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APPROACHES TO OVERCOME POST-TRAUMATIC PAIN SYNDROME IN VETERANS

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Abstract. Post-traumatic pain syndrome in combat veterans in Ukraine is today one of the most acute problems of the healthcare system and national security. The specifics of modern combat operations, characterized by a high frequency of mine-explosive injuries and combined injuries, leads to the formation of complex pain conditions that often become chronic.

The modern strategy for overcoming post-traumatic pain in veterans is based on the principles of multimodality and personalization. The traditional biomedical model, which is focused mainly on pharmacological suppression of symptoms, is now actively supplemented by the biopsychosocial model. This approach considers pain as the result of the interaction of biological disorders, psychological states and social factors.

Purpose of the research. To conduct an analysis of the scientific literature and substantiate the effectiveness of modern approaches to correct post-traumatic pain syndrome in combat veterans.

Research results. The clinical picture of post-traumatic pain is characterized by significant polymorphism. Patients may complain of localized pain in the scar area, phantom sensations after amputations, as well as diffuse pain covering large areas of the body. A special place is occupied by the neuropathic component of pain, which manifests itself as burning, shooting or electric current sensations. Clinical manifestations are often aggravated by comorbid conditions, such as sleep disorders, depressive disorders and post-traumatic stress disorder, which creates a vicious circle of pain and psychological maladjustment.

The modern strategy for overcoming post-traumatic pain in veterans is based on the principles of multimodality and personalization. Pharmacological treatment remains an important basis, but it often has limited effectiveness in chronic conditions and carries the risk of side effects or addiction. Therefore, the global medical community is increasingly turning to non-invasive methods. Among them, interventional technologies, neurostimulation methods and psychological correction occupy a special place. An important trend is the use of virtual reality and biofeedback technologies, which allow influencing the higher centers of pain regulation in the brain.

Conclusions.

1. Theoretical analysis of the problem of post-traumatic pain syndrome in war veterans has shown that this condition is a complex neurophysiological phenomenon that goes beyond a simple reaction to tissue damage.

2. The modern paradigm of veteran rehabilitation is shifting from a purely biomedical model to a biopsychosocial one, where priority is given to multidisciplinary interaction and personalized programs. It has been established that the most promising approaches are those that integrate neuromodulatory technologies, virtual reality and cognitive-behavioral methods with traditional means of recovery.

3. Physical therapy plays a key role in the system of medical rehabilitation, acting as a connecting link between clinical treatment and social reintegration. It provides not only physical recovery and restoration of mobility, but also forms in veterans the skills of self-control over pain, which is a basic condition for their independence and high quality of life.

4. The scientifically substantiated effectiveness of physical therapy methods in chronic pain is based on the principles of neuroplasticity and activation of the body's internal reserves. It has been proven that the complex use of physical rehabilitation methods (therapeutic exercises, neurodynamics, mirror therapy) allows to significantly reduce the intensity of pain, improve the functional state and psycho-emotional stability of veterans.

Keywords: post-traumatic pain syndrome, chronic pain syndrome, mine-explosive trauma, physical exercises, neurotechnology, mirror therapy, physical therapy, veterans.

Introduction. Post-traumatic pain syndrome (PTPS) in combat veterans in Ukraine today is one of the most acute problems of the healthcare system and national security. The specifics of modern combat operations, characterized by a high frequency of mine-explosive injuries and combined injuries, leads to the formation of complex pain conditions, which often become chronic. Such conditions not only limit the physical performance of veterans, but also cause deep social maladjustment, which requires the search for new, more effective approaches in physical therapy that go beyond traditional drug pain relief [1, 2].

Purpose of the research. To conduct an analysis of the scientific literature and substantiate the effectiveness of modern approaches to correct post-traumatic pain syndrome in combat veterans.

Research results. In modern scientific literature, post-traumatic pain syndrome is considered not simply as a symptom of tissue healing, but as the result of pathological restructuring of the nervous system, which includes both peripheral receptors and central mechanisms of information processing [3, 4].

The etiology of pain syndrome in combatants is often associated with damage to the musculoskeletal system and peripheral nerves [5]. The specificity of combat trauma lies in a large area of molecular shock, which leads to the formation of long-term foci of inflammation and degenerative changes in nerve fibers. In addition to the physical factor, an important component is the sensitization of the nervous system, when, as a result of repeated pain impulses, the sensitivity threshold decreases, and even ordinary touches or movements begin to be perceived as painful [6].

The clinical picture of post-traumatic pain is characterized by significant polymorphism. Patients may complain of localized pain in the scar area, phantom sensations after amputations, as well as diffuse pain covering large areas of the body.

A special place is occupied by the neuropathic component of pain, which manifests itself as burning, shooting or electric current sensations. Clinical manifestations are often aggravated by comorbid conditions, such as sleep disorders, depressive disorders and post-traumatic stress disorder (PTSD), which creates a vicious circle of pain and psychological maladjustment [7].

The clinical picture demonstrates a high degree of individualization of the pain experience, where psychological factors play no less a role than somatic ones. The presence of neuropathic and phantom components indicates a deep lesion of the conductive pathways, which requires specific methods of therapy aimed at restoring correct sensory information.

Therefore, etiological diversity requires a differentiated approach to diagnosis and the selection of physical therapy at different stages of recovery.

The relationship between etiology and pain manifestations emphasizes the need for a multidisciplinary evaluation of the veteran. Understanding that myofascial pain may be secondary to central sensitization or PTSD allows the physical therapist to appropriately prioritize treatment, from passive pain management to active cognitive-motor exercises.

The modern strategy for overcoming post-traumatic pain in veterans is based on the principles of multimodality and personalization [8]. The traditional biomedical model, which is focused mainly on pharmacological suppression of symptoms, is now actively supplemented by the biopsychosocial model. This approach considers pain as the result of the interaction of biological disorders, psychological states and social factors. Accordingly, modern rehabilitation is aimed not only at eliminating the nociceptive signal, but also at increasing the functional capabilities of a person and his adaptation to life with existing limitations [9].

Pharmacological treatment remains an important basis, but it often has limited effectiveness in chronic conditions and carries the risk of side effects or addiction.

Therefore, the global medical community is increasingly turning to non-invasive methods. Among them, interventional technologies, neurostimulation methods and psychological correction occupy a special place. An important trend is the use of virtual reality and biofeedback technologies, which allow influencing the higher centers of pain regulation in the brain [10, 11].

Modern rehabilitation also emphasizes the active participation of the patient himself in the treatment process. Instead of passively receiving procedures, veterans are involved in educational programs where they learn to understand the nature of their pain and methods of self-regulation. This allows reducing the level of pain catastrophizing and increasing motivation to perform physical exercises. The combination of technological innovations with classical approaches creates conditions for the most complete recovery of patients [12].

Analysis of modern approaches indicates a gradual transition from aggressive drug strategies to more sparing and intelligent rehabilitation methods. Pharmacotherapy remains indispensable in the acute period, however, neuromodulatory and digital technologies are becoming a priority for the treatment of chronic post-traumatic pain in veterans. This is due to their ability to directly influence the neuroplasticity of the brain, which is a key factor in overcoming central sensitization.

Of particular importance is the combination of physical methods with cognitive correction. A veteran who understands the mechanism of his pain and sees progress in virtual reality demonstrates a significantly higher level of compliance. The advantage of such methods as VR and mirror therapy lies in their safety and ability to work

with phantom sensations, which are often not amenable to conventional treatment. However, their implementation is limited by the technical base and the need for specialist training.

Physical therapy occupies a fundamental place in the system of medical rehabilitation of veterans, acting not simply as a method of auxiliary treatment, but as a strategic axis around which the entire recovery of the patient is built [13]. In the context of working with veterans suffering from post-traumatic pain syndrome, the role of the physical therapist is transformed from an exercise instructor to a specialist in the management of neuroplasticity and functional adaptation.

The basis of physical therapy in modern rehabilitation practice is the biopsychosocial approach [14]. In contrast to traditional medicine, which often focuses on eliminating the symptom (pain) with pharmacological agents, physical therapy views pain as a desynchronization between the biological state of tissues, the psychological perception of threat and the social ability of the individual to be active. The central role of the therapist is to identify and break the «vicious circle» of pain: when injury leads to pain, pain leads to mobility limitation, mobility limitation leads to atrophy and degeneration, which, in turn, increases pain sensations [15, 16].

In the system of rehabilitation of veterans, physical therapy performs several critically important functions:

1. Modulation of antinociceptive mechanisms: Due to dosed physical activity, endogenous pain suppression systems are activated (release of endorphins and endocannabinoids). This allows to lower the sensitivity threshold and reduce the phenomena of central sensitization, which is characteristic of chronic PTSD [17].

2. Reconstruction of movement stereotypes: Combat injuries, wearing heavy equipment and prolonged stay in static tense postures form pathological movement patterns. Physical therapy is aimed at retraining muscle chains, restoring normal biomechanics of walking and posture, which reduces the load on the injured segments [18].

3. Prevention of secondary degenerative changes: Prolonged pain often leads to kinesiophobia (fear of movement). The physical therapist helps the patient overcome this barrier, preventing the development of contractures, soft tissue fibrosis, and osteoporosis that often accompany chronic conditions after injury [19, 20].

4. Neurosensory integration: Working with veterans after amputations or nerve damage requires specific intervention. Physical therapy in such cases is aimed at restoring proprioception - the brain's ability to adequately perceive the body's position in space, which is key in combating phantom pain [21].

A separate aspect of the role of physical therapy is the adaptation of methods to the specifics of the «military patient». This includes working with the consequences of mine and blast injuries, where pain is often diffuse and accompanied by cognitive impairment after concussions. The therapist must have the skills to differentiate the type of pain (nociceptive, neuropathic, or nociplastic) and flexibly change the strategy: from gentle myofascial release techniques to intensive weight training [22].

An important component is also patient education (Pain Neuroscience Education). The physical therapist acts as a teacher who explains to the veteran that pain does not always equal damage. This knowledge is critical for patients whose nervous system is in a state of hyperreactivity after combat stress. By teaching the veteran self-help methods, self-massage, and ergonomics, the therapist delegates some of the responsibility for recovery to the patient himself, which significantly increases the effectiveness of the intervention [23].

Physical therapy acts as a bridge between the medical institution and the real world. By restoring physical strength and reducing pain, therapy directly affects the psychoemotional state of the veteran, reducing symptoms of depression and anxiety. Success in performing a physical exercise that the patient previously considered impossible due to pain becomes a powerful psychological incentive. The ultimate goal of physical therapy is not simply the disappearance of pain, but the achievement of a level of functioning that allows the veteran to return to professional activities, sports, and an active social life [24, 25].

Therefore, the role of physical therapy is integral and system-forming. It combines deep knowledge of anatomy and physiology with psychological support skills, creating conditions for a comprehensive transformation of a veteran from a «patient with trauma» to an «active member of society». Without professionally organized physical therapy, the rehabilitation of individuals with PTSD would remain only a passive expectation of tissue healing, while active therapy makes this process manageable, predictable and effective.

Assessment of the effectiveness of physical therapy methods in chronic pain syndrome (CPS) in veterans is a critically important aspect of modern rehabilitation science. Chronic pain after combat injuries often becomes an autonomous pathological condition that persists for a long time after the healing of primary wounds. The effectiveness of physical therapy in this context is based on the concept of neuroplasticity and the ability to modulate both peripheral and central links of the pain system. Unlike symptomatic pharmacological effects, physical therapy methods are aimed at reorganizing motor control and restoring normal afferent impulses from injured areas [26].

The scientific evidence for the use of physical exercises, manual techniques and innovative technologies (such as neurodynamics or mirror therapy) is confirmed by numerous clinical studies. The main criterion for effectiveness is not only a decrease in pain intensity on the visual analogue scale (VAS), but also an improvement in the functional capacity, quality of sleep and psychoemotional stability of the patient [27]. The success of therapy depends on the correct choice of method according to the type of pain (nociceptive, neuropathic or dysfunctional) and the stage of the rehabilitation process [28].

The analysis of the presented methods allows us to state that the maximum effectiveness of physical therapy

in chronic pain syndrome is achieved not through the isolated use of one technique, but through their integration into an individual program. Traditional exercises lay the foundation for physical fitness, while specific neurotechnologies (mirror therapy, VR) allow you to work with the most complex forms of pain - neuropathic and phantom.

The key factor in effectiveness is the transition from passive methods (where the patient only receives the impact) to active and cognitive strategies. Teaching a veteran to understand the nature of pain in combination with dosed loads allows you to reflash the body's «alarm system». This proves that physical therapy for chronic pain syndrome is a high-tech process of managing neuroplasticity, which provides not temporary relief, but a fundamental change in the functioning of the nervous system and musculoskeletal system of the veteran.

Conclusions.

1. Theoretical analysis of the problem of post-traumatic pain syndrome in war veterans showed that this condition is a complex neurophysiological phenomenon that goes beyond a simple reaction to tissue damage.

2. The modern paradigm of veteran rehabilitation is shifting from a purely biomedical model to a biopsychosocial one, where priority is given to multidisciplinary interaction and personalized programs. It has been established that the most promising approaches are those that integrate neuromodulation technologies, virtual reality and cognitive-behavioral methods with traditional means of recovery.

3. Physical therapy plays a key role in the medical rehabilitation system, acting as a connecting link between clinical treatment and social reintegration. It provides not only physical recovery and restoration of mobility, but also forms in veterans the skills of self-control over pain, which is a basic condition for their independence and high quality of life.

4. The scientifically proven effectiveness of physical therapy methods for chronic pain is based on the principles of neuroplasticity and activation of the body's internal reserves. It has been proven that the comprehensive use of physical rehabilitation methods (therapeutic exercises, neurodynamics, mirror therapy) allows to significantly reduce the intensity of pain, improve the functional state and psycho-emotional stability of veterans.

Prospects for further research. Our research is aimed at finding new and improving existing rehabilitation programs after myocardial infarction.

Conflict of interest. The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other conflict that could affect the research and its results presented in this article.

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ПІДХОДИ ЩОДО ПОДОЛАННЯ ПОСТТРАВМАТИЧНОГО БОЛЬОВОГО СИНДРОМУ У ВЕТЕРАНІВ

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Резюме. Посттравматичний больовий синдром (ПТБС) у ветеранів бойових дій в Україні сьогодні є однією з найбільш гострих проблем системи охорони здоров'я та національної безпеки. Специфіка сучасних бойових дій, що характеризуються високою частотою мінно-вибухових травм та поєднаних поранень, призводить до формування складних больових станів, які часто стають хронічними.

Сучасна стратегія подолання посттравматичного болю у ветеранів базується на принципах мультимодальності та персоналізації. Традиційна біомедична модель, яка орієнтована переважно на фармакологічне пригнічення симптомів, сьогодні активно доповнюється біопсихосоціальною моделлю. Цей підхід розглядає біль як результат взаємодії біологічних порушень, психологічних станів та соціальних факторів.

Мета дослідження. Провести аналіз наукової літератури та обґрунтувати ефективність сучасних підходів щодо корекції посттравматичного больового синдрому у ветеранів бойових дій.

Результати досліджень. Клінічна картина посттравматичного болю характеризується значним поліморфізмом. Пацієнти можуть скаржитися на локалізований біль у зоні рубців, фантомні відчуття після ампутацій, а також на дифузні болі, що охоплюють великі ділянки тіла. Особливе місце посідає нейропатичний компонент болю, який проявляється печінням, простріли або відчуттям проходження електричного струму. Клінічні прояви часто обтяжуються коморбідними станами, такими як порушення сну, депресивні розлади та посттравматичний стресовий розлад, що створює замкнене коло болю та психологічної дезадаптації.

Сучасна стратегія подолання посттравматичного болю у ветеранів базується на принципах мультимодальності та персоналізації. Фармакологічне лікування залишається важливою базою, проте воно часто має обмежену ефективність при хронічних станах і несе ризик побічних ефектів або залежності. Тому світова медична спільнота все частіше звертається до неінвазивних методів. Серед них особливе місце посідають інтервенційні технології, методи нейростимуляції та психологічна корекція. Важливою тенденцією є використання технологій віртуальної реальності та біологічного зворотнього зв'язку, які дозволяють впливати на вищі центри регуляції болю в головному мозку.

Висновки.

1. Теоретичний аналіз проблеми посттравматичного больового синдрому у ветеранів війни показав, що цей стан є складним нейрофізіологічним феноменом, який виходить за межі простої реакції на пошкодження тканин.

2. Сучасна парадигма реабілітації ветеранів зміщується від суто біомедичної моделі до біопсихосоціальної, де пріоритет надається мультидисциплінарній взаємодії та персоналізованим програмам. Встановлено, що найбільш перспективними є підходи, які інтегрують нейромодуляційні технології, віртуальну реальність та когнітивно-поведінкові методи з традиційними засобами відновлення.

3. Фізична терапія відіграє ключову роль у системі медичної реабілітації, виступаючи сполучною ланкою між клінічним лікуванням та соціальною реінтеграцією. Вона забезпечує не лише фізичне одужання та відновлення мобільності, а й формує у ветеранів навички самоконтролю над болем, що є базовою умовою їхньої незалежності та високої якості життя.

4. Науково обґрунтована ефективність методів фізичної терапії при хронічному болю базується на принципах нейропластичності та активації внутрішніх резервів організму. Доведено, що комплексне застосування засобів фізичної реабілітації (терапевтичних вправ, нейродинаміки, дзеркальної терапії) дозволяє суттєво знизити інтенсивність болю, покращити функціональний стан та психоемоційну стабільність ветеранів.

Ключові слова: посттравматичний больовий синдром, хронічний больовий синдром, мінно-вибухова травма, фізичні вправи, нейротехнології, дзеркальна терапія, фізична терапія, ветерани.

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