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Modern views on the relationship between psychoemotional state and the bioelectrical activity of facial muscles

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Abstract

The paper presents a review of the literature data reflecting the relevance and current views on the problem of facial feedback. It considers the relationship between the bioelectric activity of facial muscles and neuropsychic stress. The modern issues dedicated to the study of the correlation between the indicators assessing the tonic activity of facial muscles and psycho-emotional stress are highlighted. Particular emphasis is placed on the scientific concept of emotional proprioception, according to which facial muscle activity through the trigeminal and facial nerves affects the emotional centers of the brain, by improving or worsening the emotional state. The currently known methods for the correction of psychoemotional states, which are based on the feedback mechanism, are analyzed. The possibilities of using neuromuscular relaxation of the facial muscles to correct psychoemotional conditions are considered.

Keywords: *facial muscles, psychoemotional stress, facial feedback, emotional proprioception, neuromuscular relaxation, medical massage.*

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Introduction

In the modern scientific world, there is a growing interest in the problem of the impact of stress on the mental and physical health of people. A significant increase in workloads, information saturation, and the increasing pace of life have resulted in stress becoming a serious medical and psychological problem [1, 2]. In this regard, the search for affordable and effective methods to reduce nervous and mental stress becomes highly relevant.

The results of numerous studies have shown [3—7] that the emotional states and bioelectrical activity of facial muscles have mutual influence on each other on the principle of facial feedback. Thus, the experience of negative emotions increases the tone of facial muscles, and prolonged tension of facial muscles in turn support and enhance the negative nervous and mental states. At the same time, persistent relaxation of facial muscles through afferent channels breaks the vicious circle between muscle tension and emotional centers of the brain, positively affecting the emotional state.

Most people under stress are not ready to see a psychologist because of unconscious internal tension (anosognosia), are unable to assess and describe their own emotions (alexitism), and recourse to the services of cosmetic massage is often caused by dissatisfaction with their own appearance, which is inextricably linked with a general negative nervous and psychological background. In this regard, neuromuscular relaxation of facial muscles can become an accessible and safe way to correct psycho-emotional states and further improve the aesthetic appearance. However, despite the appearance in recent years of a large number of methods of influence on facial muscles, there is a lack of research on objectivization of the relationship between facial muscle activity and emotional states.

Effect of stress on facial musculature

Leading domestic and foreign physiologists and psychologists [8—10] repeatedly noted that emotional displays during stress experience have complex complex character and lead to disorganization of the whole psychophysiological system of an organism, reducing adaptive possi-

bilities of the person and promoting development of psychosomatic dysfunctions.

Many works [10—13] emphasize the high tonic activity of facial muscles during the stress experience. A number of authors [3, 5, 6, 14, 15] call facial muscles "emotionally significant" or "valence-sensitive", because their functional state is most mediated by neuropsychic states through the mechanism of facial expression. This emotional determinacy is provided by dozens of facial muscles, facial and trigeminal nerves, brain formations of the limbic system, hypothalamus, neocortex [16, 17].

Over the past 30 years, scientists have studied the anatomical patterns of facial muscles depending on the emotions, moods, temperament or affective disorders. The most emotionally susceptible are the chewing muscles (*m. masseter), the* cheekbone muscles (*m. zygomaticus*), the circular mouth muscle (*m. orbicularis oris*) and the eyebrow wrinkling muscle (*m. corrugator*) [18—23].

A special place in the scientific literature is occupied by the issue of *m. masseter* tension when experiencing negative emotions [20—24]. It has been established that chewing muscles are the first to react to stress events, after which the neighboring muscle structures of the face, head, neck and shoulders are involved in the tension chain [10, 24]. The connection between experimentally induced stress and the reaction of *m. masseter has* been proved [10].

According to a systematic review conducted by W. Mieszko and co-author. [23], from 2006 to 2016 about 60 papers were published, the authors of which studied the mental status of patients who complain of pain in the chewing muscles. Of these, 79% of studies focused on the relationship between pain and depression, 42% on anxiety and 21% on mood disorders.

Of scientific interest are studies on the psycho-emotional status of patients with myofascial facial syndrome (MFFL), which is accompanied by a general tension and increase in tone of chewing muscles, as well as reduced mobility of the lower jaw [21—23, 25—27]. Clinical and psychological analysis of MFBL patients showed that chewing muscle spasm in most cases occurs after acute stress and is regularly repeated due to long-term psychologically traumatic events. Patients with MFBL were also found to have complex social relationships (especially with parents), withdrawn, afraid to express feelings, not allowing themselves to express negative emotions, and many of them noted the existence of this pattern since childhood. Often these patients complain about bad moods, apathy, feelings of inner anxiety, loss of interest in life, reduction of social contacts [10, 25, 26].

In 2014. I. Cioffi and co-author. [21] revealed an increased incidence of depression in patients with orofacial pain. In the same year, L. Nadendla and co-author. [27] reported high levels of cortisol in saliva and increased depression in MFBL patients. N. Giannakopoulos and co-author. [22] found that patients with chewing muscle tension were more depressed and restless than healthy people. In investigating the physiology and pathophysiology of stress, many authors have concluded that clenching, or bruxism, has a psychological genesis and is a protective adaptive response of the body [28, 29]. P. Slavichevich [13] called the chewing muscles "an atavistic apparatus for demonstrating emotions", because in primates the exposure of teeth (grin) is used as an immediate reaction to the threat, and the modern person under increased psychological and mental stress suppresses aggression and unconsciously uses the chewing muscles to relieve accumulated negative emotions. D. Manfredini and co-author. [30] examined patients with bruxism and confirmed high levels of anxiety, depression and anger.

A large number of publications are devoted to the study of the eyebrow wrinkling muscle (*m. sorrugator*) and its connection with negative emotional states. In 1985, J. Greden and co-author. [18] in the course of clinical observations revealed that high activity of this muscle is a possible clinical predictor of depression — increased tonicity of *m. sorrugator* forms a P-shaped wrinkle of melancholics and folds of Veragut (eyebrow pulling in the middle part upwards). M. Neta and co-author. [14] defined the eyebrow wrinkling muscle as an "objective measure of the valence of emotions" because the activity of *m. sorrugator* increases reliably in response to negative stimuli and decreases in response to positive stimuli, regardless of the strength of the emotional event. E. Finzi and N. Rosenthal [6, 31, 32] using precise experiments have identified three main emotions that cause increased tone of *m. sorrugator* — anger, fear and sadness. The hyperactivity of *m. sorrugator* due to these three negative emotional states has been confirmed by many studies [15, 33—36].

M. Kunz and co-authors. [37] described the "facial expression of disgust" as a response system in which the following structures are complexly reduced: upper lip muscle (*m. levator labii superioris),* upper lip muscle and nose wing muscle (*m. levator labii superioris alaeque nasi*), mouth circular muscle (m. *orbicularis oris*). *M. corrugator* and *orbicularis oculi are* also included in the experience of disgust.

By the joint efforts of neurologists, psychiatrists and medical psychologists the experimental and theoretical basis of facial muscle neuroanatomy was summarized. Thus, according to many studies [6, 9, 10 15, 26], the increase in the bioelectrical activity of facial muscles is triggered by the limbic-reticular complex and is realized through the system of "facial trigeminal nerves".

A number of authors [38-40] have found that the almond body modulates the emotional response in the mimicry of negative emotions, and the ventromedial prefrontal cortex modulates the mimicry of positive emotions. The results of a study conducted by A. Heller and co-author. [15] in 2014, showed that the experience of negative emotions is associated with the activation of the amygdala body and deactivation of the ventromedial prefrontal cortex.

Feedback and its role in correcting psycho-emotional states

In addition to the descending influence of the central nervous system on the state of facial musculature, there is also an ascending effect — from the facial muscles through the afferent channels to the emotional centers of the brain. The *facial feedback hypothesis* is based on the fact that facial muscles not only express emotions, but also enhance emotional experiences [33, 34, 41, 42]. Stress factors and facial muscles potentiate each other mutually, forming a closed circle of experienced emotions, which is implemented on the principle of facial (mimic) feedback [31, 32, 34—36]. Studies using electromyography have confirmed the ability of facial expression to initiate emotions [5, 19, 43, 44].

American scientists E. Finzi and N. Rosenthal [6] advanced the scientific concept of "emotional proprioreception," according to which facial muscle activity through the branches of the trigeminal and facial nerves affects the brain structures that provide emotional regulation (amygdala, bluish spot of the brain stem, cingulate gyrus, ventromedial prefrontal cortex). According to the authors, persistent muscle relaxation, which breaks the vicious circle between muscle tension and emotional centers of the brain, can have a positive psycho-emotional effect [6, 31, 32].

Optimal biological model to test the E concept. Finzi and N. Rosenthal has experienced the use in neurology of botulinum toxin, which acts in the neuromuscular compounds, inhibiting the release of neurotransmitter acetylcholine, thereby weakening the contraction of muscle fibers responsible for their excessive involuntary movements.

In 2012-2014, the first randomized controlled botulinum toxin studies were conducted, which showed that a single injection into the area of the eyebrow wrinkling muscle (*m. corrugator*) can lead to long-term depression relief. In contrast, denervation of the *orbicularis oculi* (*m. orbicularis oculi*), which participates in the expression of joy and happiness, has the opposite effect — it causes depressive states [33-35, 45, 46].

E. Finzi and N. Rosenthal [6, 31-32] suggested using injections of botulinum toxin into the muscle that wrinkles the eyebrow (*m. corrugator*), the chronic tension of which, as mentioned above, leads to the development of anxiously depressive states. Patients with post-traumatic stress disorder, migraine, depressive disorder after injections of botulinum toxin type A were found to receive long-term (3 to 6 months) relief of depressive symptoms.

Modern methods of correction of psycho-emotional states based on facial feedback

K. França and T. Lotti [46] believe that botulinum therapy can become the standard therapeutic approach in treating depression. However, there is increasing evidence that botulinum toxin treatment methods have a mixed impact on the psychological reactions of patients. Thus, some scientists have found [34, 45, 47—49] that after denervation of *m. corrugator* patients have a reduced emotional reactivity, difficulties in processing the emotional language, its subtleties and shades, due to low activation in the amygdala of the brain. Besides, procedures with botulinum toxin reliably reduce sexual function, as they denervate the muscles used for sexual excitation — *m. corrugator*, *m. orbicularis oculi* [34, 50, 51]. Thus, the question of applying botulinum therapy in the correction of neuropsychiatric conditions is debatable.

In addition to botulinum therapy, body-oriented therapies that reduce chronic skeletal-muscular tension are widely used to correct facial musculature tone, which include physical exercise, massage, breathing techniques and analytical work of the patient on the understanding of body blocks.

The following areas of body-oriented therapy have gained popularity: vegan therapy (W. Reich), roll-fing (I. Rolf), the Feldelkreis method (M. Feldenkreis), bioenergetical analysis (A. Lowen), biodynamics (G. Rolph), and bioenergetical analysis (G. Rolph). Bojesen), Alexander's method (F. Alexander), Rosen-method (M. Rosen), biosynthesis (D. Boadella), in which muscle relaxation techniques are grouped according to different physiological principles and therapeutic effects [52—55].

In fundamental works on body-oriented therapy B. Reich [53] assumes the application of special methods of myogymnastics in the orbital, jaw and throat areas using postisometric relaxation of facial muscles. However, this method did not develop further, as most body-oriented therapies included work mainly on the skeletal muscles, while facial muscle recovery received little attention.

In role-playing I. Rolf [54] pays attention to the muscles serving the temporomandibular joint in one of the 10 correction stages. The relaxation of the chewing muscles according to the M. Fendelkreis method [55] is carried out with the help of slow movements of the lower jaw, when the patient is offered to recognize the imbalance in the tension of the muscles and ligaments independently. According to R. Slavichek [13], these methods of correction are ineffective, because to reduce the tone of the chewing muscles requires a comprehensive approach that affects the anatomical structures of the entire chewing apparatus — the muscles of the mouth diaphragm, the ligament apparatus of the temporomandibular system, temporal muscles, muscles that provide the position of the head, throat, neck and shoulder belt. However, body-oriented therapies were born at a time when objective measuring equipment was not available and it was difficult to verify their impact. The relaxation of the face, which is usually noted by patients after body-centric therapy procedures, can be seen as subjective sensations that are not supported by objective research. Perhaps the improved well-being is due to the effect of general relaxation. At present, an objective assessment of the effectiveness of body-centric therapy methods is difficult due to the lack of modern work based on evidence.

In medical practice, physiotherapeutic methods (laser therapy, cryotherapy, oxygen therapy, magnetotherapy), kinesiotherapy, myogymnastics, acupuncture, as well as dental trainers are used to correct facial muscle hypertonicity, which are designed to reduce parafunction in the chewing muscles [10, 26, 56]. Application of these procedures reduces muscle activity, improves metabolic processes in the area of muscle damage, restores muscle functional activity, improves the condition of blood vessels and nerve fibers.

However, most non-medical methods of exposure are usually used in connection with neurological diseases — prostopalgia of the face, facial MFBS, temporomandibular joint dysfunction, neuropathy of the facial nerve — and aim not so much to improve the psycho-emotional state, but to relieve painful discomfort [56, 57].

When the problem of increased tone of facial muscles concerns healthy ones, its solution goes beyond the scope of medical care, because manifestations of muscle hypertension are latent, do not significantly affect quality of life and manifest themselves occasionally in the form of involuntary clenching of teeth, stiffness in expression of facial expressions, swelling of soft tissues of the face, pain in chewing, swallowing or emotional stress, fatigue of muscles during articulation load [13, 24]. Often facial muscle hypertonicity is a diagnostic finding in the course of cosmetic, massage or dental procedures. However, the gradual accumulation and aggravation of tension processes can lead to neurological conditions — blepharospasm, trismus of the chewing muscles, contracture of mimic muscles requiring long-term medication correction.

Taking into account all the above and based on practical experience, we can assume that there is an affordable method of solving this problem, which is based on the positive impact of cosmetic massage on facial muscles. Thus, it has been shown [58] that cosmetic massage has a positive effect not only on the aesthetics of the face, but also on the emotional state of patients, improving their health and mood. However, these manipulations are mainly aesthetically oriented and do not solve deep muscle tension. A more elaborate and differentiated algorithm for working with facial muscles is likely to be required to improve the effectiveness of the effect.

Nowadays the directions of medical facial massage are developing, which intensively influence deep structures, having a pronounced effect on muscular, connective, adipose tissue, vessels and nerves, causing expansion of functioning and opening of reserve capillaries, due to which the tissue trophicity improves, muscle tone decreases, venous blood outflow increases, lymph circulation increases, face swelling is eliminated [59, 60]. The effectiveness of such procedures is undeniable both aesthetically and therapeutically; nevertheless, there are no data on studies demonstrating the objective influence of the presented medical massage techniques on the psycho-emotional state of patients.

Conclusion

Thus, according to the presented research review, increased bioelectrical activity of facial muscles is one of the markers of mental tension and emotional stress. Stress factors and facial muscles mutually potentiate each other, forming a closed circle of experienced emotions, which is implemented on the principle of facial (mimic) feedback. Reducing the increased bioelectrical activity of facial muscles may lead to persistent psycho-emotional relaxation. Further research aimed at studying the dynamics of psycho-emotional disorders in the course of conducting procedures of neuromuscular relaxation of the face will contribute to the formation of evidence for their possible use as a psychologically corrective tool.

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