acima.

Piracicaba, _____ de __________________ de 2003.

ASSINATURA____RG: ___________

ATENÇÃO: A sua participação em qualquer tipo de pesquisa é voluntária. Em caso de dúvida quanto aos seus direitos, escreva para o Comitê de Ética em Pesquisa da FOP-UNICAMP. Endereço - Av. Limeira, 901 - CEP/FOP - 13414-900 - Piracicaba - SP.

ANEXO 3

FICHA CLÍNICA

FACULDADE DE ODONTOLOGIA DE PIRACICABA – UNICAMP

Pós-graduação de Ortodontia – Mestrado

Número da ficha: ________

Identificação:

Nome:____ Sexo: ______________________

Endereço:____ Bairro:_____________________

Cidade:____ Estado: ______ Telefone: ____________________

Data de nascimento:___/___/___ Idade:__________ Local de nascimento: _________________________

Escola: ____

Série: _________ Turma: ______________ Sala: _______________ Turno:______________________

Filiação: Pai: ____ Local nasc: ___________________

Mãe: ____ Local nasc: ___________________

Exame Clínico:

Relação dos primeiros molares permanentes: __________ direito : ___________________________

esquerdo: _________________________

Relação dos caninos permanentes: ___________________ direito: ___________________________

esquerdo: _________________________

Relação dos caninos decíduos: _______________________ direito: ___________________________

esquerdo: _________________________

Relação dos incisivos: ____________________________ trespasse vertical: ___________________

trespasse horizontal: _________________