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The relationship between depression, anxiety, chronic pain and pain pressure threshold of the masseter muscle in healthy young subjects. A pilot study

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Abstract

Study aim: The correlation between pain and emotional status in subjects with temporomandibular disorders (TMD) is established. Nevertheless, there is a lack of up-to-date findings based on objective assessment of pain using a digital algometer on the mastication muscles. The aim of this study was to investigate the relationship between the emotional status and the chronic pain pressure threshold (PPT).

Material and methods: Thirty-eight subjects were screened for the existence of temporomandibular disorders with the 3Q/TMD questionnaire for chronic pain (GCPS) and emotional status (PHQ-9 and GAD-7). The results were evaluated in comparison with the PPT measured with a digital algometer on the masseter muscles. Each subject was examined three times (at 1 and 7 months after the initial examination). Chronic pain scores (GCPS) were found to be higher in the TMD group in all three examination sessions ($p < 0.05$).

Results: Pain, depression and anxiety levels were higher in female subjects regardless of the existence of TMD, but only some differences were significant. A correlation between chronic orofacial pain scores and PPT was found in 2 out of 3 examination sessions.

Conclusion: The PPT scores for the masseter muscles did not correlate with the emotional state in the study group.

Key words: Pain pressure treshold – Algometry – Muscle tenderness – Temporomandibular disorders – Emotional state

Introduction

Emotions are an ever-present aspect of everyday life. The emotional state changes and is influenced by many factors such as quality of relationships, free time, professional and financial success, and health. Problems within these areas of life are clear factors contributing to the development of depression [15]. The latest literature states that anxiety disorders affect approximately 3.8–25.0% of the general population [2]. The World Health Organization (WHO) reports that depression is the fourth most serious disease in the world, affecting approximately 3.8% of the general population, and predicts that it will be at the top of this ranking by 2030. According to studies, prevalence of major depressive disorder ranges from 3.0% of the Japanese population to 16.9% in the United States [40].

Researchers most often use tools assessing anxiety and depression to describe the emotional state of a person [9]. The most popular such tools are the State-Trait Anxiety Inventory (STAI), the Hospital Anxiety and Depression Scale (HAD) [9], the Generalized Anxiety Disorder 7-item scale (GAD-7) and the Patient Health Questionnaire (PHQ-9) [29, 32]. The latter two also form part of a broader diagnostic protocol for assessing the prevalence of temporomandibular disorders, i.e. the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) [29]. It considers the physical and psycho-emotional component of the patient's health and is successfully used in many countries around the world [32].

As defined by the International Society for the Study of Pain, pain is an unpleasant, sensual, and emotional sensation related to, or described as, actual or potential tissue damage [25]. There are many categories describing pain, e.g. according to its intensity, location, or duration. The

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types of pain listed in the literature also include clinical pain and induced pain [36].

Multiple questionnaires assessing the occurrence and severity of pain in general are available: the McGill Pain Questionnaire (MPQ) [36], the visual-analogue scale (VAS scale), and the Numeric Pain Rating Scale (NPRS) [16]. Also there are more precise and widely used tools such as the Graded Chronic Pain Scale (GCPS) aimed at assessing chronic orofacial pain [19, 39].

Since the sensation of pain is subjective, clinical pain is assessed on the basis of the subjective assessment of the patient, i.e. using the VAS or NPRS scale. The induced pain is defined as caused by pressure or e.g. from contact with cold water, and can be measured using an algometer. Such a measurement still has a subjective component, but the respondent does not quantify the perception of pain, as this is performed by the researcher using specialized equipment. A widely used, relatively cheap and easy-to-use device for measuring the pain threshold is an algometer [13, 26, 37]. The pain examination using a digital algometer is based on the concept of the pain pressure threshold (PPT), which refers to a stimulus that has the lowest possible intensity and is perceived as painful [1]. Another definition, mentioned in the context of the use of an algometer, refers to the stimulus with the lowest intensity which causes the sensation to change from pressure to pain [26].

Available data show high intra-examiner reliability when using a digital algometer, which makes it a valuable diagnostic tool for scientific research [14].

According to the latest reports, 90% of Americans claim that mental health is equally important as physical health [2]. Scientific literature reports that pain is associated with emotional reactions and cognitive processes [11]. It is also emphasized that the pain stimulus itself is a source of fear [11]. In accordance with the research, people with an optimistic approach to life do not feel pain as strongly as pessimists, and are less prone to catastrophize their pain sensations [36]. Moreover, research proves that intense, negative emotions are associated with greater sensitivity to pain stimuli [31]. People with a neurotic personality have a lower pain threshold, which has been found to correlate with the occurrence of greater clinical pain [36].

In the field of orofacial pain, multiple studies have shown a higher prevalence of depression and anxiety in subjects with TMD [32]. Moreover, a strong correlation has been found between the level of pain and psycho-emotional status measured by the levels of depression and somatization (based on Axis II of the Research Diagnostic Criteria for Temporomandibular Disorders – RDC/TMD). Another very interesting conclusion is that pain level is independent from structural symptoms concerning the muscles of mastication, temporomandibular joint (TMJ) or the disc inside the TMJ (together comprising Axis I of the RDC/TMD) [8]. All these psycho-emotional factors contribute to the reduction of quality of life (QOL), affecting both the personal and professional life of subjects with TMD symptoms [4].

A literature review showed that in the past ten years only a few studies examining PPT in the TMD group have been published, and none of these have tried to compare the PPT results in the TMD group with the psycho-emotional status. Hence, it seems worthwhile to test the pain threshold in patients not only in any part of the body, for example on the phalanx, but also in the masseter or the temporal muscle, whose pain is associated with temporomandibular disorders and the patient's emotional state. The location of the tender points for the above-mentioned muscles is described in the DC/TMD diagnostic protocol [29].

Another author noted the coexistence of migraines, depression and anxiety disorders as well as the lowered pain threshold, which once again emphasizes the importance of further exploring this area of interest [3].

It is interesting that the interaction between pain and emotions is two-sided. The occurrence of pain affects the deterioration of mood and the appearance of stress, while negative emotions and a lowered emotional state seem to increase pain perception. Half of people with depression report pain [6]. At the same time, approximately 30-60% of people suffering from chronic pain suffer from depression as well [12]. Based on many articles suggesting the coexistence of pain or a lowered pain threshold with depression or anxiety disorders and stress, it seems worthwhile to deepen our knowledge on this topic by analysing this relationship in depth. Thus, the aim of this study was to investigate the relationship between the psycho-emotional state, chronic pain and the pain pressure threshold measured on the masseter muscle.

Materials and methods

Materials

The study group consisted of 38 subjects (23 women and 15 men). Ultimately, the study group consisted of 38 subjects who were examined three times. All of the participants were physiotherapy degree students. The age of the subjects ranged from 21 to 25 years (22.42 ± 0.89). The participants reported good general health.

The following inclusion criteria were used:

- age between 20 and 25 years,
- good general health.

Exclusion criteria:

- chronic systemic diseases
- past injury or surgery in the head or face area,
- good oral health – no presence of any ongoing dental pain.

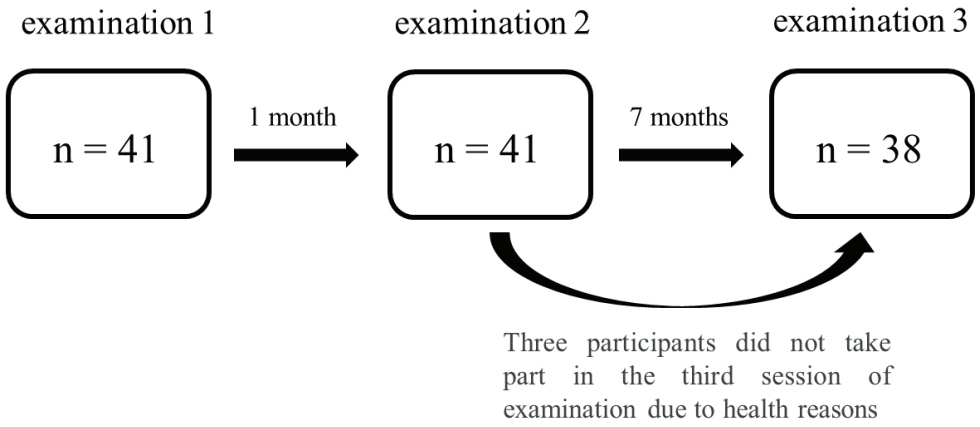


Figure 1. Group size and time schedule of the examination sessions

[source: own project].

Before each examination the participants were divided into two groups according to the 3Q/TMD questionnaire. Subjects who gave at least one positive answer to the 3Q/TMD were assigned to the TMD group. Others were assigned as controls.

Method

All the measurements were performed by one researcher. Details on the group size and time schedule of the examination sessions are presented in Figure 1. The first session of the study was performed in a less stressful period for the participants, during the academic year. The second session was carried out a month later, during the examination period, and another session was conducted 7 months after the initial examination session, during the next examination period. The tests performed in each series did not differ from each other and consisted of two parts: filling out the questionnaires and measuring the pressure pain threshold (PPT) using the digital algometer.

The explanation of the examination procedure was followed by obtaining written consent from the participants. Afterwards the subjects were asked to fill in all the below-mentioned questionnaires. The study protocol obtained approval from the university's Ethical Committee (SKE 01-03/2022).

Emotional state assessment

The participants were asked to fill in the following questionnaires: 3Q/TMD as a temporomandibular disorders screening tool, then to describe the emotional state with the PHQ-9 (Patient Health Questionnaire) and the GAD-7 (Generalized Anxiety Disorder) and finally with the GCPS (Graded Chronic Pain Scale v.2) for occurrence of chronic orofacial pain.

The examination of the pain pressure threshold (PPT) was performed with a digital algometer (Warner Instruments, Greenwich, CT, model FDX 25 with a 1 cm^2 contact area). This size is often used in scientific setups [13, 27].

Pain pressure threshold assessment

The PPT examination was performed with the patient in the prone position, with the head rotated 30° to the contralateral side from the examined muscle. The test was performed on both masseter muscles (first the right then the left muscle). Each muscle was divided into nine parts or points according to the DC/TMD clinical examination guidelines as presented in Figure 2 [29].

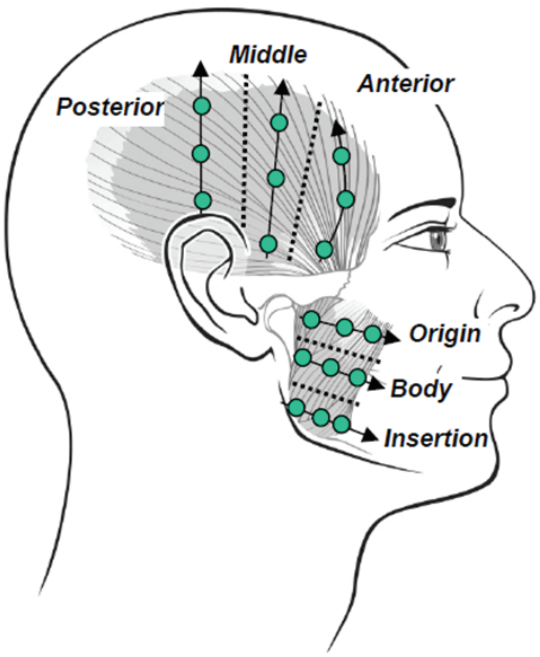


Figure 2. Localization of the points on the masseter muscle for PPT examination

[source: Schiffman et al., 2014].

The operator using the digital algometer pressed each point until the subject felt that the sensation of pressure was becoming painful. Before the examination, the subject received verbal instructions explaining that the signal indicating that change of the sensation of pressure to the feeling of pain (the first pain felt) would be to point the thumb of the hand resting on the abdomen up, so that it was visible to the researcher.

Each masseter muscle was examined twice (i.e. all nine points on each muscle), and the result was the average of the measurements taken – separately on the right and on the left side. To standardize the velocity of force application a metronome set at 60 bpm was used. Thus the pressure force was increased at the rate of 0.25 kg/cm^2/s. The researcher was looking at the algometer screen and increasing the pressure with the appropriate pace as indicated elsewhere [13]. The peak value displayed on the screen of the device was recorded and the algometer was reset to zero for subsequent measurements. The participants of the study were informed that the study may be stopped at any time.

Statistical analysis

The statistical analysis was performed using the STATISTICA (v.13.0) software. The Friedman test was used to compare the results of repeated measurements. Detailed comparisons were made post-hoc using Wilcoxon tests with Bonferroni correction.

The interdependence of the variables was assessed with the Spearman correlation coefficient. The effect size (ES) was measured with Kendall's coefficient (Friedman's test) and an equivalent correlation coefficient (Wilcoxon test). The ES scale proposed by Fritz was used [10]. The level of significance was set at alpha = 0.05.

Results

Before each examination session the same subjects were asked to fill in the 3Q/TMD questionnaire, which was the main criterion for group allocation. Therefore there was a different number of participants within the groups during the final analysis (see Table 1).

The results of the 3Q/TMD questionnaire divided the participants into a group of people with and without TMD symptoms. The results regarding chronic pain measured with the GCPS questionnaire were significantly higher in the TMD group ($p < 0.001$) than in the control group in each examination session, with the effect size being large ($R>0.50$). At the same time, no significant differences were found between the groups regarding the emotional state assessed with the PHQ-9 and the GAD-7 questionnaires (Table 2).

Analysing the dimorphic differences between the participants, it was observed that women had significantly higher scores in the GCPS questionnaire in the first session ($p < 0.05$, $R = 0.35$), in the GAD-7 questionnaire in the second session ($p < 0.05$, $R = 0.39$), and in the PHQ-9 questionnaire in the third session ($p < 0.05$, $R = 0.47$). The effect size was medium regarding the GCPS and GAD-7

Table 1. Number of participants in TMD and control groups during each examination session

Group (n = 38)	Examination 1	Examination 2	Examination 3
TMD	24 (f14, m10)	22 (f12, m10)	21 (f12, m9)
Control	14 (f9, m5)	16 (f11, m5)	17 (f11, m6)

Table 2. Results of chronic pain (GCPS) and the emotional state (PHQ-9 and GAD-7) questionnaires in the TMD and control groups in all three examination sessions

Questionnaire	TMD group			Control group			p value	Effect size (R)
	Mean	Median	Interquartile range	Mean	Median	Interquartile range		
$GCPS_1$	0.95 ± 0.95	1.00	1.00	0.71 ± 0.27	0.00	0.00	<0.001*	0.61
$GCPS_2$	1.18 ± 1.01	1.00	2.00	0.00 ± 0.00	0.00	0.00	<0.001*	0.73
$GCPS_3$	1.19 ± 1.12	1.00	3.00	0.12 ± 0.48	0.00	0.00	<0.001*	0.64
$PHQ\text{-}9_1$	8.75 ± 4.71	8.50	6.00	6.71 ± 4.71	5.00	7.00	0.187	0.26
$PHQ\text{-}9_2$	8.27 ± 4.62	8.00	6.00	11.44 ± 5.12	10.50	10.50	0.202	–0.07
$PHQ\text{-}9_3$	9.10 ± 6.39	8.00	8.00	11.76 ± 8.02	10.00	10.00	0.310	–0.20
$GAD\text{-}7_1$	9.00 ± 4.94	7.00	6.00	7.07 ± 5.20	5.00	8.00	0.202	0.25
$GAD\text{-}7_2$	8.05 ± 4.40	6.50	6.00	11.94 ± 4.40	13.00	11.00	0.523	–0.13
$GAD\text{-}7_3$	8.57 ± 5.32	7.00	8.00	11.47 ± 7.37	13.00	14.00	0.257	–0.22

Table 3. Dimorphic differences between the results of chronic pain (GCPS) and the emotional state (PHQ-9 and GAD-7) questionnaires

Questionnaire	TMD group			Control group			p value	Effect size (R)
	Mean	Median	Interquartile range	Mean	Median	Interquartile range		
$GCPS_1$	0.87 ± 1.01	1.00	1.00	0.27 ± 0.46	0.00	1.00	0.048*	0.35
$GCPS_2$	0.83 ± 1.11	0.00	2.00	0.47 ± 0.64	0.00	1.00	0.502	0.12
$GCPS_3$	0.91 ± 1.24	0.00	2.00	0.40 ± 0.51	0.00	1.00	0.429	0.14
$PHQ\text{-}9_1$	8.74 ± 4.47	8.00	7.00	6.87 ± 5.10	5.00	7.00	0.178	0.26
$PHQ\text{-}9_2$	9.96 ± 5.80	9.00	9.00	7.20 ± 5.06	6.00	9.00	0.198	0.25
$PHQ\text{-}9_3$	12.22 ± 7.60	10.00	10.00	7.33 ± 5.51	7.00	10.00	0.047*	0.39
$GAD\text{-}7_1$	9.70 ± 5.30	8.00	9.00	6.13 ± 3.89	6.00	5.00	0.059	0.37
$GAD\text{-}7_2$	10.48 ± 5.43	10.00	10.00	6.27 ± 4.27	5.00	8.00	0.016*	0.47
$GAD\text{-}7_3$	11.22 ± 6.32	10.00	11.00	7.80 ± 6.13	7.00	11.00	0.088	0.33

and large regarding the PHQ-9. The rest of the results obtained from the questionnaires did not differ between the sexes (see Table 3).

There were statistically significant differences in the PPT result on the right masseter muscle between the first and the third ($p < 0.05$) and also the second and the third examination sessions ($p < 0.05$). In the first case the effect size was medium ($R = 0.41$) and in the second it was large ($R = 0.52$). Such a correlation was not found for the left masseter muscle (Table 4).

Table 4. Pressure pain threshold (PPT) changes between the sessions (1, 2 or 3) for the right (M_R) and the left masseter muscle (M_L)

PPT	p value	Effect size (R)
$M_R1 - M_R2$	1.000	0.03
$M_R1 - M_R3$	0.032*	0.41
$M_R2 - M_R3$	0.004*	0.52
$M_L1 - M_L2$	1.000	0.08
$M_L1 - M_L3$	0.729	0.19
$M_L2 - M_L3$	0.969	0.16

Table 5. Correlation between chronic orofacial pain questionnaire (GCPS) and pressure pain threshold (PPT) between the three examination sessions. Right (M_R) and left (M_L) masseter muscles

	M_R/M_L Examination 1	M_R/M_L Examination 2	M_R/M_L Examination 3
$GCPS_1$	–0.421*/–0.437*	–	–
$GCPS_2$	–	–0.484*/–0.455*	–
$GCPS_3$	–	–	–0.315/–0.185

Another analysed aspect concerned the relationship between chronic orofacial pain assessed with the GCPS (subjective perception of pain) and the PPT measured on the masseter muscle with the algometer (objective assessment of pain). A statistically significant relationship was found between the results of the GCPS questionnaire and PPT. Such a correlation existed in the first and second examination sessions, but not in the third one. All the results are shown in Table 5.

The data showed no significant correlation between the emotional state assessed with the PHQ-9 and GAD-7 and the PPT in the studied sample.

Discussion

To date, the relationship between the emotional state and the pain pressure threshold (PPT) in TMD patients has barely been investigated. Thus in the current pilot study we attempted to clarify whether such a relationship even exists. We aimed to determine whether there is a relationship between the emotional state and orofacial pain and tenderness of the masseter muscle in people with and without TMD signs and symptoms or orofacial pain.

The relationship of the emotional state and pain has been widely described in the literature. TMD subjects show higher levels of depression and anxiety than the general population [34]. One of the main symptoms of TMD is pain; thus this premise was the main factor for choosing the material and methods for this study. The most common methods of assessing pain in people with TMD are self-report pain questionnaires [18, 35].

In the literature on the relationship between pain and emotions, this relationship has often been observed in the group of pain patients with TMD [24, 26]. In the present study we examined the existence of this relationship in groups of people with and without TMD.

We observed differences in GCPS results between the groups − TMD and control − assessed with the 3Q/TMD. In all three sessions the results of GCPS were significantly higher in the TMD group compared with controls. At the same time, the results of the questionnaires assessing the emotional state (PHQ-9 and GAD-7) did not differ between the groups. Based on these results, it is possible to conclude that the self-reported pain levels in the GCPS were more pronounced in the TMD group, but at the same time the levels of depression and anxiety did not show any differences between the groups.

The relationship between TMD and reported chronic orofacial pain is widely described in the literature. Some authors found a correlation between the existence of TMD and the GCPS as in the current study [35], whereas others did not [5]. The lack of a significant correlation between TMD and emotional state differentiate the current study's results from those that can generally be observed elsewhere. It may be due to the small sample with extremely low or extremely high scores regarding depression or anxiety assessment. Such a conclusion was drawn because in the literature where the existence of that relationship was observed, the number of participants was higher [8].

Another aspect is that in the current study, no significant relationship was found between the emotional state and chronic orofacial pain reported in the GCPS questionnaire. There are studies that have found the opposite, but they often examined only participants with facial pain or only with TMD and not both as in the current study [18, 24]. We examined a young group of students including both subjects with orofacial pain and/or TMD and subjects without it. It allows us to examine the interesting hypothesis that the mere presence of orofacial pain is not correlated with emotions, but its intensity depends on emotions [18, 24].

The last possible aspect is the examined time frame coverage within the GPCS and the PHQ-9/GAD-7 questionnaires, 7 months and 1 month respectively (after the initial session). This difference may be the reason why significance was not found between groups. The solution for further studies may be the use of similar tools regarding the examined time frame.

Regarding the depression and anxiety levels between sexes, statistically significant differences were found between women and men.

The pain regulatory mechanisms connected with TMD differ between the genders [17]. In many studies the authors decided to include only women in the examined group [21]. There are many factors that contribute to the differences in pain mechanisms between men and women. There are psychosocial, social, hormonal and biological factors [20], but in general most research shows that women experience more facial pain than men [8]. This phenomenon could be due to a lower pain threshold in women, as reported by others [23].

In the current study women had higher scores than men in all of the questionnaires, but only the following differences were significant: GCPS in the first session, GAD-7 in the second session, and PHQ-9 in the third examination session. Other authors have also reported gender differences in emotional state and pain levels [8, 22].

The literature shows that women suffer from anxiety disorders and depression more often than men [8, 22], but at the same time other authors claim that this difference sometimes is very small or even non-existent [38].

The present results are in accordance with the latter statement. The results of the PHQ-9 questionnaire completed during each session showed that the results during the first and the second rounds did not show significant differences between women and men. Only in the third round did the results show significantly higher scores in women. The same tendency applied for anxiety disorders. In the first and the third sessions of the study, no differences in the results of the GAD-7 questionnaire were noted between genders, but in the second session, the results for anxiety disorders were significantly higher in women.

The examination sessions were planned and performed three times: the initial examination, after 1 month, and 7 months later. The aim of this procedure was to check the PPT in conjunction with the changes in the emotional state. The chosen timeframe was set to be in agreement with the academic year.

The first round of examination was conducted during the semester, the second round during the examination period and the third during the next examination period. The latter is often described by students as the most stressful and the most difficult one because of the number of exams included.

The pressure pain threshold was measured using nine points on each of the masseter muscles and not only on one point on the masseter as we can observe in the literature [7, 13, 27].

PPT scores on the right masseter muscle differed significantly between first and third and between second and third sessions, which shows that the time between series of examinations performed on the same group of people is significant. This is an important conclusion because we found only a few other studies that tested PPT in the same group of people at intervals without subjecting them to any interventions, e.g. physiotherapy treatment. In one such study the authors used an eight-month interval [33].

No such relationship was found for the left masseter muscle. The reason for that could be the fact that TMD

symptoms often are one-sided [30]. The lack of symmetry suggests that in future research it would be worth noting the painful side in the TMD group. Another possible explanation for this asymmetry is that the PPT examination protocol always started with the right masseter muscle. Future protocols should involve random selection of the muscle to be tested to reduce the influence this factor.

Another aspect worth mentioning is the attempt to improve the accuracy of the PPT examination of the masseter muscle. In the current study the pressure pain threshold was measured using nine points on each of the masseter muscles and not only on one point as reported in the literature [7, 13, 27]. Additionally, the nine-point scheme adopted from the DC/TMD protocol reproduces the most recommended guidelines of the clinical examination of the temporomandibular disorders [29].

The authors of this study used an algometer to test the pressure pain threshold (PPT) with the aim to objectify pain assessment and to determine whether it correlates with patients' emotional state and also with self-reported pain levels in the questionnaires. To date, a negative correlation between PPT on the left masseter and severity of TMD has been found by different authors, but a similar observation on the right masseter was lacking [13]. It shows that this correlation is not constant. In the current study both a digital algometer and the GCPS questionnaire were used in order to assess both the subjective perception of pain (GCPS) and an objective measurement such as PPT. This protocol allowed us to gather more information about the duration of pain in the long term (i.e. the last 6 months) and also at the moment of examination. The literature reports that pain sensitivity often predisposes to the occurrence of the phenomenon of pain chronicity reported by the patients, especially among women [28].

The data show that during the first two sessions there was a relationship between the chronic orofacial pain experienced and reported in the GCPS questionnaire (subjective assessment) and the tenderness of the masseter muscle tested by means of PPT measured using a digital algometer. This relationship was proven by a correlation between PPT and both the right and the left masseter muscles and GCPS results in the first and the second session.

In this study, no significant correlation between the emotional state and the PPT in the masseter muscle was found. This finding is important because it agrees with recent reports that no correlation was found between the physiological structure and pain, depression and somatization intensity. In other words, the level of pain is independent from the muscles, the temporomandibular joint position, etc. On the other hand, pain was found to be closely correlated with the levels of depression and somatization in TMD patients [8].

The results from this pilot study show that there are reasons to continue exploring this subject by conducting further research on larger and more representative study samples.

Conclusions

1. The orofacial pain scores were higher in the TMD group than the control group.
2. The prevalence of pain, depression and anxiety was higher in female subjects, but only some differences were significant.
3. The PPT (only of the right masseter) correlates with the incidence and intensity of chronic orofacial pain assessed by the GCPS questionnaire results, but not in all cases.
4. The PPT tested with an algometer on the masseter muscles does not correlate with the emotional state measured with PHQ-9 and GAD-7 in the study group.

Study advantages

The protocol included both subjective (GCPS) and objective pain assessment (PPT) tools to gain a better understanding of the patients' symptoms and complaints. This pilot study aimed to investigate the pain-emotions relationship, which seems to be a clinically important topic.

Study limitations

The small study sample is not representative of the general population.

Conflict of interest: Authors state no conflict of interest.

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