Psychiatr. Pol. 2021; 55(3): 607–620
PL ISSN 0033-2674 (PRINT), ISSN 2391-5854 (ONLINE)
www.psychiatriapolska.pl
DOI: https://doi.org/10.12740/PP/OnlineFirst/110478

Electromyographic activity analysis of temporal and masseter muscles in psychoactive substance addicts

Adam Nowicki[1], Karolina Korwin-Piotrowska[2], Krzysztof Woźniak[3], Liliana Szyszka-Sommerfeld[3], Katarzyna Nowicka[1], Katarzyna Grocholewicz[4], Ewa Sobolewska[5]

[1] "Diamante Clinica" Dental Clinic in Lubin

[2] Individual Public Healthcare Center "ZDROJE", Clinic for People Addicted to Psychoactive Substances

[3] Pomeranian Medical University in Szczecin, Chair of Orthodontics, Department of Orthodontics

[4] Pomeranian Medical University in Szczecin, Chair of Prosthetic and Integrated Dentistry, Department of Integrated Dentistry

[5] Pomeranian Medical University in Szczecin, Chair of Prosthetic and Integrated Dentistry, Department of Prosthetic

Summary

Aim. As part of this study, a comparative analysis of the temporal and masseter muscle electrical activity at rest and during mandible excursion positions (protrusion, laterotrusion and maximal occlusion) was performed among patients aged 21 to 68 years.

Method. Each of three groups: opioid addicts, alcohol addicts and the control group – consisted of 30 individuals (90 individuals in total, including 37 females and 53 males). Electrodes were placed on the masseter venters and mandibular movements were executed: right/left lateral, protrusion, intercuspation, rest and MVC. Then the same routine was applied to the anterior parts of temporal muscles.

Results. Based on EMG data in alcohol addicts, higher electrical activity of masseters and temporal muscles was observed during the mandible excursions, compared to the control group. In comparison of opiate addicts to healthy controls, no statistical significance was observed in electrical activity of masseter and temporal muscles.

Conclusions. On the basis of the conducted research, a conclusion can be drawn that alcohol addiction significantly affects the function of the largest muscles of the stomatognathic system.

Key words: electromyography, alcohol addiction, masticatory muscles

Introduction

In anatomy, there is an equilibrium between contraction muscles and their antagonists [1, 2]. This state can be disturbed by pathological teeth attrition, parafunctions, teeth loss, accident-caused occlusion dysfunction and by the intake of muscle tension altering substances [3]. This study analyzes psychoactive substance addicts, focusing on the occurrence of stomatognathic disorders. It also discusses the potential motor aberrations of temporal and masseter muscles on the basis of the record and analysis of their electrical activity.

Skeletal muscle dysfunctions caused by chronic alcohol intake are widely described [4–10]. One can observe loss of strength, tenderness and atrophy, and these can be accompanied by necrosis, swelling, acute inflammation, and hematomas associated with cirrhosis [11]. Despite the fact that various muscular dysfunctions are observed in individuals addicted to alcohol, one can assume that at least 50% of them suffer from myopathy [12]. Taking into consideration the information obtained from studies on animal tissue, alcohol affects membrane fluidity, reduces muscular contractility and reduces protein synthesis. Apart from the direct influence, we may also observe a decrease in the amount of hormones such as testosterone and IGF-1, which are responsible for muscular metabolism regulation [13].

Except their additive potential, opiates can cause several somatic symptoms, such as: decrease in pain reception, decrease in digestive secretion, cough center reactivity, decrease in peristalsis, blood pressure, bradycardia, bradypnea, constricted pupils and their weakened reaction to light [14]. Some of the significant somatic symptoms are stiffness of thorax, mandible and abdomen [15–17], which was pictured in the studies carried out by Vankova et al. [18]. Muscular rigidity is caused primarily by the activation of the central nervous system receptors, meanwhile opioid receptors such as $\delta 1$ and $\kappa 1$can suppress its effect.

The pharmacological treatment of patients with mental and mood disorders is based on the use of antipsychotics and antidepressants. However, it is possible that such medication may cause several undesired effects, this including extra-pyramidal side effects, parkinsonism, dystonia or tardive dyskinesia [19]. There is evidence that motor disorders also affect the stomatognathic system [20]. Similarly, some of the above-mentioned symptoms may occur along with the long-term intake of psychoactive substances.

Knowledge about the muscle dysfunction scheme in individuals with psychoactive substance addiction seems essential due to the changes in force distribution in stomatognathic system during and after detoxification. The usage of noninvasive methods for medical examination such as electromyography can also ease the diagnosis of stomatognathic dysfunctions in non-addicted patients with the changed function of the stomatognathic muscles.

Aim

The aim of this study was to determine the changes in the electrical activity of mastication muscles in individuals with psychoactive substance intake.

Material

The study of muscle activity was carried out in a group of patients aged 21–68, staying at the Individual Public Healthcare Center "Zdroje" in Szczecin, addicted to opiates (30 people; group O) and alcohol (30 people; group A). The control group consisted of 30 healthy people (group C). In total 90 people participated in the study, including 37 women and 53 men. The participants were fully informed about the study. This study was approved by the Research Ethics Committee of Pomeranian Medical University in Szczecin (KB-0012/28/15). Detailed data on the studied groups are presented in Tables 1–3.

Muscle tension analysis tests were carried out at the Individual Public Healthcare Center "Zdroje" in the psychoactive drug addiction therapy ward – clinic N and alcohol addiction treatment ward – clinic A. The tests were carried out in outpatient rooms.

Exclusion criteria included: no teeth in the support areas, the presence of removable prosthetic restorations or functional disorders in the temporomandibular joints, as well as previous orthodontic treatment.

In order to diagnose the patient, a two-part study was carried out: a medical questionnaire and a physical examination. Data collected by the questionnaire are presented in Tables 1–3. The examined patients had a history of treatment and a diagnosis of addiction syndrome, therefore the medical questionnaire was modified in terms of the study profile. The questions concerned the current health condition: past diseases, injuries and surgical procedures. It also included questions defined on the basis of ICD-10, aimed at obtaining a subjective opinion of the patient about his/her addiction.

Table 1. **Group A**

No.	Age	Sex	ICD10 (max. 6)	Alcohol	Pure ethanol quantity (g)/frequency
1	51	M	0	beer, vodka	224 g x 5 days a week
2	49	W	5	beer, vodka, wine	320 g x 7days a week
3	60	M	3	beer, vodka	
4	28	M	5	beer, vodka, wine	180 g x 6days a week
5	36	M	6	beer, vodka, wine	224 g x 7 days a week
6	62	W	6	beer, vodka, wine	180 g x 5 days a week
7	33	M	0	vodka	160 g x 5 days a week
8	66	M	0	vodka	
9	25	W	0	beer, vodka, wine	

table continued on the next page

10	48	M	3	beer	54 g x 2 days a week
11	39	W	5	beer	x 7 days a week
12	28	M	6	whiskey	
13	27	W	2	beer, wine	
14	38	M	5	beer, vodka	144 g x 5 days a week
15	30	M	6	beer, vodka	
16	50	M	0	beer	184 g x 2 days a week
17	40	W	1	beer	x 5 days a week
18	50	M	6	vodka	224 g x 7 days a week
19	47	M	2	beer	
20	34	M	6	beer, vodka	320 g x 5 days a week
21	67	M	0	beer	
22	30	M	4	beer	144 g x 7 days a week
23	50	M	0	beer, vodka	54 g x 7 days a week
24	30	W	6	beer, vodka, wine	480 g x 7 days a week
25	37	W	2	beer, vodka	
26	41	W	5	vodka	160 g x 7 days a week
27	60	W	5	beer, vodka, wine	224 g x 7 days a week
28	48	W	0	beer, vodka	160 g x 7 days a week
29	23	M	6	beer, vodka, wine	72 g x 5 days a week
30	66	M	5	beer, vodka	160 g x 7 days a week

Table 2. **Group O**

No.	Age	Sex	ICD10 (max. 6)	Prescribed drug	Substance
1	58	M	6	metformex, methadone	
2	40	M	5	methadone	
3	35	M	6	methadone	morphine, oxycodone
4	60	M	6	methadone	
5	60	M	3	methadone	
6	23	M	0	methadone	
7	38	M	6	methadone	heroin
8	44	W	6	methadone	neurotop, clonazepam
9	53	M	6	methadone	heroin, amphet, barbiturate
10	39	W	1	methadone	lerivon
11	53	W	1	methadone	clonazepam

table continued on the next page

12	34	W	0	methadone	
13	41	M	6	methadone	alcohol, tramadol
14	21	M	3	methadone	opiates
15	38	M	6	methadone	
16	34	M	0	methadone	
17	46	M	0	methadone	baclofen, ketrel
18	35	W	0	methadone	propanolol, cezarius
19	38	W	6	methadone	promazine
20	41	M	6	methadone	promazine
21	22	M	6	methadone	
22	36	M	6	methadone	clonazepam
23	51	M	6	methadone	
24	38	M	4	methadone	clonazepam
25	68	W	0	methadone	amitriptyline
26	41	M	6	methadone	
27	38	M	4	methadone	
28	36	M	5	methadone	
29	32	W	5	methadone	clonazepam, relanium
30	65	M	2	methadone	

Table 3. **Healthy controls**

No.	Age	Sex
1	26	M
2	57	M
3	52	W
4	17	W
5	56	W
6	59	M
7	35	W
8	25	W
9	28	M
10	25	W
11	25	W
12	25	W
13	24	M

table continued on the next page

14	24	W
15	24	W
16	27	M
17	25	W
18	25	W
19	25	W
20	24	M
21	25	M
22	24	W
23	25	W
24	16	W
25	25	W
26	29	M
27	25	W
28	29	M
29	29	M
30	27	M

Method

After anamnesis, each patient underwent clinical examination. This consisted of: facial nerve examination, temporomandibular joint examination, evaluation of parafunctions, confirmation of the lack of extensive prosthetic restorations and orthodontic treatment, occlusion diagnostics and dental charting, as well as electromyography. The intraoral examination included assessment of the condition of oral structures and tissues, assessment of contacts in support areas (molars and premolars), examination of the temporomandibular joint, lack of extensive fixed and removable prosthetic restorations, as well as the lack of orthodontic treatment.

Electromyography was carried out using the Zebris EMG-8 Bluetooth device (Zebris, Medical GmbH, Germany). The surface electrodes were placed on the ventral portions of masseters, then the EMG signal was recorded during rest and other clinical conditions such as protrusion, right and left laterality, occlusion, and maximal voluntary contraction. Next, the electrodes were placed on the front portions of temporal muscles, and all the movements were being mimicked. Electromyography was unified for all the groups [21]. Separate examination of masseters and temporal muscles was necessary due to the clinical condition of the individuals, which manifested by tearing the electrodes off, even despite the introduction of additional adhesive methods. Reducing the one-time number of electrodes ensured accuracy and repeatability of performed movements.

Before starting electromyography, the skin at the points of contact with the electrodes was degreased with an alcohol-based agent (Kodan®, tinktur forte, Schülke). This procedure was used in control patients and opiate addicts, while alcohol addicts did not undergo alcohol degreasing for fear of patient decompensation.

Four channels of the Zebris device were used with simultaneous acquisition for the EMG recording, common grounding to all channels, low-pass filter of 7 Hz – 5 kHz, channel impedance of 10 E + 12 Ω, 12 bytes of dynamic resolution range and channel sampling frequency of 1 kHz. 20 x 25 mm silver chloride surface electrodes glued in a 10 mm distance (20 mm distance between electrode center points) were used.

The proper preparation of skin surface was monitored by the measurement of impedance on clamp pegs of active electrode pairs after their placement on the skin, onto the muscle tendons. The measurement was carried out using the Excel DT9205A multimeter (Excel Instruments, China), with 2% accuracy in a 4×10^2–4×10^3 Ω range. The impendency of skin, targeting 1×10^3–30×10^3, was a condition which had to be met in order to initiate the examination. The order of connecting the electrodes was the same in all the patients – first to the central unit and then to the electrodes. After drying the skin, surface active electrodes were placed on the patient's skin in the region of the ventral portion of both masseters, as well as in the region of the anterior portion of both temporal muscles [22]. A single reference electrode was placed below the mastoid process.

The EMG analysis of signals was performed using the WinJaw software V10.6.50 (Zebris, Medical GmbH, Germany). Most of the EMG signals were used in such a way so as to obtain the EMG amplitude value by calculating the arithmetic mean and standard deviation (data presented in Tables 4 and 5).

The normalization of measurements by referring its results to the electrical activity of the muscles obtained in the maximum voluntary contraction (MVC) was used in the quantitative analysis. Normalization was the basic tool for the statistical analysis. The performance of the normalization process as a means of initial data processing enabled comparison and further analysis. Reference values were set for each muscle separately during the maximal voluntary contraction (MVC). This was performed in sitting position by clenching the teeth with cotton rolls between the premolars on both sides.

Statistical analysis

The nonparametric tests of the statistical analysis have been performed with the application of the Statistica software (StatSoft Polska). The applied descriptive statistics has taken into consideration mean values, standard deviations and the minimum and maximum values for each of the variables. The obtained values have been compared by performing tests of significance for the mean, illustrating the level of the significance of the research. The level of significance was set at $p < 0.05$. There is a sample available in the analysis and, owing to the known value of the location or spread, it is possible to transfer the data onto the population. The authentication of data has been performed through the significance tests. The procedure consists of specific steps: a detailed question is asked regarding the currently researched phenomenon in reference to the differences in the results obtained from the alcohol – or opiate-addicted patients in the spectrum of the results characterizing the control group. The statement which testifies the significant value of the mean amongst the people from the research group has been marked as H1. An insignificant difference has been marked as H0. Subsequently, a bracket has been made in which a given test parameter should be included. In order to achieve this, the significance level needed to be determined. Determining the significance is the acceptation of an analogical digression falling into contradiction with our research consensus. In the progress of the research, it has been assumed that $\alpha = 0.05$, which means getting a higher mean which would be statistically significant. Selecting an alpha allows to create brackets after reading its value from the statistical tables. In the described research, this bracket was $(1.64, +\infty)$. The difference assessment criterion has been chosen. Depending on the obtained value, the criterion was accepted and the difference in means is statistically significant in a positive or negative manner. Statistical significance allows to generalize the research with regard to the entire population. If the *Z* selection criterion is within the significance bracket, it is assumed that the mean amongst the people from the statistically analyzed group differs from the mean set for the people from the control group, and the research can be generalized onto the entire population. However, if the *Z* assessment criterion is not within the bracket – we assume that the mean value is not statistically significant.

Results

Electromyographic data are shown in Tables 4 and 5.

Table 4. **Statistical analysis: group A**

Jaw movement	Rest				Left laterality				Right laterality				Protrusion			
Muscle	RT	LT	RM	LM	RT	LT	RM	LM	RT	LT	RM	LM	RT	LT	RM	LM
Mean [%]	37.13	35.46	18.91	29.55	31.17	117.37	99.39	46.56	94.73	38.71	37.33	76.83	59.17	78.71	68.05	84.21
Control group mean [%]	8.86	9.18	22.19	15.48	14.61	45.40	90.78	30.03	36.46	16.16	35.51	68.79	22.24	30.58	74.72	76.00
H1 hypothesis verification	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES	NO	NO	YES	YES	NO	NO

RT – right temporal; LT – left temporal; RM – right masseter; LM – left masseter;

Table 5. **Statistical analysis: group O**

Jaw movement	Rest				Left laterality				Right laterality				Protrusion			
Muscle	RT	LT	RM	LM	RT	LT	RM	LM	RT	LT	RM	LM	RT	LT	RM	LM
Mean [%]	17.92	17.23	16.90	20.12	19.46	75.49	94.11	27.95	55.33	19.42	34.59	86.98	29.16	33.16	120.28	90.09
Control group mean [%]	8.86	9.18	22.19	15.19	14.61	45.40	90.78	30.03	36.46	16.16	35.51	68.79	22.24	30.58	74.72	76.00
H1 hypothesis verification	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

RT – right temporal; LT – left temporal; RM – right masseter; LM – left masseter;

Muscles at rest

Increased electromyographic activity was observed among volunteers from group A in relation to the control group with the exception of the right masseter (RM). The activity of the other muscles was statistically significant which allowed generalization of local conclusions and their application to other representatives of the population. In group O, the increased electromyographic activity of both temporal muscles was statistically significant.

Protrusion

Increased EMG activity was observed among all muscle groups in group A with the exception of RM, however, only the activity of temporal muscles was statistically significant. In volunteers from group O, the average electromyographic activity was higher for all muscles (lower for temporal muscles and higher for masseter muscles in comparison to the counterparts in group A), however, it was not statistically significant.

Right laterality

Both of the test groups indicated higher electromyographic activity (A > O, excluding the left masseter, also in group O the activity of right masseter was lower than in the control group patients) consistent with the contraction pattern. For group A, the statistically significant value was the EMG activity of both temporal muscles, and for group O, there was no statistical significance.

Left laterality

During this movement, both of the patient groups have indicated hyperactivity (A > O, in group O the activity of right masseter was lower than in the control group) consistent with the contraction pattern. For group A, the statistically significant value was the activity of both temporal muscles and the left masseter. For group O, no statistically significant values were observed.

Discussion

The analysis of the results of electromyography of masseter and temporal muscles was performed in accordance with the assumptions of the presented work. It was observed that there was an increase in the activity of stomatognathic muscles of both study groups in relation to the control group.

The research hypothesis concerning alcohol addicts was positively verified, the obtained results confirmed a statistically significant change in muscle function in people from this group. It is a common fact that increased muscle tension (often of psychogenic etiology) can directly cause dysfunction of the stomatognathic system [23–26]. On the basis of the conducted research, it can be assumed that chronic alcohol intake may significantly increase the electrical activity of temporal and masseter muscles, despite the unknown mechanism of the influence of alcohol on muscles [13], and as a consequence can lead to dysfunction of the stomatognathic system.

To our knowledge, there are no studies demonstrating the influence of alcohol and opiates intake on masticatory muscles which can be found in the literature. Taking this into consideration, it is virtually impossible to discuss our own results with other authors.

Spontaneous electrical muscle activity is a target for many clinicians who analyze stomatognathic muscles. Studies of that kind are difficult to conduct because of inter-individual diversity and diversity of muscle activity dependent on many factors, e.g.: the time of a day [27]. Data brought up by Scopel et al. [28] reveal a physiological action asymmetry of masticatory muscles during rest.

Basing on maximal voluntary contraction values recurrence [29], it was used to normalize the values in other clinical situations.

Masticatory muscles are related to postural and excursive positions of the mandible [30]. At rest, the mandible is suspended by mutual coordination of the masticatory and depressor muscles. Analyzing muscles at rest is being carried out from the postural position determined by a 2–4 mm space between the incisors. Such position is considered neutral [31] and enables several excursive movements and so the residual muscle tension appears [32]. This situation occurs by means of myotatic reflexes, when in response to stretching the fiber, the muscle contracts [33]. It cannot be stated that muscles are inactive in such a position, as the neuromuscular tone is one of the main bone modelers [34]. Thus, electrical activity may not be visible in this phase [35–37].

During lateral movement of the mandible, a pattern of neuromuscular activation occurs as a presence of higher electrical activity of the temporal muscle on the working side and for the masseter, opposite to excursion side is more activated [38]. During protrusion, it can be observed that masseter muscles indicate a much higher EMG activity than temporal muscles [38]. The results of the electromyographic analysis were in line with the above contraction patterns. The key role of excessive fat deposit on the cheeks (around the mandibular angle) is correlated with alcoholism. These were the places where the electrodes were placed – unfortunately, the measurement of body fat, which weakens the EMG signal, was not included in this work.

The use of surface electromyography is troublesome in anatomical means. Masseters and temporal muscles are mainly used in electromyography, because a diagnostic approach can be a problem for some other muscles. Each of the muscles has its own physiological function and contraction pattern, however, contraction of one has an influence on the other muscles or groups in the stomatognathic system. The highly important issue during muscle activation study is to take inter-individual diversity into consideration [39, 40]. The cooperation with patients was good, although some inconveniences occurred resulting from the clinical and mental status. Alcohol addicts showed: muscle twitching, uncoordinated involuntary movements, trouble with focusing on a task, problems with diagnostic movement repetition and impatience. Opiate addicts treated with methadone showed: increased skin sweating and fear of being judged, on the other hand the individuals from that group were more patient and careful in performing their tasks.

Perhaps the forthcoming studies encompassing a wider sample size, a modified electrode adhesion method and taking into consideration body fat as an isolation will allow to obtain statistical significance in the group of opiate addicts, as significant changes in muscle function were observed in this group..

Conclusions

1. In individuals with alcohol addiction, higher electrical activity of masseter muscles and the anterior portion of temporal muscles was observed in comparison to the control group.
2. In individuals with opiate addiction, no statistically significant difference in electrical activity of masseter muscles and the anterior portion of temporal muscles was observed in comparison to the control group.

References

1. Miles TS. *Postural control of the human mandible*. Arch. Oral Biol. 2007; 52(4): 347–352.
2. Różyło-Kalinowska I, Jurkiewicz-Mazurek M, Czeszyk A, Łagowska-Lenard M, Lenard R. *Obrazowanie ultrasonograficzne prawidłowego i patologicznie zmienionego mięśnia żwacza*. Czas. Stomatol. 2007; 60(1): 54–60.
3. Plato G, Holtenstraβe M. *Droga do chroniczności zaburzeń czaszkowo-żuchwowych (ZCŻ)*. Manuelle Medizin. 2008; 6(46): 384–385.
4. Hed C, Lunkmark C, Fahlgren H. *Acute muscular syndrome in chronic alcoholism*. Acta Med. Scand. 1962; 171: 585–599.
5. Martin F, Ward K, Slavin G, Levi J, Peters TJ. *Alcoholic skeletal myopathy: A clinical and pathological study*. Q. J. Med. 1985; 55(218): 233–251.
6. Perkoff GT, Dioso MM, Bleisch V, Klinkerfuss G. *A spectrum of myopathy associated with alcoholism: I. Clinical and laboratory features*. Ann. Intern. Med. 1967; 67(3; Part 1): 481–492.
7. Rubin E. *Alcohol myopathy in heart and skeletal muscle*. N. Engl. J. Med. 1979; 301(1): 28–33.
8. Rubin E, Katz AM, Lieber CS, Stein EP, Puszkin S. *Muscle damage produced by chronic alcohol consumption*. Am. J. Pathol. 1976; 83(3): 499–516.
9. Saville PD, Lieber CS. *Increases in skeletal calcium and femur cortex thickness produced by undernutrition*. J. Nutr. 1965; 99(2): 141–144.
10. Song SK, Rubin E. *Ethanol produced muscle damage in human volunteers*. Science. 1972; 175(4019): 327–328.
11. Sugiyama C, Akai A, Yamakita N, Ikeda T, Yasuda K. *Muscle hematoma: A critically important complication of alcoholic liver cirrhosis*. World J. Gastroenterol. 2009; 15(35): 4457–4460.
12. Worden RE. *Pattern of muscle and nerve pathology in alcoholism*. Ann. N Y Acad. Sci. 1976; 273: 351–359.
13. Sonntag WE, Boyd RL, D’Costa A, Breese CR. *Influence of ethanol on functional and biochemical characteristics of skeletal muscle*. Drug and Alcohol Abuse Reviews, t. 2. Humana Press; 1991. P. 403–423.
14. Heinz AJ, Epstein DH, Schroeder JR, Singleton EG, Heishman SJ, Preston KL. *Heroin and cocaine craving and use during treatment: Measurement validation and potential relationships*. J. Subst. Abuse Treat. 2006; 31(4): 355–364.
15. Chang J, Fish KJ. *Acute respiratory arrest and rigidity after anesthesia with sufentanil: A case report*. Anesthesiology. 1985; 63(6): 710–711.
16. Dewhirst E, Naguib A, Tobias JD. *Chest wall rigidity in two infants after low-dose fentanyl administration*. Pediatr. Emerg. Care. 2012; 28(5): 465–458.
17. Vaughn RL, Bennett CR. *Fentanyl chest wall rigidity syndrome – A case report*. Anesth. Prog. 1981; 28(2): 50–51.
18. Vankova ME, Weinger MB, Chen DY, Bronson JB, Motis V, Koob GF. *Role of central mu, delta-1, and kappa-1 opioid receptors in opioid-induced muscle rigidity in the rat*. Anesthesiology. 1996; 85(3): 574–583.
19. Olivera de RH, Hallak JE, Siéssere S, Sousa de LG, Semprini M, Sena de MF et al. *Electromyographic analysis of masseter and temporal muscles, bite force, masticatory efficiency in medicated individuals with schizophrenia and mood disorers compared with healthy controls*. J. Oral Rehabil. 2014; 41(6): 399–408.

20. Manfredini D, Fabbi A, Peretta R, Guarda-Nardini L, Lobbezoo F. *Influence of psychological symptoms of psychological symptoms on home-recorded sleep-time masticatory muscle activity in healthy subjects*. J. Oral Rehabil. 2011; 38(12): 902–911.
21. Woźniak K, Lipski M, Lichota D, Buczkowska-Radlińska J. *Elektromiografia powierzchniowa w stomatologii: system EMG 8 – Bluetooth*. Implantoprot. 2008; 3(32): 52–55.
22. Cram JR, Kasman GS, Holtz J. *Introduction to surface electromyography*. Gaithersburg, Md.: Aspen Publishers. 1998. P. 65–75.
23. Carvalho AL, Cury AA, Garcia RC. *Prevalence of bruxism and emotional stress and the association between them in Brazilian police officers*. Braz. Oral Res. 2008; 22(1): 31–35.
24. Krywult M, Baron S, Kokot T. *Etiopatogeneza oraz epidemiologia zaburzeń układu ruchowego narządu żucia*. Twój Przegl. Stomatol. 2006; 11: 10–15.
25. Panek H, Śpikowska-Szostak J. *Wpływ stresu i cech osobowości na dysfunkcje skroniowo--żuchwowe i bruksizm na podstawie piśmiennictwa i badań własnych*. Dent. Med. Probl. 2009; 46(1): 11–16.
26. Poveda Roda R, Bagan JV, Díaz Fernández JM, Hernández Bazán S, Jiménez Soriano Y. *Review of temporomandibular joint pathology. Part I: Classification, epidemiology and risk factors*. Med. Oral Patol. Oral Cir. Bucal. 2007; 12(4): E292–298.
27. Dahlström L, Carlsson SG, Swahn SO. *Variability in electromyographic surface recordings of the human masseter muscle*. Electromyogr. Clin. Neurophysiol. 1989: 29(2): 105–108.
28. Scopel V, Alves da Costa GS, Urias D. *An electromyographic study of masseter and anterior temporalis muscles in extra-articular myogenous TMJ pain patients compared to an asymptomatic and normal population*. Cranio. 2005; 23(3): 194–203.
29. Glaros AG, Waghela R. *Psychophysiological definitions of clenching*. Cranio. 2006; 24(4): 252–257.
30. Sonnesen L, Svensson P. *Temporomandibular disorders and psychological status in adult patients with a deep bite*. Eur. J. Orthod. 2008; 30(6): 621–629.
31. Zuccolotto MC, Vitti M, Nóbilo KA, Regalo SC, Siéssere S, Bataglion C. *Electromyographic evaluation of masseter and anterior temporalis muscles in rest position of edentulous patients with temporomandibular disorders, before and after using complete dentures with sliding plates*. Gerodontology. 2007; 24(2): 105–110.
32. Miles TS. *Postural control of the human mandible*. Arch. Oral Biol. 2007; 52(4): 347–352.
33. Rancan SV, Bataglion C, Bataglion SA, Bechara OM, Semprini M, Siéssere S et al. *Acupuncture and temporomandibular disorders: A 3 month follow-up EMG study*. J. Altern. Complement. Med. 2009; 15(12): 1307–1310.
34. Rantalainen T, Sievänen H, Linnamo V, Hoffrén M, Ishikawa M, Kyröläinen H et al. *Bone rigidity to neuromuscular performance ratio in young and elderly men*. Bone. 2009; 45(5): 956–963.
35. Regalo SC, Vitti M, Semprini M, Rosa LB, Martinez FH, Santos CM et al. *Electromyographic analysis of the masseter and temporal muscles in oralized deaf individuals*. Electromyogr. Clin. Neurophysiol. 2006; 46(4): 217–222.
36. Sgobbi de Faria S, Bérzin F. *Electromyographic study of the temporal, masseter and suprahyoid muscle in mandibular rest position*. J. Oral Rehab. 1998; 25(10): 776–780.
37. Voudouris JC, Kuftinic MM. *Improved clinical use of twin-block and herbst as a result of radiating viscoelastic tissue forces on the condyle and fossa in treatment and long-term retention: Growth relativity*. Am. J. Orthod. Dentofacial Orthop. 2000; 117(3): 247–266.

38. Santos M, Vitti, Matsumotto W, Berro J, Semprini M, Hallak J et al. *Using overdenture on implants and complete dentures: Effects on postural maintenance of masticatory musculature*. Braz. J. Oral. Sci. 2008; 7(25): 1550–1554.
39. Gay T, Piecuch JF. *An electromyographic analysis of jaw movements in man*. Electromyogr. Clin. Neurophysiol. 1986; 26(5–6): 365–384.
40. Wood WW. *A review of masticatory muscle function*. J. Prosthet. Dent. 1987; 57(2): 222–232.

Address: Adam Nowicki
Diamante Clinica Dental Clinic
59-300 Lubin, Sportowa Street 48a/c
e-mail: adamusnowicki@gmail.com