CASE REPORT

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Analysis of changes in electromyographic masticatory muscle activity in relation to the selected correction of refractive error

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Abstract

Wearing glasses is safe, effective, and the most popular method in correcting myopia. The study aimed to analyze the changes in electromyographic activity of the masticatory muscles about the selected correction of refractive error. Two muscle pairs were analyzed: the anterior part of the temporalis muszle and the superficial part of the masseter muscle. The patient was fitted with 20/200, 20/40 20/20, 20/10 corrections of refractive terror, and during each correction of refractive error, the changes in the recording of bioelectrical activity during rest, during maximal voluntary clenching, during maximal voluntary clenching on dental rollers were analyzed. With greater correction of refractive error, resting temporal muscle activity increases. Appropriate correction of refractive error may be an option in the treatment of masticatory muscle pathology. This phenomenon requires further research.

Keyw ords

electromyography, vision, myopia, masticatory muscles, optometry, correction of refractive error, eyeglasses

INTRODUCTION

Probably as far back as 5000 BC, even before rock was used to make sapphires, semi-precious stones were the prototype for eyeglasses [1]. In 54 AD, Pliny recorded an instance of Nero wearing a gemstone lens attached to a ring on his thumb. In the 11th century, stone became more popular as an aid to reading [1], and the earliest recommendation on the use of lenses for optical purposes was recorded in 1268 by Roger Bacon [1]. An analysis of the historical literature indicates that information about eyeglasses appeared in Chinese and European literature at about the same time. In 1907, Berthold Laufer speculated that India was the country of originof eyeglasses [2]. It is difficult to indicate where they were first invented and the identity of their creator. Glasses play an important role in the correction of refractive error and have become an integral part of ophthalmology and optometry.

Myopia (near-sightedness) is a common refractive error, but its causes and rapid elevation in society are still unknown [3, 4]. It is estimated that by the end of the first half of the 21st century, there will be 4.8 billion people with nea-sightedness globally [5]. In this condition, light rays are focused in front of the retina instead of on it, and could be caused by an abnormal elongation of an eyeball, or less often by a cornea that is too steeply curved. This results in the blurring of objects when viewed from a distance [6]. In myopia, two limits were adopted, a threshold value equal to the refractive error of error ≤ −0.50 diopters (D), with the limit of high myopia defined as ≤ −6.00 D in either eye [3]. Myopia can develop most prominently in childhood and early adulthood [6]. High myopia is associated with serious health problems, such as cataracts, open-angle glaucoma and retinal detachment [7, 8]. These conditions associated with high myopia can lead to permanent visual disability. Myopia is most often corrected with glasses and contact lenses [7]. Wearing glasses is safe, effective and the most popular method in correcting near-sightedness [9]. The results of a recent meta-analysis (2021) suggest that myopic eyes that are fully corrected with non-cycloplegic refraction with a maximum plus sphere are less likely to progress to myopia, compared with those that were undercorrected [10].

The results of several studies suggest an effect of visual impairment on the alteration of the bioelectrical activity of the masticatory and cervical muscles in myopic patients [11, 12]. This phenomenon, despite numerous reports, has not been fully investigated. Increased bioelectrical activity may predispose to temporomandibular disorders (TMDs) [13], which are conditions related to the masticatory muscles, temporomandibular joints, and surrounding tissues [14]. They are characterized mainly by joint and/or muscle pain, auditory manifestations in the temporomandibular joints, and limited mandibular mobility. They are primarily

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characterized by joint and/or muscle pain, crepitations and crackles in the temporomandibular joints, and limited mandibular mobility [15]. TMDs is a serious problem affecting the quality of life, and has been identified as the third most common dental disease [16]. TMDs is estimated to affect more women than men, with an estimated prevalence of 5 to 12% in the community [17]. TMDs are associated with headaches and tinnitus [18–20].

The study aimed to analyze changes in electromyographic activity of the masticatory muscles in relation to the selected correction of refractive error.

MATERIALS AND METHOD

One healthy male aged 25 years was invited to the study. The subject did not have any neurological disorder, musculoskeletal disease, cancer or head and neck injuries over a 5-year period. The participant was diagnosed for myopia 18 years ago. The subject has been informed of the purposes of the study and the opportunity to withdraw at any time and gave his consent to participate in writing.

The subject was examined by a stomatologist, Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) examination. TMDs was not demonstrated. The subject's occlusion was assessed which showed four arch support zones, comprehensive dentition, Angle class I.

Subsequently, an ocular examination was performed by an ophthalmologist, which incuded: visual acuity (VA), keratometry, refraction, axial length assessment of anterior and posterior segment of both eyes. A slit lamp was used to evaluate the knob structures. No changes were found. The topcon KR-800 autokeratorefractometer test (Topcon Co., Tokyo, Japan) and a study at the Snellen chart. The subject was assessed to have a best corrected visual acuity of -5.5 D in the right eye and -4.5 D in the left eye. The patient was diagnosed with axial myopia. Based on the IOL Master 500 (Carl Zeiss Meditec, Jena, Germany) study, the axial length of the eyeball was 25.19 mm for the right eye and 25.06 mm for the left eye. Intraocular pressure was normal. Tonopen (Reichert, Depew, New York, USA) testing was performed and 15mm Hg was found in the right eye and the left eye.

A physiotherapeutic examination was performed to exclude any injuries and myofascial trigger points in the masticatory and cervical muscles. The patient also had no history of trauma or surgical intervention in the past five years.

Study Protocol – Ophthalmological Examination. The Snellen chart is used to test visual acuity and is the most commonly used tool in clinical practice to test visual acuity [21, 22]. It was therefore selected for this study. The correct vision value is 20/20.

In the fraction shown, the numerator means the distance the subject stands from the board. The denominator in the described fraction represents the distance from which a subject with perfect vision is still able to read the smallest value [21]. The subject was fitted with correction of refractive error for 20/200, 20/40, 20/20, 20/10. This used Trial Frame UTF 4880 glasses. The examination took place at a distance of five meters.

Surface electromyography examination. For the surface electromyography (sEMG) study, four channels of a BioEMG III electromyograph (BioResearch Associates, Inc., Milwaukee, WI, USA) were performed. The examination was performed according to standard procedure in adental chair, after cleaning the abbreviation with 90% ethanol in the morning [12, 23, 24].

Two muscle pairs were analyzed: the anterior part of the temporalis muscle (TA) and the superficial part of the masseter muscle (MM). The muscles studied were chosen because they are the largest muscles that directly affect the masticatory organ.

The electrode placement was according to the SENIAM programme [25]. The reference electrode, in accordance with previous studies, was placed in an area where there is no typical muscle tissue under the skin – the forehead [12, 23, 24]. 30 mm electrodes (SORIMEX, Torun, Poland) also used in previous studies were used for this study [12, 23, 24].

The patient was looking ahead with no objects in his field of vision. After fitting the appropriate correction of refractive error, the patient waited 20 minutes for visual adaptation while looking ahead at rest. The first recording was performed with glasses and eyes closed and without glasses and eyes closed. This was to verify possible interference flows. The samples did not different from one another ($p>0.05$). To rule out possible glass weight as a variable, the same analysis was performed with eyes closed, in glasses without lenses, compared to glasses with lenses in the 20/200, 20/40, 20/20 and 20/10 correction of refractive error. Statistical analysis showed no differences ($p>0.05$). The standard sEMG test was performed under four conditions: at rest (10 seconds), during maximal voluntary clenching of the teeth in the interdigital position (three clenches of three seconds each with two seconds between them were performed), during maximal voluntary clenching of the teeth on the dental rollers (three clenches of three seconds each with two seconds between them were performed), and during maximal mouth opening (three openings of three seconds each with two seconds between them were performed) [23]. A five-minute break was then taken and each procedure was repeated. The mean of the three measurements was included in the analysis (Fig. 1). Analysis and normalization of the sEMG signal were performed using the BioPAK Measurement System software (BioResearch Associates, Inc. Milwaukee, WI, USA). Noise was reduced by 40 dB using the Noise Buster digital filtering in the BioPAK, which automatically removes 99% of any remaining 50/60 Hz noise.

Statistical evaluation. Statistical evaluations were performed using Statistica version 13.3 (TIBCO Software Inc., Palo Alto, CA, USA). Normal distribution of the data was verified with the Shapiro-Wilk test. All values deviated from the normal distribution. The Spearman rank correlation coefficient (R, rho) was used. Spearman rho varies between -1 (perfect negative monotonic association) and +1 (perfect positive monotonic association). The Spearman rank correlation coefficient (R, rho) was used to test the relationship between the selected correction of refractive error (20/200, 20/40, 20/20, 20/10) and bioelectrical activity of TA and MM muscles. According to standard thresholds, values of 0.3 and 0.5 were used for moderate correlation, and values greater than 0.5 for high [26].

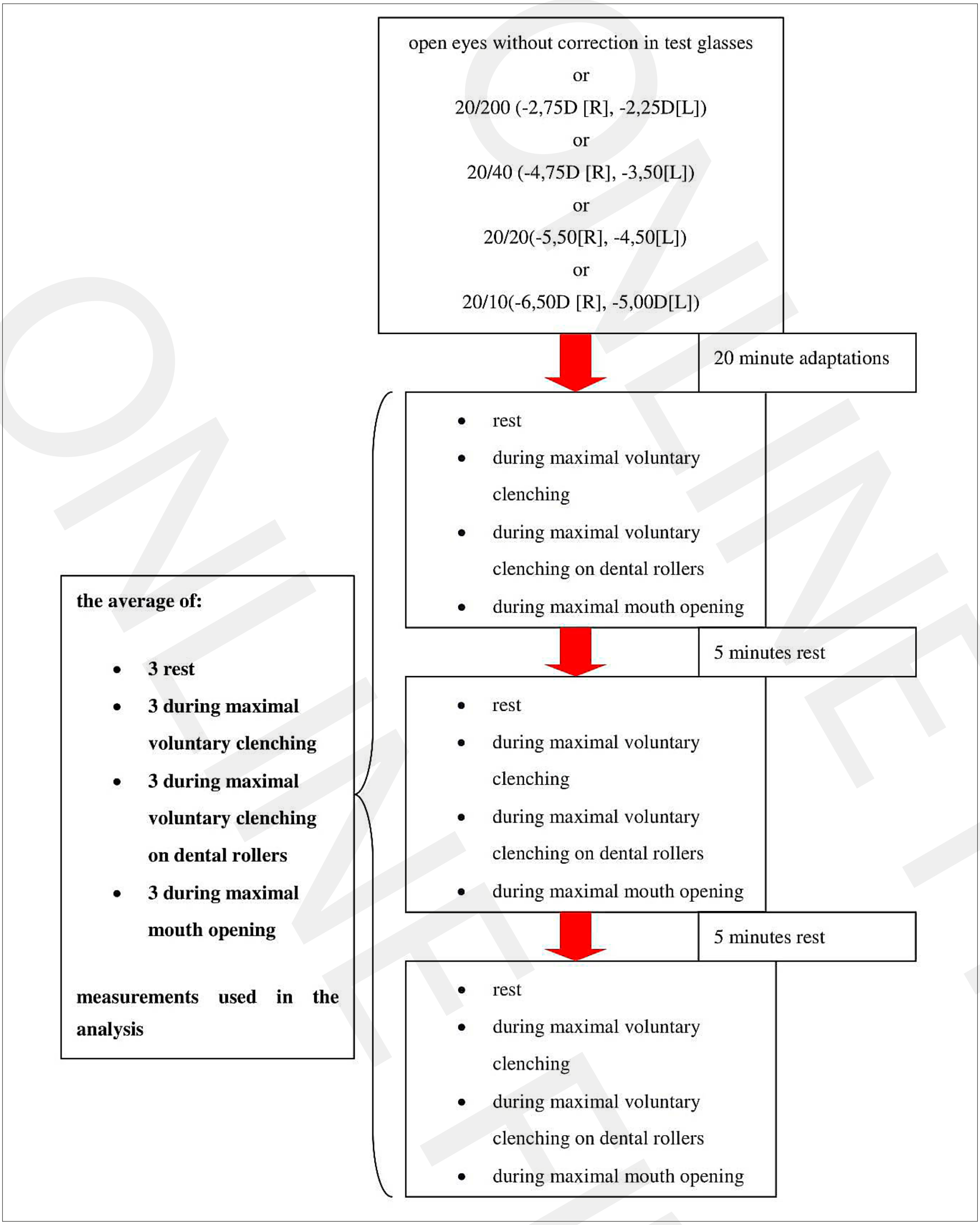

Figure 1. Study protocol. D – Diopters; R – right eye; L – left eye.

RESULTS

It was observed that as the correction of refractive error increases, there is an increase in resting activity on TA and MM (Tab. 1, Fig. 2). In clenching in the intercuspal position, it was observed that with increasing correction of refractive error there was an initial decrease and then an increase in bioelectrical activity on TA and MM. In clenching on dental cotton rollers, no major changes were observed in the mean activity of TA Mean and MM Mean (Tab. 1). At maximum mouth opening, an initial decrease and then an increase in bioelectrical activity was observed (Tab. 1).

Statistical analysis showed a positive correlation between TA-R, TA-L and SD TA at rest, a negative correlation in clenching on dental cotton rollers on TA-L, and a negative correlation in maximum mouth opening on MM-L (Tab. 2).

DISCUSSION

The main objective of this study was to analyze the correlation between the electromyographic activity of the masticatory muscles in relation to the selected correction of refractive error. The results confirmed the relationship between

Table 1. Average results obtained from the three trials.

		TA-R	TA-L	TA Mean	MM-R	MM-L	MM Mean
Rest	without correction of refractive error	0.63	0.60	0.62	1.57	1.43	1.50
	SD	0.15	0.10	0.13	1.01	0.60	0.79
	20/200	0.87	0.77	0.82	1.70	1.53	1.62
	SD	0.15	0.15	0.14	0.00	0.21	0.10
	20/40	0.73	0.70	0.72	1.97	1.47	1.72
	SD	0.06	0.10	0.08	0.31	0.35	0.33
	20/20	1.20	0.93	1.07	2.03	2.17	2.10
	SD	0.26	0.32	0.29	0.21	0.12	0.15
	20/10	1.13	0.97	1.05	2.10	1.67	1.88
	SD	0.21	0.12	0.13	0.26	0.12	0.16
Clenching in the intercuspal position	without correction of refractive error	247.50	232.50	240.00	444.13	396.63	420.38
	SD	13.96	15.42	14.64	47.55	37.44	42.42
	20/200	201.23	194.33	197.78	343.67	313.40	328.53
	SD	15.25	13.05	13.37	25.88	24.48	25.18
	20/40	248.57	234.43	241.50	440.00	406.13	423.07
	SD	19.24	19.92	19.58	48.43	38.40	43.28
	20/20	298.70	209.03	253.87	415.30	375.80	395.55
	SD	62.79	13.82	37.70	32.76	43.68	38.19
	20/10	228.03	203.33	215.68	434.77	408.20	421.48
	SD	20.92	27.74	23.77	8.57	17.68	12.51
Clenching on dental cotton rollers	without correction of refractive error	231.13	225.70	228.42	432.30	409.03	420.67
	SD	17.48	9.21	12.82	22.06	31.06	25.02
	20/200	208.07	213.23	210.65	416.53	397.47	407.00
	SD	37.93	23.56	30.66	92.67	72.90	81.69
	20/40	245.37	204.97	225.17	471.43	457.63	464.53
	SD	21.26	10.85	5.24	40.91	22.17	31.54
	20/20	281.77	186.13	233.95	439.27	407.77	423.52
	SD	53.60	19.05	25.68	39.28	21.75	30.11
	20/10	196.20	166.77	181.48	419.00	400.70	409.85
	SD	10.61	5.63	7.08	14.98	16.11	15.21
Maximum mouth opening	without correction of refractive error	5.67	6.20	5.93	6.90	15.57	11.23
	SD	1.94	3.24	2.59	2.88	2.95	2.85
	20/200	3.17	2.60	2.88	4.07	10.87	7.47
	SD	0.64	0.62	0.63	0.64	0.31	0.46
	20/40	3.33	3.13	3.23	4.63	9.33	6.98
	SD	0.35	0.92	0.63	0.59	2.92	1.75
	20/20	4.00	3.60	3.80	4.83	10.50	7.67
	SD	0.69	0.56	0.59	0.31	2.00	1.09
	20/10	3.60	4.00	3.80	5.30	9.13	7.22
	SD	0.61	0.89	0.74	0.82	1.68	1.24

TA - temporalis anterior; MM - superficial part of the masseter muscle; R - right side; L - left side.

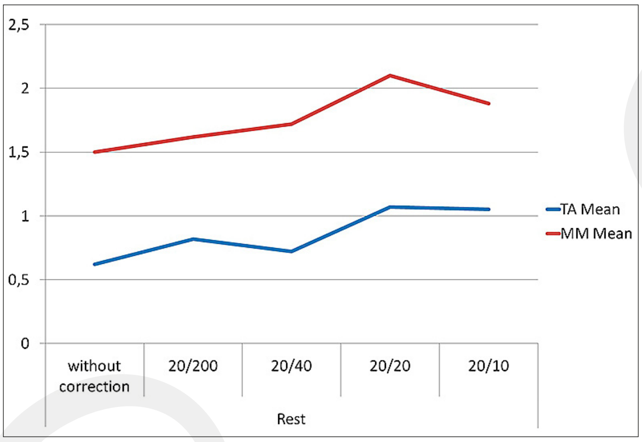

Figure 2. Average TA and MM bioelectrical activity at rest

Table 2. Results of statistical analysis

		Spearman R	t(N-2)	p
Rest	TA - R	0.73	3.88	**0.00***
	TA - L	0.70	3.54	**0.00***
	TA Mean	0.88	4.05	**0.00***
	MM - R	0.45	1.84	0.09
	MM - L	0.43	1.69	0.11
	MM Mean	0.41	1.60	0.13
Clenching in intercuspal position	TA - R	0.04	0.16	0.88
	TA - L	-0.16	-0.58	0.57
	TA Mean	0.09	0.32	0.76
	MM - R	0.62	0.22	0.83
	MM - L	0.22	0.80	0.44
	MM Mean	0.13	0.46	0.65
Clenching on dental cotton rollers	TA - R	-0.16	-0.57	0.57
	TA - L	-0.84	-5.57	**0.00***
	TA Mean	-0.36	-1.38	0.19
	MM - R	-0.13	-0.46	0.65
	MM - L	0.00	0.01	0.66
	MM Mean	-0.12	-0.45	066
Maximum mouth opening	TA - R	-0.23	-0.86	0.41
	TA - L	-0.04	-0.16	0.88
	TA Mean	-0.11	-0.39	0.71
	MM - R	0.00	0.00	0.99
	MM - L	-0.67	-3.24	**0.01***
	MM Mean	-0.47	-1.94	0.08

T - temporalis anterior; MM - the superficial part of the masseter muscle; R - right side; L - left side; * Significant difference.

the power of correction and the change in activity of the masticatory muscles. A highly significant positive correlation occurred at rest on the temporalis anterior muscles. Negative correction on temporalis anterior and masseter muscles was also noticed during functional activity.

The results obtained confirm the observations of previous authors on the connections between the organ of vision and the stomatognathic system [11, 12, 27]. Undoubtedly, this is a phenomenon that requires further study from an anatomical, biomechanical, and physiological point of view. The results of the obtained correlation suggest a neurological connection between the systems. There was no analyzed change in the visual input in the form of open and closed eyes, as occurred in other studies [11, 12, 27]. This helps to rule out changes in the myofascial network. Due to the fact that this was a case study, anthropometric changes in eyeball length can also be excluded. Based on the above discussion, it can be assumed that the changes are related to the nervous system.

The neurological connection between the stomatognathic and ocular systems will focus primarily on the vestibulo-ocular reflex (VOR). This reflex keeps us balanced, even if our eyes and head are constantly moving. When we make a head movement, our eye muscles are immediately activated to produce an eye movement opposite to the head movement at exactly the same speed [28]. It is worth noting that information is processed by three sources: the visual system through the eyes, proprioceptive receptors and, vestibular receptors in the inner ear. The vestibular complex receives afferent information from other parts of the central nervous system, e.g. the reticular formation, parts of midbrain nuclei, cerebellum, and especially from the spinal cord [29]. The reticular formation receives many direct and indirect afferent stimuli from cutaneous, vestibular, trigeminal, proprioceptive, auditory, and autonomic neurons [29]. The reticular formation also plays an important role in gaze, head movements, and coordination of saccadic movements [30]. It is worth noting here that trigeminal neurons project directly into the reticular formation nuclei and exhibit a response to afferent stimuli through reflex movement. Stimulation of the reticular formation nuclei can cause increased muscle tone and muscle contractions e.g. causing facial and neck muscle tremors [31]. The sensory nuclei of the trigeminal nerve are so large that they mediate the impulses of all cranial nerves [29]. This may explain the correlations obtained.

The practical aspect of the obtained results concernsa possible cooperation between ophthalmology, dentistry, optometry, and physiotherapy specialists in terms of therapy and treatment of people with e.g. TMDs and myopia. People with refractive error are more likely to experience headaches [32, 33]. A study by Lajmi et al. notes that therapy based on the management of risk factors, including a healthy lifestyle and appropriate correction of refractive error, is important in the treatment of headaches [33]. The correlation results implicate the effect of correction of refractive error on changes in muscle activity, which is an important relationship in headache therapy. However, this phenomenon requires further research.

Limitations of the study. The present study has several limitations. The first is an analysis of only one male participant. Subsequent studies should be conducted on a larger number of genetically diverse individuals. Secondly, the subject was healthy, without any dysfunction within the stomatognathic system; therefore, to verify the possible connection between the organ of vision and the somatogenic system, the study should be repeated on subjects with TMDs.

CONCLUSIONS

Correction of refractive error is particularly important in the resting activity of the temporalis anterior muscles. Appropriate correction of refractive error may be an option in the treatment of masticatory muscle pathology. This phenomenon requires further research.

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