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EFFECTIVENESS OF ANATOMICAL COMPRESSION TEXTILES COMBINED WITH MANUAL MASSAGE DEVICES IN POST-TRAUMATIC REHABILITATION

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Abstract. *The article focuses on analyzing the effectiveness of anatomical compression garments combined with manual massage devices in the process of post-traumatic rehabilitation. The aim of the study is to explore practical applications and new approaches to using anatomical compression garments and manual massage tools in rehabilitation after trauma. The study employed general scientific methods of cognition: analysis, synthesis, generalization, systematization, modeling, as well as elements of empirical observation. The findings indicate that anatomical compression garments serve as an effective tool for external therapeutic stabilization due to the precisely measured pressure they provide, which enhances proprioceptive control, reduces pain, normalizes blood circulation and lymphatic drainage, and supports musculoskeletal balance. It was found that mechanical support of damaged structures is complemented by a positive impact on neurophysiological processes occurring during recovery. A high level of effectiveness is achieved through the use of personalized products tailored to the patient's morphofunctional characteristics using three-dimensional scanning technology. The study also examined the effect of massage tools, particularly percussion devices, on soft tissue structures. It was demonstrated that these tools activate the mechanoreceptor system, stimulate regenerative processes, improve microcirculation, reduce pain, and eliminate fascial restrictions. The use of percussion devices was proven to effectively decrease muscle tension, increase range of motion, and reduce muscle fatigue, which is especially important during the early rehabilitation stage. The practical value of the study lies in the development of an effective individualized recovery system after trauma, which can be implemented in both clinical and outpatient practice.*

Keywords*: compression garments, massage devices, neuroorthopedics, rehabilitation, personalization.*

Introduction

Post-traumatic rehabilitation encompasses a wide range of clinical, physiological, and functional challenges. All of these not only affect the duration and quality of the recovery process but also significantly worsen patients' overall well-being and reduce their motivation to actively engage in rehabilitation programs. Among the most common complications are chronic pain, instability of affected anatomical structures, decreased proprioception, muscle weakness, reduced tolerance to physical exertion, as well as anxiety and depressive symptoms [1].

Chronic pain syndrome holds a particularly significant place among these complications. Its development is usually associated with prolonged inflammatory or

degenerative changes in the joints and soft tissue structures. Pain complicates mobilization, disrupts physical activity, and lowers treatment compliance. Concurrently, repeated microtraumas, neuromuscular coordination disorders, and the formation of compensatory movement patterns may occur, further exacerbating functional limitations.

Issues of the post-traumatic period have been extensively covered in scientific literature. Researchers highlight not only chronic pain but also major difficulties in restoring joint stability – especially in cases involving ligamentous damage. This creates favorable conditions for re-injury and complicates the recovery of active motor control [1]. When traumatic injuries are accompanied by disrupted sensorimotor integration, the need arises for additional external stabilization tools and sensory support.

In clinical practice, some patients opt for specialized compression garments to support anatomical stability and enhance proprioceptive control. Others turn to manual methods, such as massage or the use of specialized handheld massage devices. Both approaches are actively discussed in scientific and applied expert literature. However, the combination of these two methods – compression therapy and manual mechanostimulation – requires systematic investigation. This combination may offer a more holistic, physiologically grounded approach to post-injury recovery and represents the primary focus of this study.

Literature Review

Significant contributions to the understanding of compression therapy have been made by authors such as K. Benistan, B. Pontier, C. Leblond et al. [1], who demonstrated the effectiveness of compression garments in reducing pain among patients with Ehlers-Danlos syndrome, which may also be relevant for post-traumatic rehabilitation. R. Liu and X. Guo [5], along with Y. Shi and co-authors [8, 9], focused on the design, biomechanical assessment, and modeling of textiles, enabling the adaptation of compression tools to individual patient characteristics.

As for massage devices, the study by S. Butala, P.V. Galido, and B.K.P. Woo [2] examined consumer perceptions of home percussion massagers. Additionally, the

systematic review by R.M. Ferreira et al. [3] summarized the effects of massage guns on recovery and physical performance, directly related to the rehabilitation topic. The work by J. Martin [7] critically evaluated the effectiveness of such devices for lower limb mobility, highlighting both positive and controversial aspects of their use.

The research also involved expert literature from contemporary online sources, including materials from Physio-pedia [4], Amplify-pt [6], Opusbiological [10], and Donaldmowldsmd [11], which cover practical aspects of using compression and massage in rehabilitation practices.

The aim of the study is to explore practical applications and new approaches to using anatomical compression garments and manual massage devices in post-traumatic rehabilitation.

Research Results

Anatomical compression garments are gradually becoming an important element in the modern system of post-traumatic rehabilitation due to their ability to influence a range of pathological processes that occur after injury. These processes include chronic inflammation, joint instability, edema, tissue trophic disorders, sensorimotor dysfunctions, and various types of pain syndromes, including neuropathic pain. Their clinical effectiveness directly depends on the precisely calculated external pressure generated by the structure of the textile material, which envelops the patient's body and interacts with it according to the laws of physics and mechanics [9].

In a research context, Shi Y., Ye C., and Liu R. paid particular attention to the anatomical structure of the lower limbs, where they identified three main components:

- superficial tissues, including the skin, subcutaneous fat, and superficial venous system;
- deep soft tissues, represented by muscles, tendons, and deep veins;
- rigid structures, including the bony component.

To model biomechanical processes in the compression system, the researchers recommend using artificial biomodels made from materials that closely replicate the properties of biological tissues. These include, for example, silicone and polyurethane composites, which make it possible to accurately reproduce the tissue response to

compression and, consequently, improve the parameters of compression textiles for clinical use [9].

Beyond the physiological effects of compression garments, the subjective aspects of wearing them are also crucial. Ergonomic comfort, assessed using specialized scales such as the visual analog scale and standardized questionnaires, has demonstrated its key role in enhancing therapeutic adherence. This is particularly important during the active phase of rehabilitation, when physical activity increases and patients must engage in regular exercise. The comfort of the garment, its anatomical fit, and the quality of sensory perception significantly influence the overall effectiveness of the recovery process [8].

Scientific studies [8–9] also confirm that compression textiles can serve as an effective adjunct in physical therapy for conditions such as chronic venous insufficiency, lymphostasis, musculoskeletal instability, and scar formation. Research on the mechanisms of action of compression textiles [5] emphasizes the crucial role of the physical and mechanical properties of the fabric – its elasticity, stiffness, resilience, and hysteresis – which depend on technological factors such as weaving technique, fiber composition, and usage conditions. These properties determine the garment's ability to fulfill its function without causing additional strain or discomfort [5].

Particular attention has been given to a cohort study analyzing the use of custom-made compression garments in patients with the hypermobile type of Ehlers-Danlos syndrome. Over a two-year period, clinical changes were regularly assessed using pain, proprioception, balance, subluxation frequency, and functional autonomy scales. A significant reduction in pain intensity was observed as early as six months into the study and was maintained throughout the observation period. In addition to the analgesic effect, improvements in stability, a decrease in dislocation frequency, and positive trends in balance measures were recorded. Although not all parameters reached statistical significance, the overall trend was consistently positive [1].

The complex mechanism of action of compression garments is determined by several key factors.

First, improved proprioception is observed, which is linked to increased sensory

activity of cutaneous and subcutaneous receptors involved in joint position regulation and motor coordination.

Second, a reduction in neuropathic pain intensity likely results from the blocking of nociceptive signals at the spinal cord level, in accordance with the “gate control” theory.

Third, soft tissue stabilization and the reduction of micromovements in the injury area contribute to decreased inflammatory activity.

Equally important is the psychophysiological component: the sensation of external stabilization helps reduce anxiety and fear of pain or re-injury, which positively affects the patient’s emotional state [1].

Overall, a well-fitted compression garment not only performs a mechanical function but also integrates into the body’s complex neurophysiological system, supporting a more holistic and effective post-traumatic recovery. Its use requires a systematic approach based on both objective biomechanical indicators and the subjective experience of patients undergoing the demanding process of rehabilitation.

Massage, in turn, as one of the oldest and most widely used physical therapy methods, plays a key role in physiological recovery after injury. Its application is based on the ability to influence several critical aspects of pathological conditions – pain relief, improved circulation, reduced muscle tension, enhanced tissue metabolism, and overall improvement of the musculoskeletal system’s functional state. Advances in clinical physiotherapy have led to the development of specialized techniques with proven effectiveness in treating traumatic injuries. One such method is instrument-assisted myofascial mobilization, which uses specialized tools to target the skin, fascia, muscles, and tendons. This allows for more precise control over the force and direction of mechanical impact, which is particularly important when treating structural changes in soft tissues resulting from trauma, surgery, or chronic overuse [4].

The physiological mechanism of action behind instrument-assisted myofascial mobilization involves controlled microtrauma to the soft tissues, triggering a localized inflammatory response. This initiates cell regeneration, stimulates fibroblast proliferation, increases collagen synthesis, and promotes extracellular matrix

remodeling. As a result, adhesions, fibrotic tissue, and excessive scar formation – which often hinder tissue elasticity and limit normal range of motion – can be reduced or eliminated [4].

In addition to morphological changes, this method also produces significant neurophysiological effects. Stimulating mechanosensitive receptors in the tissues improves sensory feedback, enhances two-point discrimination, and lowers the pain perception threshold through modulation of nociceptor activity. These neurophysiological effects make the method especially promising for treating musculoskeletal pain, fascial restrictions, and myofascial pain syndrome [4].

Alongside manual techniques, handheld massage tools – particularly percussion-type devices – occupy a valuable niche in post-injury rehabilitation. In a review study, Martin J. analyzed the effectiveness of so-called “massage guns” in improving lower limb muscle function. The analysis compared these devices to other self-myofascial release methods. It was found that percussion devices contribute to increased joint range of motion and reduced muscle soreness and discomfort, especially in cases of delayed-onset muscle soreness after physical exertion. However, no significant effects on muscle strength or activation were observed following their use [7].

According to a systematic review of studies, massage devices are moderately effective in improving soft tissue properties in the lower limbs. This is particularly evident in the flexibility of muscle groups such as the iliopsoas, hamstrings, calf muscles, and the muscles of the posterior thigh. Their use is associated with reduced muscle stiffness and increased range of motion, which is especially important during the early phase of post-traumatic rehabilitation, when patients experience limited mobility due to pain, swelling, or muscle overstrain [3].

In addition to enhancing flexibility and comfort, massage devices show potential in reducing fatigue and muscle soreness after training or in cases of overload, which is typical for patients with musculoskeletal injuries. This effect is believed to be caused by localized increases in blood flow, reduced muscle fiber tone, and decreased fascial tension. These mechanisms contribute to an overall reduction in sensory discomfort and improved movement quality in functionally restricted areas [3].

At the same time, despite these advantages, no reliable positive effects have been identified regarding functional parameters such as muscle strength, balance, speed, or explosive power. In some cases, short-term declines in these indicators were recorded, which may result from temporary reductions in neuromuscular activation following intensive percussion stimulation. Moreover, no statistically significant changes were found in physiological indicators such as muscle contraction duration, perceived exertion, or blood lactate concentration, suggesting limited capacity of these devices to influence systemic adaptations in the body [3].

A qualitative thematic analysis of user experiences with a popular percussion massage gun revealed that most users rated the method highly for pain management and muscle tension relief. Respondents highlighted ease of use, versatility, and accessibility—both financially and practically. However, a notable gap was identified between the device's popularity and users' awareness of scientifically validated application parameters. This points to the need for standardizing the use of such devices in clinical settings [2].

Table 1 summarizes the effects of compression garments and massage on post-injury recovery.

In the context of modern rehabilitation following musculoskeletal injuries, particular scientific and clinical attention is drawn to strategies that combine diverse therapeutic influences – mechanical, sensory, orthopedic, and neurophysiological. Compression garments on the one hand, and massage tools on the other, have traditionally been used as separate modalities. However, accumulated empirical and scientific data suggest that their combination can produce a synergistic effect and significantly enhance the impact on key elements of the pathological process during the post-traumatic period.

Despite the widely recognized effectiveness of compression therapy, its application in clinical practice is often limited by challenges in tailoring garments to the individual anatomical characteristics of patients. One of the main difficulties is the uneven distribution of pressure along the limb, which reduces therapeutic precision, causes discomfort, and negatively affects treatment adherence. This inconsistency

results from both the anatomical and biomechanical variability of tissues and the limitations of manufacturing approaches based on standardized models that fail to account for post-traumatic changes such as edema, atrophy, hypertrophy, or localized scarring [9].

Table 1 – The impact of anatomical compression garments combined with handheld massage devices in post-traumatic rehabilitation

Impact factor	Massage	Compression garments
Reduction of swelling	Lymphatic massage promotes fluid drainage after surgery or trauma [11]	Prevents fluid accumulation in the area of surgical intervention [11]
Improvement of lymphatic drainage	MLD activates the lymphatic system to remove toxins and excess fluid [11]	Indirectly supports lymphatic drainage through consistent pressure [10]
Enhancement of microcirculation and tissue oxygenation	Manual and instrument-assisted massage (IASTM) improves local blood flow [6]	Improves venous return and oxygen delivery to tissues [10]
Pain reduction	Massage reduces pain perception through mechanoneural stimulation [6]	Reduces pain by stabilizing and limiting excessive movement [10]
Acceleration of tissue healing	IASTM promotes microtrauma and stimulates fibroblast activity for regeneration [6]	Speeds up tissue regeneration through optimal perfusion [10]
Improvement of range of motion	Massage and IASTM increase ROM by reducing tissue restrictions [6]	Supports the musculoskeletal system, contributing to improved ROM [10]
Reduction of muscle stiffness and adhesions	Instrumental techniques break down adhesions and scar tissue, improving mobility [6]	Does not directly affect adhesions, but reduces inflammation [10]
Improvement of comfort and function	Increases patient comfort by reducing pain and tension [6]	Patients report a sense of stability and comfort [11]
Reduction of muscle fatigue and post-exercise recovery	Helps alleviate DOMS (delayed-onset muscle soreness) [6]	Enhances recovery after physical exertion in athletes [10]

Note: systematized by the author based on sources [6, 10, 11]

To overcome these limitations, researchers have proposed a novel digital approach to designing individualized compression garments. By using three-dimensional limb scanning and reverse engineering techniques, it became possible to create textiles precisely adapted to the patient's morphological parameters. Seamless 3D knitting technology allows for pressure modulation according to local geometry, thereby delivering a therapeutically relevant effect without overloading or creating

zones of uneven compression.

Within this approach, an innovative solution involves integrating compression with massage stimulation, expanding the functional potential of compression garments. This method is embodied in the TISA Neuro-Ortho Therapy rehabilitation complex developed by Ukrainian researcher Ihor Sarnov. The concept combines individualized compression textiles with mechanical stimulation provided by specially designed massage tools patented as rehabilitation devices.

This method includes the use of massage tools featuring precisely calibrated geometric shapes with multipoint contact zones that enable variable tissue stimulation. Devices such as “Tetrakom,” “Octopus,” “Turtle,” and “Star” are designed for passive muscular and lymphatic stimulation, as well as for activating proprioceptors through pressure redistribution. Their application in combination with compression garments—produced using seamless 3D-knitting technology and incorporating natural fibers such as cotton and wool – ensures optimal comfort, breathability, and thermoregulation. This integrated approach produces a multi-level effect, simultaneously targeting the skin, subcutaneous tissue, muscles, and fasciae, while also contributing to sensory integration. This contributes to more comprehensive recovery, reduced pain, improved blood and lymph circulation, normalized motor control, and decreased neurophysiological stress associated with post-traumatic limitations.

An additional element of this innovative model includes the use of supportive tools such as cooling packs that provide anti-inflammatory effects through localized therapy. This combination of compression, localized mechanical stimulation, and cooling gives the TISA method a comprehensive, multifactorial character. It allows not only for symptom relief but also for modulation of the pathogenic mechanisms underlying post-traumatic musculoskeletal disorders.

Therefore, the TISA Neuro-Ortho Therapy method represents an innovative, multicomponent approach that combines individualized compression and controlled mechanical stimulation. Its patented instrumental component and digital textile adaptation ensure integration of orthopedic, sensorimotor, and neurophysiological therapy. This approach opens new prospects for personalized rehabilitation in patients

with musculoskeletal injuries, targeting not only symptomatic relief but also structural and functional restoration, motor autonomy, and improved quality of life.

Conclusions

Anatomical compression garments serve as an effective means of external therapeutic stabilization, providing precisely dosed pressure that enhances proprioceptive control, reduces pain, normalizes blood and lymph circulation, and maintains musculoskeletal balance. Their use not only offers mechanical support for injured structures but also indirectly influences neurophysiological recovery processes. A high level of therapeutic effectiveness is achieved through individualized products based on 3D scanning that accounts for the geometry and morphofunctional specifics of limbs after injury.

Massage and massage tools, particularly instrument-assisted devices, demonstrate a comprehensive effect on soft tissue structures. They activate mechanoreceptor systems, stimulate regenerative processes, improve microcirculation, eliminate fascial restrictions, and reduce pain intensity. Percussion devices, increasingly used in both clinical and outpatient settings, are especially effective in relieving muscle tension, increasing range of motion, and reducing post-exercise fatigue, which is critically important during the early stages of recovery.

The combined use of compression garments and handheld massage devices, as realized in the innovative TISA Neuro-Ortho Therapy method, represents a new model of personalized neuro-orthopedic rehabilitation. Through the synergistic effect of both components, a multi-level therapeutic impact is achieved: stabilization, neurosensory activation, improved motor control, and lower pain thresholds. The integration of digital technologies in the design of compression garments and the use of patented massage tools open new opportunities for the development of effective, individually tailored rehabilitation programs that meet the modern standards of multidisciplinary medicine.

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