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Review paper

The impact of stress on psychological and physiological aspects of health of patients with TMD: A literature review from 2015–2020

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Abstract

Introduction: Studies suggest that temporomandibular disorders (TMD) are a complex disorder with many causes consistent with the biopsychosocial disease model. One of the important areas of TMD etiology are psychological factors, including stress, but its role in the mechanism of TMD formation is ambiguous.

Aim: The aim of this literature review was to summarize the latest study about the impact of stress in relation to temporomandibular joint disorders.

Material and methods: Articles from PubMed and PEDro online databases were identified using the keywords 'stress,' 'distress,' 'TMD.' The review included works published in the period from October 1, 2015 to March 6, 2020. Finally, 10 articles were qualified for the review.

Results and discussion: The most frequently used research tool was the questionnaire. Other methods used to evaluate a level of stress in TMD patients were measurement of cortisol level and surface electromyography of masticatory muscles.

Conclusions: Stress is one of the psychological factors involved in TMD pathophysiology. Increased levels of stress in patients with TMD are associated with elevated levels of cortisol, hyperactivity of the HPA axis and increased bioelectric activity of the masticatory muscles. There is a need to extend research on the effects of stress on TMD by more objective methods.

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1. INTRODUCTION

Temporomandibular disorders (TMD) concerns pathology of masticatory muscles, temporomandibular joints (TMJ) and surrounding tissues.[1] The symptoms are considered as reduced range of movements of the mandible, masticatory muscles pain, TMJ pain, presence of joint sounds during the function, generalized myofascial pain and functional restrictions or mouth opening deviations.[2] TMJ and related anatomical structures play a key role when performing activities such as mastication, swallowing or speaking.[3] This suggests that dysfunctions in this area may affect the daily functioning of the patient with TMD and his quality of life.[4]

Presently it is recognized that biological, environmental, social, emotional, cognitive, postural and genetic factors affect the functional balance between the basic elements of the stomatognathic system.[3] Prospective cohort OPPERA studies suggest that TMD is a complex disorder with many causes consistent with the biopsychosocial disease model.[5] One of the important areas of TMD etiology are psychological factors, including stress, but its role in the mechanism of TMD formation is ambiguous.[6]

Stress is part of the physiological functioning of human, but when its intensity begins to exceed the adaptability of the body, it leads to disorganization of the body system and the formation of a pathological condition.[7] Psychological factor, e.g. anxiety, depression, emotional pressure or aggression may be a risk factors of psychosomatic diseases. Emotional frustrations may affect the formation of negative internal picture of the disease and worsen patient's reactions to treatment.[8] Stress is considered as a direct, strong factor that contributes to the formation and persistence of pain.[9] This can be explained by the occurrence of hyperalgesia and central sensitivity of pain in response to chronic stress.[10] However, pain and stress can lead to the formation of parafunctional habits, e.g. of tooth grinding or clenching, that can be associated with increased alertness and somatosensory stimulation.[9] Many authors link the occurrence of parafunctions with the signs and symptoms of TMD.[2,6,11,12] In turn patients who suffer from TMD also have increased levels of cortisol and the coexistence of other negative emotional states such as depression or somatization of symptoms.[13] Considering that stress is a risk factor in para-functional habits and TMD, high levels of cortisol can combine these two disorders. However, in the current literature there is a lack of publications summarizing the impact of stress in TMD.

2. AIM

The aim of this literature review was to summarize the latest study about the influence of stress in relation to TMJ disorders.

3. MATERIAL AND METHODS

The material for this literature review were articles from PubMed and PEDro online databases. To identify the articles accurately the keywords 'stress,' 'distress,' 'TMD' were used. The review included works published in the period from October 1, 2015 to March 6, 2020. The literature review consisted of three stages consisting of the analysis of publications in terms of exclusion criteria. As first, the publication titles searched by using keywords were analyzed. The next stage consisted of reviewing abstracts of articles initially included in the review. In the last stage, full versions of the publications were analyzed. The lack of a Polish or English full-text version of the publications, publications older than 5 years, post-conference summaries, animal studies, studies on children, literature reviews, case reports, studies on post-traumatic stress disorder (PTSD) were the exclusion criteria. The flow diagram is shown in Figure 1.

The limitation of the presented literature review is the exclusion of PTSD from the analysis.

4. RESULTS

Finally, 10 articles were qualified for the review (Table 1).

The most frequently used research tool was questionnaires. In the publications of Ahuja et al.,[14] Stocka et al.,[15] Staniszewski et al.,[16] Augusto et al.,[17] Salameh et al.,[18] Sójka et al.,[19] Paulino et al.,[20] Natu et al.[21] and Chisnoiu et al.,[22] subjective methods of assessing stress levels (questionnaires) indicate higher results of perceived stress or/and anxiety/depression in patients with TMD. Salameh et al. reported a higher level of depression and stress in patients with TMD ($P = 0.000$).[18] Augusto et al. reported, that almost half of

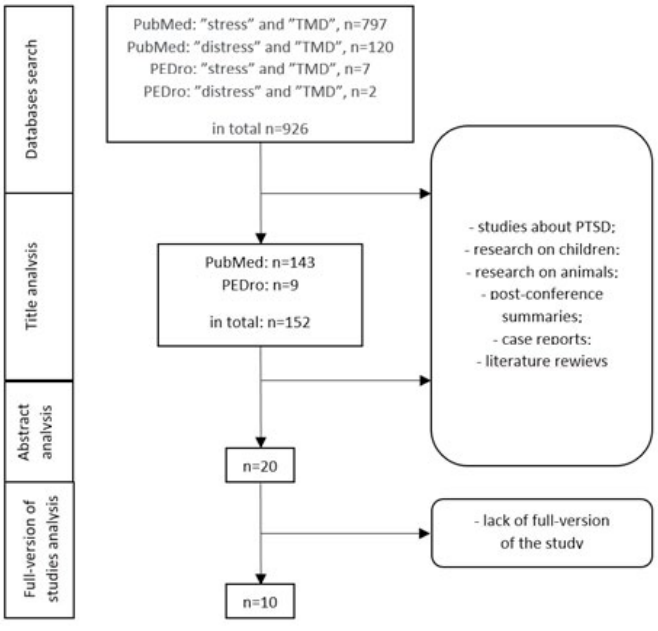

Figure 1. Flow diagram of articles illustrating the stages of the review.

Table 1. Articles qualified to the literature review.

Authors, reference number	Participants characteristics	Stress assesment	Measured results (symptoms/parameters)
Salameh et al.[18]	Study group: 42 women and 18 men, aged 19–44 Control group: 60 people, sex- and age-matched	Perceived stress scale 10 (PSS 10) Research diagnostic criteria for temporomandibular disorders axis II Salivary cortisol levels	Patients with TMD showed a higher level of depression and stress ($P = 0.000$). Significant differences in salivary cortisol levels were observed between TMD patients and the control group ($P = 0.000$).
Ahuja et al.[14]	Undergraduate students (91.4%) and postgraduate students (8.6%), mostly of 21–25 years of age (64.3%), males (52.7%), females 47.3%	PSS-10	TMJ disorders were more common in udergraduate students in the 21–25 age group, the stress score in the dental environment and the PSS-10 score indicate statistically significant results.
Sójka et al.[19]	324 students	Intensity of stress symptoms (4DSQ), Diagnostic criteria for TMD axis II	In students with TMD, the study showed a higher level of somatic symptoms and more common symptoms of anxiety, stress and depression, and a lower level of sense of coherence than students without TMD symptoms.
Stocka et al.[15]	103 women and 98 men, aged 18 to 21 (mean 19 years)	PSS-10	The average values of masseter muscle activity in the group of people with low stress (75.52 μV ± 15.97) were statistically different from the groups with medium (82.43 μV ± 15.04) and high (81.33 ± 12.05) perceived stress ($P < 0.05$).
Augusto et al.[17]	586 students, 450 (76.8%) female, mean age 24 ± 7 years old	PSS-10 Self-reporting questionnaire (SRQ-20)	The mean perceived stress score was 30.9 ± 6.0 and the median was 32. The median score was used to classify stress as high perceived stress (above the median) and low perceived stress (below the median), obtaining almost half of the sample, 288 students (49.3%) with high perceived stress.
Staniszewski et al.[16]	44 patients with TMD and 44 healthy controls, sex- and age-matched	Salivary cortisol levels	Patients with TMD may have increased hypothalami–pituitary–adrenal (HPA) axis expression with higher cortisol secretion from the adrenal cortex. The results of anxiety/depression and pain scales were significantly higher in the TMD group. Psychological factors may contribute to chronically increased HPA axis expression.
Natu et al.[21]	362 students, including diploma students (aged 17 to 21 years) and postgraduate diploma students (aged 21 years and above)	Depression, anxiety and stress scales-21 (DASS-21)	The total incidence of TMD was 41.8% ($n = 102$), and the majority of oral health impact profile for TMD, including functional limitation ($P = 0.000$), physical pain ($P = 0.000$), decreased fitness ($P = 0.000$) and mental discomfort ($P = 0.001$) showed significant differences in mean scores depending on the severity of TMD. A similar trend was observed for DASS-21. Most participants with TMD (69.6%; $n = 71$) had poor sleep quality ($P = 0.004$).
Paulino et al.[20]	303 students from both sexes, aged 15–25 years old	Hospital anxiety and depression scale (HADS) and oral health-related quality of life (OHRQL) scale using the short version (OHIP-14)	The presence of TMD signs and symptoms was statistically associated ($P \leq 0.05$) with female sex, parafunctional habits, emotional stress and anxiety. Patients represented a greater impairment of OHRQL.
Chisnoiu et al.[22]	Study group: 37 Control group: 42	The Beck anxiety index (BAI)	The values in the BAI questionnaires obtained in patients with TMD were significantly higher compared with the values obtained from patients in the control group.
Toscato et al.[23]	49 women, aged 18–40 years	Salivary cortisol levels	Women with more severe TMD had a higher electrical activity of the masticatory muscles, especially in the anterior temporal muscle, and had higher cortisol levels.

the participants of the study (49,3%) had high levels of perceived stress.[17] In Chisnoiu et al. study, patients with TMD had significantly higher values in the BAI questionnaire: TMD group – median 20 (11;30); control group – median 10 (6; 18). According to the results, presence and levels of anxiety were connected with the sympthoms of anxiety and TMD ($P < 0.001$).[22] Also, in study of Sójka et al., students with TMD had more common symptoms of stress, anxiety and depression and higher level of somatic symptoms.[19] Similar results show study of Staniszewski et al., in which group with TMD had significantly higher scales of depression/anxiety and pain.[16] Paulino et al. study reported, that TMD symptoms and signs are connected with emotional stress and anxiety, but also with parafunctional habits and female sex.[20] In study of Ahuja et al., TMD were more common in undergraduate students (aged 21–25) compared to the post-graduate students, also the PSS score of undergraduate students were higher. In reference to the symptoms of TMD, higher results of PSS score showed statistically significant results only in difficulty in mouth opening ($P = 0.045$).[14] Study of Natu et al. shows, that in patients with TMD physical pain ($P = 0.000$), decreased fitness

(P = 0.000), functional limitation (P = 0.000) and mental discomfort (P = 0.001) showed significant differences in mean scores depending on the TMD severity. Moreover, most TMD patients (69.6%) had a poor quality of sleep.[21] In turn, Chisnoiu et al. and Paulino et al. figure out stress as an important factor affecting TMJ disorders, but it was not the only psychological factor involved in the formation of these dysfunctions.[20,22]

Despite the different methods and research groups Salameh et al.,[18] Staniszewski et al.[16] and Tosato et al.[23] showed increased salivary cortisol levels in patients with TMD. In addition, adults with higher levels of perceived stress usually showed increased activity of chewing muscles, as shown by Tosato et al.[23] and Stocka et al.[15] research. In study of Stocka et al., the average values of bioelectrical activity of masseter muscles in patients with TMD and low level of perceived stress were statistically different from the groups with TMD and medium or high levels of perceived stress (consecutively: 75.52 μV ± 15.97; 82.43 μV ± 15.04; 81.33 ± 12.05).[15] In turn, in Tosato et al. study, female sex and more severe TMD were connected with higher cortisol levels and higher bioelectrical activity of masticatory muscles (especially in the anterior temporal muscles).[23] Research by Staniszewski et al. also indicates increased HPA axis expression in people with TMD. Moreover, the authors suggest that psychological factors may affect to chronically increased expression of HPA axis in TMD patients.[16]

5. DISCUSSION

According to the biopsychosocial treatment model, TMD etiology is multidimensional and takes into account biomechanical (occlusive overload and parafunction), neuromuscular, psychosocial (e.g. stress, anxiety, depression) and biological (e.g. elevated levels of estrogen hormones).[24] It is believed that stress is not only an etiological factor, but it can also exacerbate the symptoms of TMD, including pain in the mandible, temple or ear area.[15] Due to distinct paths of etiology and development of these disorders,[25] determining the impact of stress on the physiological and psychological aspects of health in patients with TMD can help develop comprehensive diagnostics and optimal treatment strategies.

In the author's literature review, all authors except Tosato et al.[23] used questionnaires in their research to assess stress and other psychological parameters in correlation with TMD. The following questionnaires were used: PSS-10, 4DSQ, DASS-21, HADS, BAI. In these works, the level of perceived stress was higher in people with TMD than among those in the control group without TMD, but it was not clearly associated with specific dysfunctions or the intensity of pain. However, as already mentioned, psychological stress is not the only psychological factor correlated with TMD. Anxiety disorders, including anxiety, are discussed in four papers included in this review.[16,19,21,22] In each of them, a significantly higher level of anxiety was observed in people with TMD. Questionnaires for measuring depression symptoms were also used in three studies included in the literature review.[16,19,21] Their results were also significantly higher in patients with TMD. In turn, in the work of Natu et al., people with TMD had a low quality of sleep.[21] Psychological factors are included as factors predisposing to other dysfunctions, in particular those with pain. In the meta-analysis by Stubbs et al. back pain was associated with conditions such as depression, anxiety disorders, sleep disorders and exposure to varying stress levels.[26] High stress episodes are also one of the most common headache triggers for migraine and tension pain.[27] Psychological factors and psychological stress are also often identified in fibromyalgia.[28] All these reports suggest that psychological variables, including exposure to high levels of psychological stress, are associated with pain dysfunctions. However, the mechanism of stress influence in these disorders has not yet been clearly defined.

In the works qualified for the author's review of the literature, in addition to questionnaires, the authors also used objective research methods. Studies on cortisol levels in patients with TMD focused on the effects of stress in combination with other factors. Analysis of Salameh et al. research work results suggests that compared to people without TMD, patients suffering from TMD have higher levels of salivary cortisol, as well as higher levels of depression and anxiety measured by questionnaires.[18] Similar research results can be observed in Staniszewski's papers where patients with advanced TMD have been shown to have significantly higher levels of cortisol than those in the control group, but also a higher total glucocorticosteroid concentration. Also in this study, patients with TMD showed higher anxiety and depression scores, in addition, the results of the questionnaires measuring the level of pain indicated higher values compared to people without TMD.[16] The results of the research of Staniszewski et al.[16] and Salameh et al.[18] overlap with existing knowledge about cortisol. Stress affects cortisol, which is a powerful anti-inflammatory hormone that works to mobilize glucose reserves and modulate inflammation.[29–31] However, a prolonged and/or exaggerated stress response can cause cortisol release dysfunction, causing inflammation. In addition, studies have shown a link between inflammatory cytokines and chronic stress-related pain.[31] Mental stress can also lead to dysregulation of the HPA axis. Disorders of the amount of cortisol produced and controlled by the HPA axis can be defined as hypoactivity or hyperactivity. In relation to TMD, patients most often exhibit hyperactivity of HPA axis.[32,33] This condition is also observed in such disorders as melancholic depression, anxiety disorders or obsessive-compulsive disorder.[32] It is worth emphasizing that the majority of mediators involved in stress response are also substances involved in pain modulation, which explains the contribution of stress to pain transmission and perception.[32]

Another study included in the author's review was the research of Tosato et al., in which the level of cortisol in saliva was correlated with the bioelectric activity of the masticatory muscles.[23] The above authors showed an increased concentration of glucocorticosteroids in correlation with increased masticatory muscle tone and greater severity of

TMD symptoms. Numerous studies indicate increased bioelectrical activity of the masticatory muscles in patients with TMD, however, the mechanism of this phenomenon is not yet known. The work of Tosato et al. allows the hypothesis that increased muscle tension is associated with the activity of the HPA axis.[23] However, according to studies by Glaros et al., increased muscle tone can cause pain.[34] Therefore, this coincides with the thesis that mediators of the stress response and substances involved in pain modulation overlap.[32] In addition, increased muscle tone and pain are factors involved in the formation of parafunctions that are often observed in patients with TMD.[6,9,35] Contrarily, parafunctions like bruxism may be caused also by anxiety and physical or mental stress. In turn, bruxism can affect to e.g. muscles pain or hypertrophy.[36] This situation may lead to the kind of vicious circle of pain – stress cause hyperactivation of HPA axis, next, the tension of masticatory muscles increased, which may affect pain. Pain and hyperactivity of masticatory muscles may be a trigger factor to development of bruxism. In turn, bruxism may lead to escalating of pain and disorders of masticatory muscles. For this reason, it is important to consider the psychological factors in diagnosis and treatment of temporomandibular disorders.

Pain in TMD seems to be a more complex issue. TMD contain different disorders of individual parts of the stomatognathic apparatus, and statistical data are different from each other in different research groups. One of the important factors affecting pain modulation is genetic factors. In the review of Zorina-Lichtenwalter et al. 24 genes combined with chronic pain in TMD were identified and these genes influence among others neurotransmission, immune response, cell growth or metabolism.[37] Moreover, some of them, such as NR3C1, are connected with functioning of the HPA axis.[38] In turn, another, e.g. the COMT gene, is associated with the catecholamine pathway, whose dysfunctions are associated with the occurrence of chronic pain.[39]

The discussed relationships emphasize the need to consider various factors in the etiology of TMD. However, psychological stress seems to combine various groups of factors, including psychological, biochemical and biomechanical factors. The number of parameters discussed, which are affected by high levels of stress, shows its significant role in the formation and process temporomandibular disorders. However, most of the studies included in the review used questionnaire methods, so it is necessary to supplement the issue with more objective research methods, such as electromyography, biochemical methods or genetic research.

6. CONCLUSIONS

(1) Stress is one of the psychological factors involved in TMD pathophysiology.
(2) Increased levels of stress in patients with TMD are associated with elevated levels of cortisol, hyperactivity of the HPA axis and increased bioelectric activity of the masticatory muscles.
(3) There is a need to extend research on the effects of stress on TMD by more objective methods.

Conflict of interest

The authors have no conflicts of interest to declare.

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