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ORGINAL ARTICLE

CORRELATION BETWEEN CERVICAL SPINE MUSCLE DISORDERS AND THE OCCURRENCE OF SYMPTOMS OF TEMPOROMANDIBULAR JOINT DYSFUNCTION

KORELACJA POMIĘDZY NIEPRAWIDŁOWOŚCIAMI MIĘŚNI ODCINKA SZYJNEGO KRĘGOSŁUPA A WYSTĘPOWANIEM OBJAWÓW DYSFUNKCJI STAWÓW SKRONIOWO-ŻUCHWOWYCH

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ABSTRACT

Introduction

This study evaluated the correlation between the occurrence of disorders of selected muscles of the cervical spine and the occurrence of symptoms of TMJ dysfunction.

Material and methods

The study was conducted with 60 participants. The examination includes a personal questionnaire, physical examination (measuring ranges of mandibular mobility, examination of the mandibular path and its deviations during the abduction, examination of the presence of TMJ acoustic symptoms in abduction, lateral movements and forward movement on both sides, evaluation of the tenderness of the temporomandibular joints area) and algometer measurement on the upper fibers of the trapezius, levator scapula, sternocleidomastoid and rectus capitis posterior major to define pressure sensitivity.

Results

In algometer measurements, no differences were found between the results of the pressure sensitivity on the myofascial trigger points and the occurrence of TMJ dysfunction.

Conclusions

Tenderness of muscles of the cervical spine does not correlate with the occurrence of dysfunction of the temporomandibular joints. There was no correlation found between the completed orthodontic treatment and the development of temporomandibular joints dysfunction.

Trial registration

Bioethics Committee at the Medical University of Karol Marcinkowski in Poznań; Resolution No. 676/22.

Keywords: TMJ disorders, pressure sensitivity, algometer, young adults, myofascial pain, orthodontic treatment

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STRESZCZENIE

Wstęp

Badanie miało na celu zbadanie czy istnieje korelacja pomiędzy nieprawidłowościami mięśni odcinka szyjnego kręgosłupa a występowaniem objawów dysfunkcji stawów skroniowo-żuchwowych.

Materiał i metody

Badaniem objęto 60 uczestników. Badanie składało się z kwestionariusza osobowego, badania przedmiotowego (pomiar zakresów ruchomości żuchwy, zbadanie toru żuchwy i jej odchyleń podczas odwodzenia, zbadanie występowania objawów akustycznych ze strony TMJ w odwodzeniu, ruchach bocznych i ruchu doprzednim po obu stronach i ocenę tkliwości okolicy stawów skroniowo-żuchwowych) i pomiaru algometrem wrażliwości uciskowej wybranych mięśni tj. górnych włókien czworobocznego grzbietu, dźwigacza łopatki, mostkowo-obojczykowo-sutkowego i prostego tylnego głowy większego.

Wyniki

W badaniu algometrem nie wykazano różnic pomiędzy wynikami badania wrażliwości uciskowej na mięśniowo-powięziowych punktach spustowych a występowaniem dysfunkcji stawów skroniowo-żuchwowych.

Wnioski

Tkliwość mięśni odcinka szyjnego kręgosłupa nie koreluje z występowaniem dysfunkcji stawów skroniowo-żuchwowych. Nie wykazano również korelacji między przebytym leczeniem ortodontycznym a rozwinięciem się dysfunkcji stawów skroniowo-żuchwowych.

Słowa kluczowe: dysfunkcje TMJ, tkliwość uciskowa, algometr, młodzi dorośli, ból mięśniowo-powięziowy, leczenie ortodontyczne

Introduction

Currently, disorders of the temporomandibular joints (TMJ) are an increasingly frequent cause of patients visiting the dentist's office. It is estimated that this problem affects 30–90% of the adult population (Oleszek-Listopad *et al.,* 2019), and this problem is becoming more and more important due to the ubiquitous stress accompanying us in everyday life, which is indicated as one of the main causes of TMJ dysfunction due to excessive muscle tension and activity, which the body tries to unload through parafunctions harmful to the temporomandibular joints (Panek and Śpikowska, 2009). Also, Sójka's studies show that the level of stress in everyday life is higher in the group of patients with TMD (temporomandibular disorder) (Sójka *et al.,* 2019). A common symptom reported by patients is a pain in the temporomandibular joints or myofascial structures in the head and neck (Ciancaglini *et al.,* 1999). Many studies have shown significant associations between cervical disorders and jaw disorders in patients with TMD (Kirveskar *et al.,* 1988). It was also found that patients with TMD show significant limitations in flexion, extension and both lateral flexion movements compared to asymptomatic people (De Laat *et al.,* 1998; Kirveskar *et al.,* 1988; Stiesch-Scholz *et al.,* 2003), but there was no relationship between head protraction or postural defects and the occurrence of temporomandibular joint dysfunction or excessive tenderness of head muscles (Darlow *et al.,* 1987; Hackney *et al.,* 1933). Other studies also indicate that the condition of the stomatognathic system is significantly related to both the mobility of the cervical spine and the tenderness of the neck and shoulder muscles (Kirveskari *et al.,* 1988). The above dependencies indicate the need to undertake therapy of the neck muscles in patients with TMD. Contemporary literature indicates that working on trigger points of the neck muscles reduces the sensation of pain in the area of the temporomandibular joints, which was confirmed by the research of P. Gawda *et al.* on the example of the trapezius muscle of the descending part using electromyographic measurements and the VAS scale (Gawda *et al.,* 2016). On the other hand, E. Ferendiuk *et al.* researched 1258 people and showed that myofascial pain is located in the neck muscles only in 3% of the respondents (Ferendiuk *et al.,* 2018). On the contrary, the study by R. Ciancaglini *et al.* found a significant relationship between neck pain and TMJ dysfunction, and that the feeling of stiffness or fatigue of the jaw as well as facial and jaw pain were significantly associated with neck pain, and confirmed an independent correlation of neck pain only with facial pain and jaws (Ciancaglini *et al.,* 1999). The above facts induced the authors to research whether there is a correlation between cervical spine muscle disorders and the occurrence of symptoms of temporomandibular joint dysfunction. In addition, the authors considered it necessary to conduct the study due to the small number of articles on this topic and the large increase in the number of patients. In addition, determining whether there is such a relationship may be useful in planning therapy, as it will be possible to determine whether the disorders of the given muscles are typical of TMJ dysfunction.

Material and research methods

The study included 42 women (70%) and 18 men (30%) aged 19 to 25 on the day of the study. Inclusion criteria, apart from age, were relatively good health and consent to participate in the research experiment. The study excluded people with skin problems in the head and neck area that made the examination impossible, previous head and neck surgeries and traffic injuries, coagulation disorders or taking medications that reduce blood coagulability, venous thrombosis in the neck area, sensory disorders, dislocation of the jaw in the past. Furthermore, an additional exclusion criterion was taking painkillers 12 hours before starting the study, being under orthodontic treatment or physiotherapeutic treatment focused on TMJ dysfunctions. In the study group, 24 people (44%) had used fixed or removable braces or both types of orthodontic appliances in the past.

The group was divided into a control group, which included people who did not show signs of temporomandibular joint dysfunction and a study group with signs of TMJ dysfunction. TMD (temporomandibular disorder) was determined based on one of the following factors observed during the examination: acoustic symptoms, present temporomandibular joint pain, problems with opening the mouth, deviation of the jaw during the abduction, or reported locking of the jaw. The groups did not differ statistically significantly in age. The detailed characteristics of the groups are presented in Table 1.

Table. 1 Characteristics of age in control and study group.

	Control group	**Study group**
Number of people	30	30
Average	22.73 ± (0,91)	22.67 ± (1,24)
Min	21	19
Max	24	25
Median	23	23
p*	0.9	

*p calculated by using t student test

Before starting the study, the examiner informed the participant about the purpose, methods and his rights, and answered any questions. Then, she conducted an initial questionnaire consisting of an interview and examination.

The interview included collecting personal data and necessary consents, determining whether the exclusion criteria were met, determining the resting position of the tongue and whether, according to the patient, the following symptoms of dysfunction are present, i.e., pain in the temporomandibular joints, deviation of the jaw, blockage of the jaw, difficulty in opening the mouth, clicking or crackling. All given symptoms were later verified by the examiner.

The examination consisted of a physical examination and an algometer measurement. The physical examination included measuring the ranges of motion (ROM) of the mandible with a ruler (Figure.1), examining the trajectory of the mandible and its deviations by observing the patient during the abduction, examining the presence of acoustic symptoms from the TMJ in abduction, lateral and forward movement on both sides and assessing the tenderness of the temporomandibular joint area.

Then, the pressure sensitivity of selected muscles was measured, i.e., the upper fibers of the trapezius, levator scapula, sternocleidomastoid and rectus capitis posterior major using an algometer. Before the measurement, it was explained that the moment of the first pain sensation is important and that is when the participant is asked to signal it to the examiner. In addition, to illustrate and practice the procedure and to teach the participant to distinguish pressure from pain and projection of pain, the examiner demonstrated this pressure with a device for evaluation of the pressure force and the related sensations on the forearm muscles. Measurements were made on myofascial trigger points, respectively, for the upper fibers of the trapezius muscle – upper part of the arms, levator scapulae – attachment at the superior angle of the scapula, sternocleidomastoid – mastoid process, point 1 and the upper edge of the clavicle on the sternal extremity, point 2, rectus capitis posterior major- along the course of the muscle in the suboccipital region. The location of the above myofascial trigger points is shown in Figure. 2. Such a point was first localized by palpation by feeling an excessively tense band of muscle fibers with the fingertips. Then, the algometer head was applied to the found point at an angle of 90° and, increasing the pressure at a speed of about 100g/s, three measurements were made (with breaks between measurements) until the first sensation of pain, which the patient verbally signaled by saying "stop". At this point, the measurement was stopped and the value was read from the display and recorded on the test card.

1-measurement of the forward movement (from labial surface of the upper central incisors to the labial surface of the lower central incisors); 2-measurement of the abduction (from the upper incisal edge of the central incisor to the lower incisal edge of the central incisor); 3&4-measurement of the lateral movement (from the midline between the upper central incisors to the point on the lower central incisor where was passing the midline of the mandible and we make a measurement when the jaw is fully located on the left or right side).

A Digital Force Algometer with a compression head of 1 cm², dimensions of 140 × 30 × 95 mm and a 30 × 20 mm LCD was used for the measurements. The device can read the measurement in four units, but for unification, the author chose the kilogramme unit. The measurement result was measured to the hundredth of a unit. The unit kg/cm² was used in the following work. During the algometer test, the patient assumes a sitting position, and the algometer display with the measurement result was not visible to the tested person.

Results

Statistical analysis was performed in the Statistical program, and $p < 0.05$ was considered

Figure 1. JBS

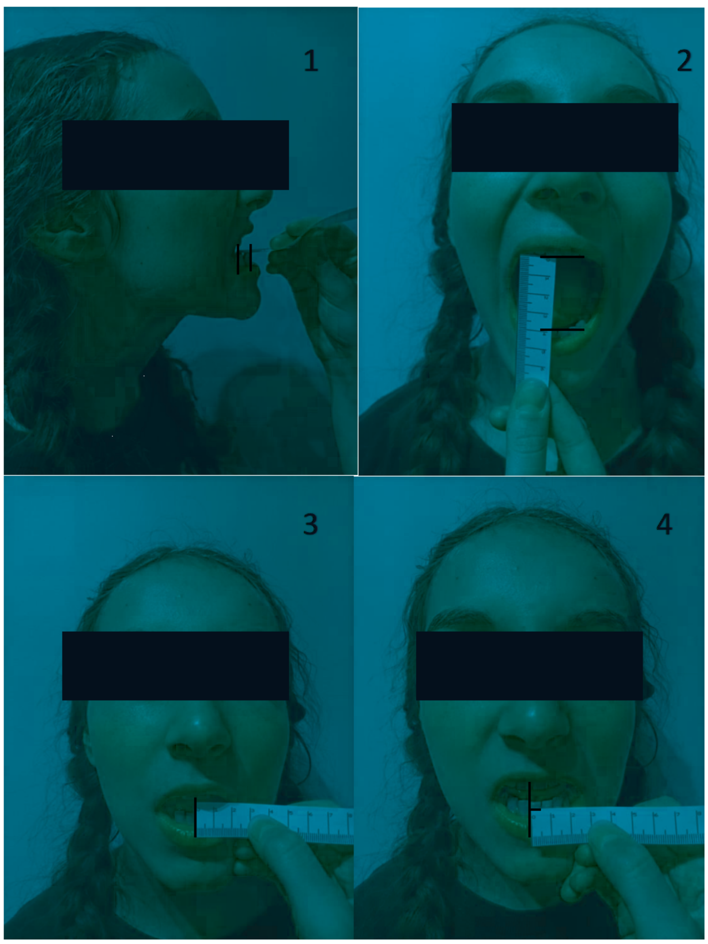

Figure 2. Measurements of ROM of the mandible

statistically significant. The normality of the distribution was checked with the W-Shapiro-Wilk test. Then, if $p \geq 0.05$, the student's t-test was performed, if $p < 0.05$, the U Mann-Whitney sensitivity or clicking and crackling in the temporomandibular joints in the functional test. All results are included in Table. 2.

Table. 2 ROM of the mandible- comparison of study and control group and with other variables.

	Abduction	Forward movement	Lateral movement in left	Lateral movement in right
Average in study group	4.79 ± (0.74)	0.54 ± (0.34)	1.70 ± (0.5)	1.66 ± (0.53)
Average in control group	4.81 ± (0.87)	0.51 ± (0.2)	1.64 ± (0.4)	1.60 ± (0.37)
Median in study group	5.00	0.50	1.50	1.70
Median in control group	4.55	0.50	1.50	1.50
Min of study group	3.20	0.00	0.80	0.80
Min of control group	3.50	0.10	0.80	0.90
Max of study group	6.00	1.50	3.50	3.50
Max of control group	7.00	1.00	2.50	2.50
p*	0.87	0.85	0.84	0.56
Other variables				
Present dysfunction of TMJ	p* = 0.87	p* = 0.71	p* = 0.23	p* = 0.63
Orthodontic treatment in the past	p* = 0.32	p* = 0.13	p* = 0.71	p* = 0.47
Present pressure sensitivity in the area of TMJ	p* = 0.53	p* = 0.78	p* = 0.18	p* = 0.26
Present acoustic symptoms	p* = 0.75	p* = 0.79	p* = 0.7	p* = 0.23

* p calculated by using U Mann-Whitney test

test was used. The Pearson correlation for numerical variables was used to determine the existence of correlations. For descriptive variables, two-way tables were used, in which, depending on the total number and expected numbers, an appropriate test was selected and the odds ratio for such a relationship was determined.

Range of jaw movements

The study group and the control group were homogeneous in terms of the range of mandibular movements. The exact results are presented in Table. 2.

After statistical analysis, no differences were found between the ranges of mandibular movements or the current TMJ dysfunction in people who had orthodontic treatment in the past and people who did not use braces. Also, these ranges of motion did not differ significantly in people who had pressure

Orthodontic treatment

Completed orthodontic treatment, as mentioned above, does not limit the ROM of the mandible (Table. 2). It was also found that there is no statistically significant difference between the study group and the control group in orthodontic treatment (p = 0.30), so it does not predispose to TMJ dysfunction. There is also no evidence of its effect on reducing the threshold of pressure tenderness of the neck muscles, which is presented in Table. 3. Person with current dysfunction of the temporomandibular joint has a chance of lack of this parafunction at the level of 0.29%.

Algometer test

In the algometer measurements, no differences were found between the results of pressure sensitivity tests on myofascial trigger points and the occurrence of temporomandibular joint dysfunctions, which is presented

Table. 3 Correlation between an orthodontic treatment in the past and pressure sensitivity.

	Group with orthodontic treatment in the past	Group without orthodontic treatment in the past	p*
Average left levator scapulae muscle	1.08 ± (0.64)	1.03 ± (0.51)	0.37
Average right levator scapulae muscle	1.06 ± (0.89)	1.28 ± (0.58)	0.09
Average left trapezius muscle	1.16 ± (0.66)	1.13 ± (0.44)	0.11
Average right trapezius muscle	1.20 ± (0.64)	1.16 ± (0.54)	0.50
Average left rectus capitis posterior major muscle	0.67 ± (0.62)	0.80 ± (0.43)	0.14
Average right rectus capitis posterior major muscle	0.66 ± (0.56)	0.84 ± (0.52)	0.78
Average left sternocleidomastoid muscle point 1	0.55 ± (0.45)	0.68 ± (0.31)	0.15
Average right sternocleidomastoid muscle point 1	0.66 ± (0.58)	0.64 ± (0.39)	0.11
Average left sternocleidomastoid muscle point 2	0.35 ± (0.34)	0.47 ± (0.27)	0.33
Average right sternocleidomastoid muscle point 2	0.52 ± (0.38)	0.54 ± (0.52)	0.12

*p calculated by using t student test

Table. 4 Pressure sensitivity of neck muscles- comparison of study and control group.

	Study group	Control group	p*
Average left levator scapulae muscle	1.10 ± (0.69)	1.18 ± (0.67)	0.63
Average right levator scapulae muscle	1.18 ± (0.74)	1.47 ± (1.02)	0.22
Average left trapezius muscle	1.06 ± (0.64)	1.28 ± (0.59)	0.17
Average right trapezius muscle	1.04 ± (0.56)	1.29 ± (0.62)	0.11
Average left rectus capitis posterior major muscle	0.86 ± (0.64)	0.73 ± (0.57)	0.40
Average right rectus capitis posterior major muscle	0.81 ± (0.65)	0.84 ± (0.59)	0.86
Average left sternocleidomastoid muscle point 1	0.71 ± (0.43)	0.65 ± (0.46)	0.58
Average right sternocleidomastoid muscle point 1	0.60 ± (0.44)	0.77 ± (0.61)	0.22
Average left sternocleidomastoid muscle point 2	0.48 ± (0.34)	0.36 ± (0.26)	0.12
Average right sternocleidomastoid muscle point 2	0.61 ± (0.44)	0.49 ± (0.38)	0.28

*p calculated by using t student test

in Table 4. These differences are also not found in comparison to the measurements of mandibular movements.

The presence of correlations between the ranges of mandibular movements and the results of tests using an algometer was also checked. The mandibular abduction movement shows a weak positive relationship between the rectus capitis posterior major on the left side – 8% and on the right side – 11%, and between the sternocleidomastoid muscle point 2 on the left side – 11% and on the right side – 12%. The anterior movement of the mandible shows a weak positive relationship between the levator scapulae muscle on the left 8% and the right 7%, sternocleidomastoid point 1 on the left 10% and right 7%, and trapezius on the left 7%. Lateral movement of the mandible to the right shows a weak negative relationship between the trapezius muscle on the left 12% and the right 8%, the rectus capitis posterior major on the left 8% and the right 9%, and the sternocleidomastoid point 1 on the left 7% and right 9%. In contrast, lateral movement to the left shows no correlation. All results are presented in Table. 5.

Table. 5 Correlation between abduction and pressure sensitivity of neck muscles.

	Abduction*	Forward movement*	Lateral movement in left*	Lateral movement in right*
Left levator scapulae muscle	p = 0.25 r^2 = 0.02	p = 0.03 r^2 = 0.08	p = 0.99 r^2 = 0.000005	p = 0.08 r^2 = 0.05
Right levator scapulae muscle	p = 0.36 r^2 = 0.01	p = 0.04 r^2 = 0.07	p = 0.28 r^2 = 0.02	p = 0.13 r^2 = 0.04
Left trapezius muscle	p = 0.06 r^2 = 0.06	p = 0.048 r^2 = 0.07	p = 0.93 r^2 = 0.0001	p = 0.007 r^2 = 0.12
Right trapezius muscle	p = 0.27 r^2 = 0.02	p = 0.3 r^2 = 0.02	p = 0.42 r^2 = 0.01	p = 0.03 r^2 = 0.08
Left rectus capitis posterior major muscle	p = 0.03 r^2 = 0.08	p = 0.18 r^2 = 0.03	p = 0.89 r^2 = 0.0003	p = 0.01 r^2 = 0.10
Right rectus capitis posterior major muscle	p = 0.009 r^2 = 0.11	p = 0.07 r^2 = 0.06	p = 0.48 r^2 = 0.009	p = 0.04 r^2 = 0.07
Left sternocleidomastoid muscle point 1	p = 0.29 r^2 = 0.02	p = 0.13 r^2 = 0.04	p = 0.52 r^2 = 0.007	p = 0.04 r^2 = 0.07
Right sternocleidomastoid muscle point 1	p = 0.29 r^2 = 0.02	p = 0.45 r^2 = 0.01	p = 0.76 r^2 = 0.002	p = 0.02 r^2 = 0.09
Left sternocleidomastoid muscle point 2	p = 0.009 r^2 = 0.11	p = 0.02 r^2 = 0.10	p = 0.77 r^2 = 0.001	p = 1.00 r^2 = 0
Right sternocleidomastoid muscle point 2	p = 0.006 r^2 = 0.12	p = 0.047 r^2 = 0.07	p = 0.47 r^2 = 0.009	p = 0.07 r^2 = 0.05

*p calculated by using Pearson's correlation

Discussion

Dysfunctions of the masticatory system are becoming an increasingly common problem in dental and physiotherapeutic offices. A lot of young people are starting to have problems in this area. The literature gives different frequencies of occurrence. Studies by M. Łapuć *et al.* estimate that this problem affects 72% of people aged 20–30 (Łapuć *et al.*, 2011). In an article by De Kanter *et al.*, during a study on the Dutch population, they found that 44.4% of the population showed clinical signs and symptoms of TMJ dysfunction (De Kanter *et al.*, 1993). The results of our study are comparable to the previously cited articles.

In the above studies, there was no statistically significant increase in cervical muscle tenderness in people with TMJ dysfunction. The tenderness of these muscles may have little importance for the diagnosis of temporomandibular joint dysfunction, as it occurs only in 3% of patients (Ferendiuk *et al.*, 2018). Some studies show even lower tenderness of the cervical structures in TMD patients compared to the control group (Bragatto *et al.*, 2016; da Costa *et al.*, 2015; Silveira *et al.*, 2014; von Piekartz *et al.*, 2016). On the other hand, some researchers find a correlation between TMD and pain in the neck muscles (Almoznino *et al.*, 2020, 2019; Armijo-Olivo and Magee, 2012; De Laat *et al.*, 1998; Ferreira *et al.*, 2019; Miyake *et al.*, 2004; Stiesch-Scholz *et al.*, 2003), especially with increasing severity of TMJ symptoms (Ciancaglini *et al.*, 1999; Silveira *et al.*, 2015). Some studies, despite showing a strong correlation, underline that the difference is so small that cannot be stated the clinical significance of these reports (Armijo-Olivo and Magee, 2012). Unfortunately, contemporary literature is not consistent on this subject and does not draw uniform conclusions. This may be due to large differences in the age of the subjects, which may make it difficult to draw the same conclusions, because, as stated by R. Ciancaglini *et al.*, the level of pain in the neck muscles increases with age (*Ciancaglini et al.*, 1999).

The lack of correlation between neck muscle tenderness and the presence of temporomandibular joint dysfunction may be because, according to the literature, the presence of TMD does not affect the position of the head and neck, which is confirmed by

Iunes DH research *et al.*, which used three methods: photographic, radiographic and visual (Dh *et al.*, 2009), as well as research by C. M. Visscher, in which the head position in TMD and healthy people was compared using photographic images in the sitting and standing position as well as X-ray images (Visscher *et al.*, 2002). Also, studies by C. Rodolfo Ray *et al.* examining the distance between C0 and C1 did not show any significant differences between women with TMD and the control group (Raya *et al.*, 2017). J. Hackney in his research showed that people with diagnosed TMJ dysfunction do not have increased head protraction compared to healthy people (Hackney *et al.*, 1933). Based on the cited articles, it could be hypothesized that since the presence of TMJ dysfunction does not affect the position of the head and neck, the neck muscles remain in their physiological position (they are not lengthened or shortened) and are not subject to excessive overload, which could manifest as excessive tenderness, what should be checked in the future. Further studies are necessary due to the odds in the literature. Some scientific articles say that although there is no statistically significant difference in head position, there are small differences between asymptomatic and symptomatic people (López-de-Uralde-Villanueva *et al.*, 2015) or even show that head protraction is more common in people with symptoms of TMJ dysfunction (Uritani *et al.*, 2014) and that the presence of TMD is strongly correlated with neck symptoms, including neck muscle tenderness (De Laat *et al.*, 1998; Kirveskari *et al.*, 1988; Silveira *et al.*, 2015; Stiesch-Scholz *et al.*, 2003). Due to differences in the current knowledge on this subject, the authors cannot give a clear reason for the lack of correlation between neck muscle tenderness and the presence of temporomandibular joint dysfunction. They can only make a hypothesis and state the need to confirm it in further research.

On the other hand, there is Sójka's studies which show that the majority of patients didn't know that they have TMJ disorder but by using axiographic recordings researchers found significant asymmetry between the right and left TMJ in Bennett's angle and movement and also retrusion (Sójka *et al.*, 2015). Sójka's studies also show that the incisal ROM during the lateral movement on the left is correlated with the one on the right and conversely, correlations between the condylar ROM of the left and right TMJ during the abduction (Sójka *et al.*, 2017). The authors stated that the analysis of measurable parameters, function charts and clinical findings are very helpful in the evaluation of TMJ condition what can prove the significance of the above parameters in the diagnosis of TMD (Sójka *et al.*, 2017, 2015).

The literature on the impact of orthodontic treatment on the temporomandibular joints is inconsistent. Some researchers are inclined to a negative impact (Slami *et al.*, 2006; Tomasz *et al.*, 2003) by increasing the number of functional disorders of the temporomandibular joints in people with normal and disturbed occlusion after orthodontic treatment, especially with a fixed appliance. Others are inclined to the effect of reducing and eliminating the pathological symptoms of TMD (Kijak *et al.*, 2016; Pawlaczyk-Kamieńska *et al.*, 2012) because, after orthodontic treatment, patients reported a reduction or disappearance of TMJ symptoms, which was also confirmed by objective tests (with the exclusion of acoustic symptoms). There is also an opinion that an orthodontic treatment neither prevents nor increases the occurrences of TMJ dysfunctions (Mohlin *et al.*, 2004; Roda *et al.*, 2007). Our study showed no difference in the incidence of temporomandibular joint dysfunction and orthodontic treatment.

In our studies, we did not show that mandibular ROM limitation was more common in people with TMJ dysfunction than in healthy people, the same as in many other studies (Miyake *et al.*, 2004; Ohrbach *et al.*, 2011; Stiesch-Scholz *et al.*, 2003). This fact is confirmed by the contemporary literature, which states that the limited range of mandibular movements is not a predisposing factor for TMD (Ohrbach *et al.,* 2013). Also, no effect of orthodontic treatment on the ranges of mandibular mobility was demonstrated, which is confirmed by A. Ortega's research examining the condition before and after orthodontic treatment, where no restrictions were found in the ROM of the mandible and no evidence of limiting the ranges (Ortega *et al.,* 2016).

Limitations

The above study had several limitations. Firstly, the research group should have been larger in order to obtain more definitive results. It would also be worthwhile to include people with more severe TMJ symptoms in the study. In addition, more objective tools should be used to assess the occurrence of temporomandibular joint dysfunction, such as: face bow, condylograph or a vision system examination.

Conclusions

1. Muscle tenderness of the cervical spine muscles does not correlate with the occurrence of dysfunction of the temporomandibular joints.
2. Excessive tenderness of the muscles of the cervical spine can affect the range of movements of the jaw.
3. There was no correlation found between the completed orthodontic treatment and the development of TMD.

List of abbreviations

TMJ – temporomandibular joint
TMD – temporomandibular disorder
ROM – range of motion

Declarations

Ethics approval and consent to participate
Bioethics Committee at the Medical University of Karol Marcinkowski in Poznań approved this study; Resolution No. 676/22.

Competing interests
The authors declare that they have no competing interests.

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Not applicable *Authors' contributions* D.C. analysis and interpretation of data, performed interview and examination, drafted the work J.G. revised work, designed conception of article, drafted the work.

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