Original article
DOI: 10.14529/hsm25s224

THE EFFICACY OF MECHANOTHERAPY FOR MUSCLE PAIN SYNDROME

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Abstract. **Aim.** This study investigates the efficacy of mechanotherapy using Cordus&Sacrus devices for inducing paravertebral muscle relaxation. **Materials and methods.** The study involved thirty patients (age range 25–45 years) with various muscle pain syndromes. The intervention consisted of gravity therapy. Objective outcomes were assessed using the MyotonPro device to measure asymmetry in the paraspinal muscles. Postural balance was also evaluated. **Results.** Post-intervention, a significant reduction in muscle tone asymmetry was observed. The asymmetry between the right (15.69 ± 0.17 Hz) and left (15.71 ± 0.14 Hz) medial trapezius muscles was notably decreased. A similar decrease in asymmetry was found in the lateral gastrocnemius muscle. The normalization of postural balance in these muscle groups coincided with a significant reduction in pain scores, with the mean VAS scores decreasing from 7.8 ± 0.7 to 3.2 ± 0.5. In a subgroup of 10 participants with elevated baseline tone, specific relaxation of the spinal erectors was observed. Within the same subgroup, initially elevated stiffness and tone significantly decreased ($p > 0.05$) bilaterally post-intervention. **Conclusion.** A single session of gravity therapy was effective in eliminating pain, reducing asymmetry in paravertebral and lower limb muscle tone, and alleviating hypertonicity of the spinal extensors. These changes were associated with improved statodynamic characteristics in patients.
Keywords: gravity therapy, myofascial pain syndrome, paravertebral muscles, tone

For citation: Solar G., Koryukalov Yu.I., Epishev V.V., Lapshin M.S. The efficacy of mechanotherapy for muscle pain syndrome. *Human. Sport. Medicine*. 2025;25(S2):189–197. DOI: 10.14529/hsm25s224

Научная статья
УДК 612.741.4
DOI: 10.14529/hsm25s224

ЭФФЕКТИВНОСТЬ МЕХАНОТЕРАПЕВТИЧЕСКОЙ ИНТЕРВЕНЦИИ ПРИ СИНДРОМЕ МЫШЕЧНОЙ БОЛИ

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Аннотация. **Цель:** изучить эффективность механотерапии с использованием аппаратов Cordus&Sacrus для паравертебральной релаксации. **Материалы и методы.** В исследовании приняла участие группа из тридцати пациентов в возрасте от 25 до 45 лет с различными болевыми синдромами опорно-двигательного аппарата. Воздействие на паравертебральные мышцы осуществлялось методом гравитационной терапии. Асимметрию параспинальных мышц оценивали с помощью аппарата MyotonPro, а также определяли постуральный баланс. **Результаты.** После гравитационной терапии наблюдалось заметное снижение асимметрии тонуса трапециевидных мышц, а также снижение асимметрии между правой (15,69 ± 0,17 Гц) и левой (15,71 ± 0,14 Гц) медиальными трапециевидными мышцами. Кроме того, гравитационная терапия привела к снижению асимметрии тонуса латеральной икроножной мышцы. Нормализация постурального баланса в трапециевидной, медиальной и латеральной икроножной мышцах с течением времени сопровождалась снижением показателей болевого синдрома (средний показатель ВАШ снизился с 7,8 ± 0,7 до 3,2 ± 0,5). У 10 человек из общей выборки после процедуры наблюдались индивидуальные изменения, связанные с релаксацией мышц-разгибателей позвоночника, в случаях, когда исходный тонус был повышен. Кроме того, в этой же группе из 10 человек скованность и тонус позвоночника, которые были повышены в начале исследования, достоверно ($p > 0,05$) снизились с обеих сторон после первого сеанса. **Заключение.** После однократного сеанса гравитационной терапии у пациентов отмечалось устранение болевого синдрома, уменьшение асимметрии тонуса паравертебральных мышц и мышц нижних конечностей, снижение гипертонуса разгибателей позвоночника. Статодинамические характеристики пациентов улучшились после коррекции.

Ключевые слова: гравитационная терапия, мышечный болевой синдром, паравертебральные мышцы, тонус

Для цитирования: The efficacy of mechanotherapy for muscle pain syndrome / G. Solar, Yu.I. Koryukalov, V.V. Epishev, M.S. Lapshin // Человек. Спорт. Медицина. 2025. Т. 25, № S2. С. 189–197. DOI: 10.14529/ hsm25s224

Introduction. Muscle pain syndrome (MPS) is a prevalent clinical manifestation of musculoskeletal diseases and injuries, notable for causing significant temporary and permanent disability. Affecting 40–60 % of the global population, MPS represents a critical and relevant area of research [5]. Among patients seeking medical treatment for pain, the reported prevalence of MPS ranges from 30 to 93 % [4, 23]. Despite its high frequency, the pathophysiology of MPS remains largely unexplored. This condition encompasses a broad spectrum of symptoms, from generalized pain to painful trigger points that are often associated with fatigue and depression [10]. Simon defined MPS as “a complex of sensory, motor, and vegetative symptoms caused by myofascial trigger points.” A substantial role in the pathogenesis of MPS is attributed to developmental anomalies, biomechanical and functional factors, and vascular components [8, 11].

A specific form of MPS, local myogenic pain syndrome, affects approximately 24 % of the population annually and occurs primarily in the paraspinal muscles. It is believed to result from repetitive low-level muscle contractions, maximal or submaximal concentric contractions, and prolonged strain on specific muscle groups, such as in postural overuse [6, 24].

Myofascial trigger zones (TZ) are found in 30 to 90 % of patients visiting general practitioners [7]. Trigger points generate pain foci that are often described as dull, aching, or burning. Their formation involves alterations in the peripheral nervous system, including functional disturbances and degeneration of axonal neurofilaments and microtubules [20]. Such alterations can be caused by multilevel nerve compression or reflex mechanisms originating from a peripheral focus. The pain patterns in MPS indicate a neuropathic component, with its uniqueness stemming from a combination of cutaneous-nerve and neuropathic features. Furthermore, the subjective character of the symptoms is significantly influenced by the patient's individual perception [3].

Epidemiological data from Russia indicate that chronic back pain affects 45.4–60.7 % of patients, primarily impacting socially active individuals aged 30–50 years [14]. Functional rehabilitation for patients exposed to high physical loads or hypodynamia may include various manual and mechanical methods, such as modern physiotherapy and gravity therapy [14, 24]. Gravity therapy utilizing Cordus&Sacrus devices has shown promise as a safe and effective approach for paraspinal relaxation in the comprehensive treatment of pain syndromes and osteochondrosis [23]. It has been found that spinal extension and load relief can facilitate the reabsorption of fluid into intervertebral discs, thereby contributing to the restoration of their normal structure [2, 12, 16, 17, 22].

Aim: therefore, the aim of this study was to investigate the efficacy of gravity therapy using

Cordus&Sacrus devices for achieving paraspinal relaxation.

Materials and methods. The gravity therapy intervention was conducted at the Research Center for Sports Science and the Laboratory of Psychophysiology at South Ural State University (Chelyabinsk, Russia). The experimental protocol was approved by the University's Ethics Committee in accordance with the Declaration of Helsinki. All participants were informed of the study's potential risks and benefits and retained the right to withdraw at any time. Individual written informed consent was obtained from each subject prior to their participation. The study involved thirty patients, aged 25 to 45 years, presenting with various muscle pain syndromes. Prior to the study, physiotherapists were trained in the characteristics, application, and proper handling of the devices. Each participant underwent a single procedure, which included spinal unloading using the Cordus&Sacrus devices, complemented by special exercises for spinal mobilization.

The gravity therapy method employing the Cordus&Sacrus devices is based on a safe, physiological approach designed to relax muscles and ligaments. The Cordus device targets relaxation of the paravertebral muscles, while the Sacrus device focuses on the muscles of the skull, pelvis, and diaphragm. This gentle stretching technique aims to facilitate the recovery of spinal function. This device-assisted method is certified for medical use in the European Union (TSU Piestany, No. 231299081).

The innovative design of the Cordus device allows for targeted 'immersion' into the paravertebral muscle zone to induce relaxation. It was primarily applied for mechanotherapy in patients with osteochondrosis and protrusions.

The Sacrus device, conversely, is engineered to relax muscles across various spinal segments. Its exterior is anatomically contoured for the thoracic region, making it particularly effective for relaxing the pectoral muscles and managing sciatic pain.

Following an initial conversation and the provision of informed consent, the spinal correction procedure was initiated. Participants received comprehensive information about the device-assisted technique and all relevant contraindications.

Quantitative pain assessment was performed using a visual analogue scale (VAS).

Mechanical Properties of Muscles. The mechanical properties of muscles were assessed using the MyotonPro device (MyotonPRO AS, Estonia). Measurements of stiffness, tone, and elasticity were taken on the trapezius (TMd), erector spinae (Es), and gastrocnemius (Gn) muscles [1, 4].

Postural balance assessment. Postural balance was evaluated using a two-legged European stance (heels together, toes apart). The protocol consisted of two 30-second tests, one with eyes open and one with eyes closed, while maintaining a straight head position. Data were acquired using the MBN Stabilo (Russia) force platform, in accordance with established clinical stabilometry recommendations [19]. The technical specifications of the platform are as follows:

– platform dimensions – 500×400×100 mm,
– load range – 20 to 150 kg,
– coordinate measurement accuracy – 1 mm,
– coordinate discretization – 1 mm,
– sensor sampling rate – 100 Hz.

Participants stood barefoot on the platform in a comfortable position with their feet hip-width apart. After a 1-minute acclimatization period, data recording commenced following a 10-second delay to eliminate transition effects. A single 60-second recording was used to analyze two parameters:

– FP ML COP (mm) – the mean location of the COP in the frontal plane;
– SP ML COP (mm) – the mean location of the COP in the sagittal plane.

Statistical Analysis. The Kolmogorov-Smirnov test confirmed a normal distribution for all variables ($p > 0.05$). Data are presented as the arithmetic mean (M) and its standard error (m). Statistically significant differences were determined using the Mann – Whitney U test for two-group comparisons. All statistical analyses were performed with the Statistica 8.0 for Windows software package.

Results. Prior to gravity therapy, a significant asymmetry was observed in the trapezius muscle tone of the overall patient cohort. The oscillation frequency, a key indicator of resting muscle tone, was significantly elevated on the right side (18.08 ± 0.52 Hz) compared to the left (16.85 ± 1.42 Hz).

This asymmetry was also evident in other mechanical properties. The stiffness of the right trapezius (408.68 ± 73.69 N/m) was significantly greater than that of the left (325.90 ± 26.43 N/m). Similarly, the elasticity (logarithmic decrement) was higher on the right side (1.57 ± 0.15 arb) compared to the left (1.35 ± 0.17).

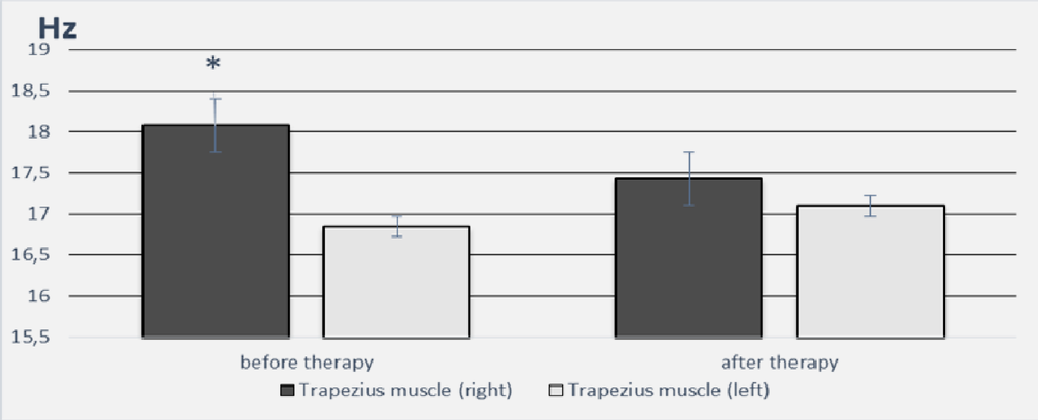

Fig. 1. Post-therapy oscillation frequency of the trapezius muscles.
*** indicates a statistically significant difference between sides, p < 0.05**

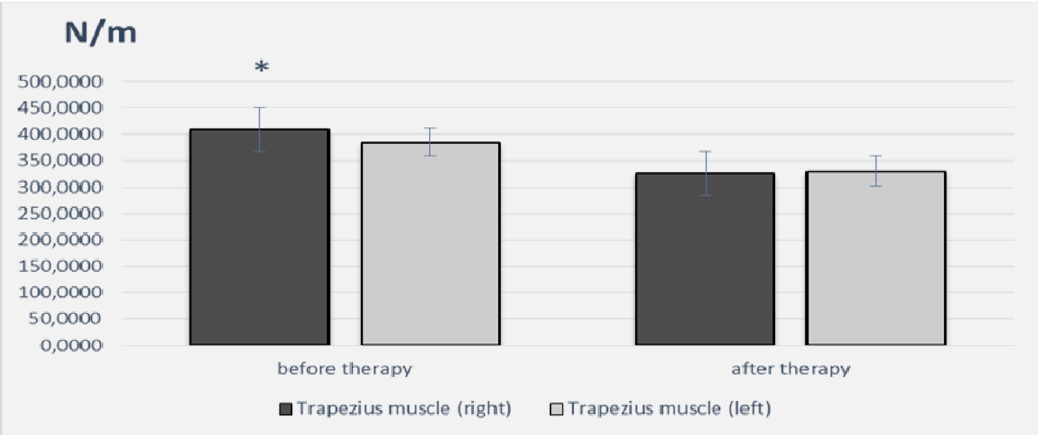

Fig. 2. Post-therapy dynamic stiffness of the trapezius muscles.
*** indicates a statistically significant difference between sides, p < 0.05**

Following gravity therapy, a substantial reduction in this trapezius muscle asymmetry was observed (Figs. 1, 2).

In the overall patient cohort, no significant differences were observed in the relaxation time or elasticity of the muscles following mechanical stress, either before or after therapy.

Prior to therapy, significant asymmetry was found in the erector spinae muscle. The relaxation time, being the time required for tissue recovery after displacement, was significantly longer on the right side (19.99 ± 4.43 ms) than on the left (18.77 ± 3.19 ms). Similarly, elasticity, which reflects the relationship between relaxation time and deformation, was also significantly higher on the right side (1.15 ± 0.23 arb) compared to the left (1.06 ± 0.014 arb). Following therapy, the relaxation time showed a slight increase bilaterally (right: 20.96 ± 2.90 ms; left: 20.04 ± 2.42 ms). A concurrent trend towards increased elasticity was also observed on both sides (right: 1.17 ± 0.13 arb; left: 1.12 ± 0.11 arb). The remaining parameters in the overall cohort exhibited no significant changes.

Analysis of the medial gastrocnemius muscle also revealed baseline asymmetry. Prior to therapy, muscle tone was significantly elevated in the left leg (15.83 ± 1.02 Hz) compared to the right (14.15 ± 2.13 Hz). The relaxation time was significantly shorter in the left leg (20.27 ± 0.62 ms) than in the right (21.03 ± 1.96 ms).

After therapy, a reduction in this inter-leg asymmetry was observed (right: 15.69 ± 0.17 Hz; left: 15.71 ± 0.14 Hz) (Fig. 3).

The study identified a significant baseline asymmetry in the dynamic stiffness of the lateral gastrocnemius muscles. At baseline, dynamic stiffness, being a measure of a tissue's resistance to deformation, was higher in the left leg (298.30 ± 49.16 N/m) than in the right leg (264.77 ± 48.66 N/m). No other measured parameters showed significant differences at this stage.

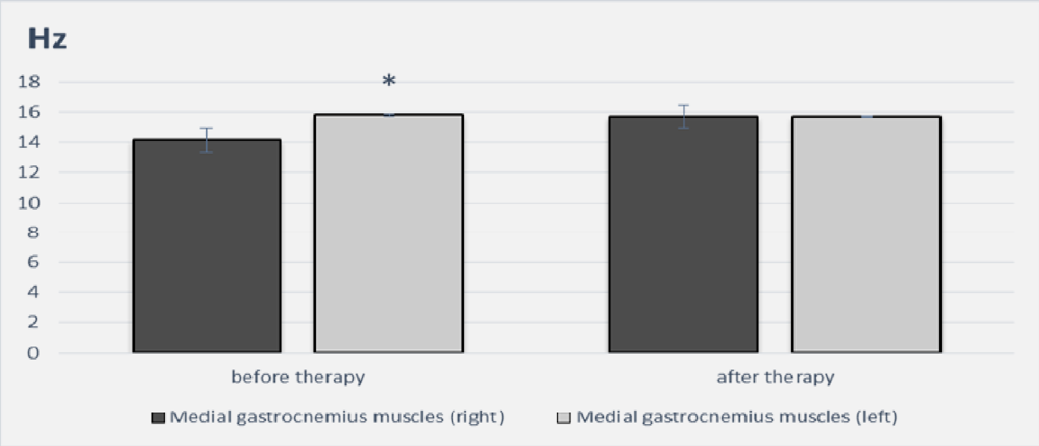

Fig. 3. Post-therapy oscillation frequency of the medial gastrocnemius muscles.
*** indicates a statistically significant difference between legs, p < 0.05 U**

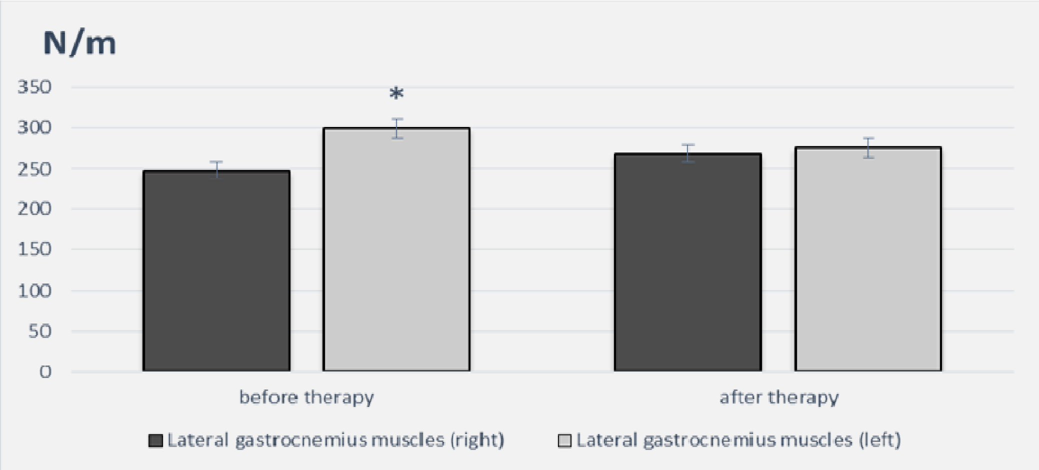

Fig. 4. Post-therapy dynamic stiffness of the lateral gastrocnemius muscles.
*** indicates a statistically significant difference between legs, p < 0.05 U**

Following therapy, the asymmetry in the lateral gastrocnemius was resolved. The dynamic stiffness values between the right and left legs showed a clear convergence (Fig. 4).

The remaining indicators for the gastrocnemius muscle showed no significant alterations. The normalization of postural balance in the trapezius, medial gastrocnemius, and lateral gastrocnemius muscles coincided with an alleviation of pain syndrome, as evidenced by a reduction in the mean VAS score from 7.8 ± 0.7 to 3.2 ± 0.5. In addition to relaxation, participants reported a sensation of warmth flowing along their legs, a phenomenon presumably related to exercise-induced hemodynamic effects and subsequent peripheral vasodilation.

In a subgroup of 10 participants with elevated baseline tone, specific relaxation of the spinal erectors was observed. Within the same subgroup, initially elevated stiffness and tone significantly decreased ($p > 0.05$) bilaterally post-intervention.

The results of the postural balance assessment before and after the treatment course are presented in Table 1.

Analysis of the COP data prior to gravity therapy revealed postural displacements in both the frontal and sagittal planes (Table 1). In patients with MPS during the open-eyed trial, the COP was displaced an average of 25.15 mm to the right (FP ML COP) and 7.03 mm posteriorly (SP ML COP). A similar pattern was observed in the closed-eyed trial, with a rightward displacement of 28.92 mm (FP ML COP) and a posterior displacement of 28.09 mm (SP ML COP).

Re-examination post-therapy indicated specific changes associated with the intervention (Table 1). The mean COP location in the frontal

Table 1

Mean location of the COP in the frontal and sagittal planes before and after intervention (M ± m)

Parameter		FP ML COP (mm)	SP ML COP (mm)
		M ± m	M ± m
After	Open eyes	25.15 ± 8.53	–7.03 ± 4.15
	Closed eyes	28.92 ± 9.56	–5.58 ± 4.12
P		≥ 0.05	≥ 0.05
Before	Open eyes	27.22 ± 7.41	0.74 ± 3.56
	Closed eyes	28.09 ± 8.01	1.27 ± 2.94
P		≥ 0.05	≥ 0.05
t After / Before	Open eyes	≥ 0.05	≤ 0.05
	Closed eyes	≥ 0.05	≤ 0.05

plane remained largely unchanged ($p \geq 0.05$). In contrast, statistically significant changes were observed in the sagittal plane. A notable anterior shift of the COP was observed in both the open-eyed (7.77 mm) and closed-eyed (6.85 mm) trials ($p \leq 0.05$). These SP ML COP values approached those of the reference, converging close to 0 mm.

The prevalence of MPS among patients presenting with pain ranges from 30 to 93 % [21]. The pathogenesis is widely attributed to sustained or repetitive low-level muscle contractions [4], maximal and submaximal concentric contractions, and prolonged tension in individual muscle groups, often manifesting as delayed onset muscle soreness during periods of hypokinesia. The source of pain is believed to reside in the region between the motor endplate and the muscle fascicle, involving disturbances in the microcirculatory bed and neurotransmitters at the cellular level [7, 24].

Muscle spasm stimulates nociceptors within the muscle itself. This spasm leads to local hyperemia, which further sensitizes muscle nociceptors [9, 15]. The spasm itself becomes a source of additional afferent impulses that increase the activity of anterior motor neurons, leading to a self-sustaining cycle of pain and muscle spasm.

The results of this study demonstrate that a single session of gravity therapy using the Cordus&Sacrus devices reduced asymmetry in the trapezius muscle tone. The initial, statistically significant differences in oscillation frequency and dynamic stiffness between the right and left trapezius muscles were no longer present following the intervention.

Following therapy, a reduction in muscle tone asymmetry was observed between the right and left medial and lateral gastrocnemius muscles. Furthermore, in a subgroup of 10 patients with initially elevated tone, mechanotherapy promoted relaxation of the erector spinae muscle ($p > 0.05$). In these same participants, a bilateral decrease in erector spinae stiffness was also noted ($p > 0.05$).

The normalization of postural balance in the trapezius, medial gastrocnemius, and lateral gastrocnemius muscles coincided with the alleviation of pain syndrome. Patients also reported changes in their psychoemotional state and a subjective feeling of lightness in the spine. These outcomes support the use of this device within a comprehensive approach for correcting musculoskeletal disorders.

The Sacrus device acts directly on the lumbar spine by activating muscle proprioceptors to induce relaxation, stabilizing the lumbar region, alleviating pain in piriformis syndrome, and influencing lower-limb muscle function. By targeting reflex zones, it relaxes the paravertebral muscles, thereby improving impulse transmission to internal organs and enhancing pelvic blood circulation (Mogendovich's theory of motor-visceral reflexes).

The therapeutic effect is achieved through acupressure spikes that engage tense muscles and ligaments, facilitating gentle and physiological relaxation. This leads to the relaxation and correction of key spinal segments, including the ligaments. Consequently, joint mobility is restored, and blood circulation is improved.

The Sacrus Physio device utilizes slow-frequency microcurrents to induce relaxation, including in remote muscle groups. Study results confirmed that a single application of the Sacrus device influences the lower-limb muscles, particularly the gastrocnemius.

This systemic effect can be contextualized by Tom Myers' theory of anatomy trains, which proposes that the fascia forms a functionally integrated network operating through defined myofascial meridians [18]. The data support that the

Sacrus device directly impacts the first myofascial meridian, which is responsible for maintaining vertical posture and reducing stiffness in the neck, back, and calves. Thus, by applying localized pressure to a specific spinal segment, the device produces integrated effects on both the skeletal muscle system and visceral organs.

The Cordus device was applied to the cervical, thoracic, and lumbar regions of the spine. This method facilitates targeted influence on the paravertebral muscles and promotes spinal traction, yielding multiple positive outcomes such as the alleviation of spinal compression [13]. The mechanism of the Cordus device can be compared to Qigong exercise, as it simultaneously engages visceral organs, the skeletal muscle system, and an individual's psychological state (a holistic approach). This is confirmed by the positive shifts in patients' psychoemotional state observed immediately after the procedure.

Analysis of the COP identified deviations in both the frontal and sagittal planes prior to gravity therapy. In patients with myofascial syndrome, the COP was displaced during open-eyed trials. A similar displacement pattern was observed under closed-eye conditions. This indicates that visual deprivation does not significantly alter the mean COP location, suggesting that postural control in individuals with myofascial syndrome is predominantly influenced by the functional state of the muscles responsible for maintaining vertical posture. These observed changes can be interpreted as compensatory adjustments in the tone and length of the posterior muscular chain, particularly the spinal muscles. Therefore, the mean COP location in the frontal plane appears dependent on symmetric tension of the paravertebral muscles and scoliotic deformations, while its location in the sagittal plane is linked to the tone and length of the paravertebral muscles that modulate the spine's natural curvatures.

Re-analysis of the COP data following gravity therapy revealed specific changes. The mean COP location in the frontal plane remained largely unchanged ($p \geq 0.05$) in both visual conditions. Conversely, the mean COP location in the sagittal plane demonstrated statistically significant changes.

Conclusions. The devices act on both muscle proprioceptors and joint receptors. This action alleviates tension in the erector spinae muscle, inducing relaxation in the targeted spinal region. Pain relief is typically achieved within one to three sessions. The gravity therapy for the paravertebral muscles reduces muscle stiffness and right-left asymmetry while improving elasticity. When combined with distraction mobilization exercises, the therapy alleviates vertebrogenic and myofascial pain syndromes, relaxes muscle spasms, enhances limb blood supply, and restores spinal joint mobility. Consequently, gravity therapy, through its effect on the paravertebral muscles, modulates the mean COP location in the sagittal plane.

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The authors declare no conflict of interests.

Вклад авторов:

Все авторы сделали эквивалентный вклад в подготовку публикации.

Авторы заявляют об отсутствии конфликта интересов.

The article was submitted 26.04.2025
Статья поступила в редакцию 26.04.2025