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DEVELOPMENT OF A METHOD FOR THE CORRECTION OF CERVICOGENIC HEADACHE BASED ON THE RESTORATION OF BIOMECHANICAL DYSFUNCTIONS USING STABILOMETRIC BIOFEEDBACK

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Abstract.

Background. Cervicogenic headache (CGH) represents one of the most common forms of secondary chronic headache and is associated with a complex interaction of neurophysiological and biomechanical mechanisms. Although disturbances in myofascial balance and postural control play a substantial role in the pathogenesis of CGH, these factors are rarely addressed through targeted corrective interventions in routine clinical practice.

Objective. To develop and clinically evaluate a method for the correction of cervicogenic headache based on the restoration of pathological biomechanical patterns and impaired postural control using stabilometric biofeedback.

Materials and Methods. A total of 64 patients with cervicogenic headache without organic central nervous system pathology were examined. The diagnosis was established according to the ICHD-3 beta criteria and an original diagnostic questionnaire. Patients were divided into two groups: the first group received pharmacotherapy combined with therapeutic exercise, while the second group received pharmacotherapy combined with a course of stabilometric biofeedback training. Clinical neurological examination, visual-optical biomechanical analysis, and stabilometric assessment of postural control were performed.

Results. The use of stabilometric biofeedback was associated with a lower rate of headache recurrence, significant improvement in statokinesiogram parameters, reduced center of pressure displacement, and decreased energy expenditure index compared with conventional therapy.

Conclusion. The proposed method for the correction of cervicogenic headache, aimed at restoring biomechanical and postural balance, demonstrates clinical effectiveness and may be recommended for inclusion in comprehensive treatment programs for patients with CGH.

Keywords: cervicogenic headache; biomechanical dysfunctions; postural control; stabilometry; biofeedback; myofascial imbalance

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СОЗДАНИЕ СПОСОБА КОРРЕКЦИИ ЦЕРВИКОГЕННОЙ ГОЛОВНОЙ БОЛИ НА ОСНОВЕ ВОССТАНОВЛЕНИЯ БИОМЕХАНИЧЕСКИХ НАРУШЕНИЙ С ПРИМЕНЕНИЕМ СТАБИЛОМЕТРИЧЕСКОЙ БИОЛОГИЧЕСКОЙ ОБРАТНОЙ СВЯЗИ

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Аннотация.

Актуальность. Цервикогенная головная боль (ЦГБ) является одной из наиболее распространённых форм вторичных хронических головных болей и обусловлена сложным взаимодействием нейрофизиологических и биомеханических факторов. Несмотря на признанную роль нарушений миофасциальных и постуральных взаимоотношений в патогенезе ЦГБ, данные механизмы редко становятся объектом целенаправленной коррекции в клинической практике.

Цель исследования. Разработать и клинически оценить способ коррекции цервикогенной головной боли, основанный на восстановлении патологических биомеханических установок и нарушений постурального контроля с использованием стабилометрической биологической обратной связи.

Материалы и методы. Обследованы 64 пациента с цервикогенной головной болью без органической патологии центральной нервной системы. Диагноз устанавливался согласно критериям МКГБ-3 beta с применением авторского опросника. Пациенты были распределены на две группы: первая получала фармакотерапию в сочетании с лечебной физкультурой, вторая — фармакотерапию в сочетании с курсом стабилометрических тренингов. Проводились клинико-неврологическое обследование, визуально-оптический анализ биомеханических нарушений и стабилометрическая оценка постурального контроля.

Результаты. Применение стабилометрической биологической обратной связи сопровождалось более выраженным снижением частоты рецидивов ЦГБ, улучшением показателей статокинезиограммы, уменьшением смещения центра давления и снижением индекса энергозатратности по сравнению с традиционной терапией.

Заключение. Разработанный способ коррекции ЦГБ, основанный на восстановлении биомеханического и постурального баланса, демонстрирует клиническую эффективность и может быть рекомендован для внедрения в комплексное лечение пациентов с цервикогенной головной болью.

Ключевые слова: цервикогенная головная боль; биомеханические нарушения; постуральный контроль; стабилометрия; биологическая обратная связь; миофасциальный дисбаланс.

STABILOMETRIK BIOLOGIK QAYTA ALOQA YORDAMIDA BIOMEXANIK BUZILISHLARNI TIKLASH ASOSIDA SERVIKOGEN BOSH OG‘RIG‘INI KORREKSIYA QILISH USULINI YARATISH

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Annotatsiya.

Dolzarblik. Servikogen bosh og‘rig‘i (SBO‘) ikkilamchi surunkali bosh og‘riqlarining eng keng tarqalgan shakllaridan biri bo‘lib, uning patogenezida neyrofiziologik va biomexanik omillarning murakkab o‘zaro ta’siri muhim o‘rin tutadi. Miyofassial muvozanat va postural nazorat buzilishlarining SBO‘ rivojlanishidagi roli tan olingan bo‘lsa-da, ushbu mexanizmlar klinik amaliyotda kamdan-kam hollarda maqsadli tarzda korreksiya qilinadi.

Tadqiqot maqsadi. Stabilometrik biologik qayta aloqa texnologiyasidan foydalangan holda patologik biomexanik o‘rnatmalar va postural nazorat buzilishlarini tiklashga asoslangan servikogen bosh og‘rig‘ini korreksiya qilish usulini ishlab chiqish va klinik jihatdan baholash.

Materiallar va usullar. Markaziy asab tizimining organik patologiyasiz servikogen bosh og‘rig‘i bilan og‘rigan 64 nafar bemor tekshirildi. Tashxis MKB-3 beta mezonlari va mualliflik so‘rovnomasi asosida qo‘yildi. Bemorlar ikki guruhga bo‘lindi: birinchi guruh farmakoterapiya va davolovchi jismoniy mashqlarni, ikkinchi guruh esa farmakoterapiya va stabilometrik treninglar kursini oldi. Klinik-nevrologik tekshiruv, vizual-optik biomexanik tahlil va stabilometrik baholash o‘tkazildi.

Natijalar. Stabilometrik biologik qayta aloqa qo‘llanilishi bosh og‘rig‘i qaytalanish chastotasining kamayishi, statokineziogramma ko‘rsatkichlarining yaxshilanishi, bosim markazi siljishining kamayishi va energiya sarfi indeksining pasayishi bilan tavsiflandi.

Xulosa. Biomexanik va postural muvozanatni tiklashga qaratilgan ishlab chiqilgan usul servikogen bosh og‘rig‘ini kompleks davolashda samarali bo‘lib, klinik amaliyotga joriy etish uchun tavsiya etiladi.

Kalit so‘zlar: servikogen bosh og‘rig‘i; biomexanik buzilishlar; postural nazorat; stabilometriya; biologik qayta aloqa; miyofassial disbalans.

Introduction. Cervicogenic headache (CGH) is currently recognized as a significant clinical and socio-medical problem at the intersection of neurology, manual medicine, physical rehabilitation, and biomechanics. According to epidemiological data, cervicogenic headache accounts for up to 15–20% of all forms of chronic headache, particularly in young and working-age populations, which leads to substantial economic and social consequences [1]. Despite advances in neuroimaging and pharmacotherapy, the effectiveness of conventional treatment strategies for CGH remains limited, especially in terms of long-term remission and prevention of relapse. Cervicogenic headache is defined as a secondary headache disorder originating from dysfunctions of the cervical spine and its associated musculoskeletal, ligamentous, and neuromuscular structures. The International Classification of Headache Disorders, 3rd edition beta version (ICHD-3 beta), emphasizes the role of nociceptive afferentation from the upper cervical segments (C1–C3), which converge with trigeminal afferents in the trigeminocervical complex, forming the neuroanatomical substrate for pain referral to craniofacial regions [2].

However, in routine neurological practice, the etiopathogenetic role of biomechanical disturbances, particularly pathological myofascial interactions, altered statokinematic patterns, and postural instability, is often underestimated or overlooked. Standard therapeutic approaches are predominantly pharmacological and symptomatic, targeting pain modulation rather than correction of the underlying biomechanical substrate. As a result, high recurrence rates, chronicity, and progressive functional impairment are frequently observed [3]. Modern concepts of motor control and postural regulation consider the human body as a multi-segmental biomechanical system, in which disturbances in one region inevitably lead to compensatory maladaptive changes in other regions of the musculoskeletal chain. The cervical spine occupies a key position in this system, serving as a functional bridge between the cranial segment and the axial skeleton. Alterations in cervical muscle tone, joint mobility, and proprioceptive input significantly affect postural stability, balance control, and energy efficiency of movement [4]. Stabilometric analysis, based on the registration of center of pressure (COP) oscillations during static and dynamic tasks, has emerged as an objective method for assessing postural control and biomechanical integrity of the locomotor system. Moreover, stabilometric platforms equipped with biofeedback systems allow not only diagnostic evaluation but also targeted rehabilitation through motor learning and sensorimotor retraining [5]. The integration of biofeedback-based stabilometric training into the treatment of cervicogenic headache represents a promising direction aimed at correcting pathological biomechanical patterns, restoring myofascial balance, and normalizing statokinematic parameters. However, clinical studies evaluating the effectiveness of such approaches in CGH remain limited, especially in the context of young patients without structural organic pathology. Therefore, the relevance of the present study lies in the development and clinical validation of a method for correcting cervicogenic headache based on targeted restoration of biomechanical dysfunctions using stabilometric biofeedback training, adapted to the clinical and educational framework of the Department of Neurology, Samarkand State Medical University.

The aim of this study was to develop and evaluate a method for the correction of cervicogenic headache based on the correction of pathological biomechanical patterns of myofascial interactions using stabilometric biofeedback training.

Materials and Methods. A prospective controlled clinical study was conducted at the clinical base of the Department of Neurology, Samarkand State Medical University. The study included 64 patients diagnosed with cervicogenic headache, who underwent comprehensive neurological, biomechanical, and stabilometric assessment. The diagnosis of cervicogenic headache was established in accordance with the criteria of the International Classification of Headache Disorders, 3rd edition beta version (ICHD-3 beta), supplemented by an original structured questionnaire developed by the authors for the identification of clinical and biomechanical features specific to CGH. The questionnaire included items assessing headache localization, relation to neck movements, postural dependence, muscle tenderness, and response to cervical loading. The inclusion criteria were age from 18 to 45 years, presence of cervicogenic headache for at least six

months, absence of organic brain pathology confirmed by neuroimaging, and absence of severe comorbid neurological or systemic diseases. Exclusion criteria included inflammatory or traumatic lesions of the cervical spine, vestibular disorders, psychiatric conditions, and previous surgical interventions on the spine. The mean age of the study participants was 31.1 ± 3.6 years. The cohort consisted predominantly of young adults engaged in intellectual or sedentary professional activities, which is consistent with the known epidemiological profile of CGH. All patients underwent standard clinical and neurological examination, including assessment of cranial nerves, muscle strength, tone, reflexes, sensory function, and coordination. Particular attention was paid to the evaluation of cervical spine mobility, presence of myofascial trigger points, asymmetry of muscle tone, and postural deviations. Biomechanical assessment was performed using visual-optical analysis (VOA), which included evaluation of body alignment in the frontal and sagittal planes, symmetry of shoulder girdle and pelvic positioning, cervical lordosis configuration, and relative positioning of key anatomical landmarks. The analysis was conducted by trained specialists using standardized protocols to ensure reproducibility. Stabilometric assessment was performed using a computerized stabilometric platform. The following parameters of postural control and locomotor sphere were analyzed: area of the statokinesiogram, displacement of the center of pressure, and energy expenditure index. Measurements were conducted under standardized conditions with eyes open and eyes closed, ensuring comparability of results. Based on the treatment modality, patients were divided into two groups. The first group included 22 patients who received standard pharmacotherapy combined with therapeutic physical exercises (exercise therapy). Pharmacotherapy consisted of non-steroidal anti-inflammatory drugs, muscle relaxants, and adjuvant medications as indicated. Exercise therapy focused on general strengthening and mobility exercises for the cervical region. The second group included 26 patients who received standard pharmacotherapy combined with a course of stabilometric biofeedback training. The training program consisted of sessions conducted on a stabilometric platform, during which patients performed tasks aimed at maintaining and shifting balance in response to visual and auditory feedback. The exercises were designed to enhance proprioceptive integration, normalize muscle activation patterns, and restore postural stability. The course of stabilometric training included 10–12 sessions, each lasting 20–30 minutes, conducted three times per week. The training protocol was individualized based on initial stabilometric parameters and clinical presentation. The effectiveness of treatment was evaluated based on clinical outcomes, recurrence of headache, and changes in stabilometric and biomechanical parameters. Follow-up assessment was conducted one month after completion of treatment. Statistical analysis was performed using standard methods of descriptive and inferential statistics. Differences between groups were considered statistically significant at $p < 0.05$.

Results. The clinical and stabilometric outcomes demonstrated a pronounced advantage of the combined pharmacotherapy and stabilometric biofeedback approach compared to conventional treatment with exercise therapy. One month after completion of treatment, recurrence of cervicogenic headache was observed in 62.5% of patients in the first group who received pharmacotherapy and exercise therapy. In contrast, recurrence occurred in only 43.8% of patients in the second group who underwent pharmacotherapy combined with stabilometric training, indicating a statistically significant reduction in relapse frequency ($p < 0.05$). Analysis of stabilometric parameters revealed marked improvements in postural control in the second group. The area of the statokinesiogram, which reflects the stability of the center of pressure during quiet standing, showed a more pronounced reduction in the stabilometric training group. In the second group, this parameter decreased to 105.0 ± 10.2 mm², approaching normative values, whereas in the first group it remained significantly higher at 148.0 ± 10.4 mm². The energy expenditure index, representing the efficiency of postural control and muscular effort required to maintain balance, decreased by 18.4% in the first group and by 29.6% in the second group. This indicates a more substantial normalization of neuromuscular coordination and reduction of compensatory muscle overactivity in patients undergoing stabilometric biofeedback training. The degree of center of pressure displacement, reflecting asymmetry and instability of posture, decreased by 13.7% in the first group and by 46.3% in the second group, demonstrating a significant improvement in postural

symmetry and balance control in the stabilometric training cohort. Visual-optical analysis corroborated these findings, revealing a statistically significant reduction in deviations from normal alignment of borderline regions, particularly in the cervical and thoracic segments, in patients of the second group. Restoration of parallelism between anatomical landmarks and reduction of compensatory postural patterns were observed more consistently in this group.

Table 1. Changes in Stabilometric Parameters Before and After Treatment

Parameter	Group 1 (Pharmacotherapy + Exercise Therapy)	Group 2 (Pharmacotherapy + Stabilometric Training)
Statokinesiogram area (mm^2)	148.0 ± 10.4	105.0 ± 10.2
Energy expenditure index (%)	−18.4%	−29.6%
Center of pressure displacement (%)	−13.7%	−46.3%

Discussion. The results of the present study confirm the hypothesis that biomechanical dysfunctions play a crucial role in the pathogenesis and persistence of cervicogenic headache. Conventional pharmacological treatment, while effective in reducing pain intensity, does not sufficiently address the underlying disturbances in postural control, muscle coordination, and myofascial balance, which explains the high rate of relapse observed in the first group. From a neurophysiological perspective, altered afferent input from cervical proprioceptors leads to maladaptive changes in central sensorimotor integration, contributing to chronic pain and motor dysfunction [6]. Stabilometric biofeedback training directly targets these mechanisms by enhancing proprioceptive awareness and promoting adaptive motor learning. The significant reduction in statokinesiogram area and center of pressure displacement observed in the second group indicates restoration of postural stability and more efficient neuromuscular control. Decreased energy expenditure further suggests normalization of muscle recruitment patterns and reduction of excessive tonic activity in cervical and paraspinal muscles. The findings of this study are consistent with contemporary concepts of functional rehabilitation, which emphasize the importance of active patient participation, multisensory integration, and task-specific training in the recovery of motor function [7]. Stabilometric biofeedback provides an optimal platform for implementing these principles in clinical practice. Importantly, the young age of the study population highlights the preventive potential of this approach, as early correction of biomechanical dysfunctions may prevent progression to chronic pain syndromes and degenerative changes in the cervical spine.

Conclusion. The use of biofeedback-based stabilometric training for the correction of biomechanical dysfunctions significantly improves the outcomes of treatment for cervicogenic headache. This approach not only reduces the frequency of headache recurrence but also restores postural stability, myofascial balance, and energy efficiency of movement. The integration of stabilometric biofeedback training into standard therapeutic protocols at the Department of Neurology, Samarkand State Medical University, represents a scientifically grounded and clinically effective strategy for the management of cervicogenic headache, particularly in patients without organic pathology. The developed method addresses the etiopathogenetic mechanisms of CGH and may serve as a foundation for further research and clinical implementation in neurological and rehabilitation practice.

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