

DOI 10.65491/3106-5538-2026-3-46-53

УДК 616.711-001.5:622-057.2:612.8

## OCCUPATIONAL FACTORS AND SOMATOSENSORY DYSFUNCTION IN MINERS WITH CHRONIC VERTEBROGENIC LUMBOSACRAL PAIN

Fazylova M-D. A.<sup>1</sup>

<sup>1</sup>NC JSC «National Centre Occupational Health and Diseases» (100017, Republic of Kazakhstan, Karaganda, Mustafina str. 15, e-mail: info@naoncgt.kz)

1. Fazylova M-D. A., Candidate of Medical Sciences, Head of the Department of Occupational Neurology, NC JSC «National Centre Occupational Health and Diseases» (Republic of Kazakhstan, Karaganda, Mustafina str., 15), e-mail: mangaz\_dana@bk.ru

The article presents the results of a study of afferent somatosensory pathways in 225 miners with vertebrogenic pathology of the lumbosacral spine. Electromyography and somatosensory evoked potentials revealed abnormalities in peripheral and central sensory conduction, which increased with the severity of pain syndrome. Long-term exposure to occupational factors was associated with dysfunction of somatosensory systems and central sensitization. Somatosensory evoked potentials may be used for objective assessment of the severity of vertebrogenic pain syndrome.

*Keywords:* miners, vertebrogenic pathology, chronic pain syndrome, somatosensory evoked potentials, electromyography, occupational diseases, afferent pathways.

**Introduction.** Occupational diseases of the musculoskeletal and peripheral nervous systems remain a major medical and social problem worldwide. Among industrial workers, miners represent a high-risk occupational group due to continuous exposure to vibration, heavy physical work, prolonged static postures, and repetitive mechanical stress. These adverse occupational factors significantly increase the risk of vertebrogenic pathology, particularly chronic lumbosacral radiculopathy accompanied by persistent pain syndrome.

Lumbar spine disorders account for a substantial proportion of temporary disability and occupational incapacity in working-age populations. Chronic vertebrogenic pain not only reduces quality of life but also contributes to psychological stress, impaired motor activity, and long-term disability. Despite considerable progress in neuro-

physiological diagnostics, the mechanisms underlying chronic pain formation in occupational vertebral disorders remain insufficiently understood.

Modern concepts of pain pathogenesis emphasize the important role of peripheral afferent dysfunction and central sensitization. Persistent nociceptive stimulation may lead to hyperexcitability of spinal and supraspinal sensory pathways, resulting in chronic pain persistence even in the absence of severe structural lesions. Somatosensory evoked potentials and electromyography provide objective assessment of the functional state of sensory and motor conduction systems at peripheral, spinal, and cortical levels.

Previous studies have demonstrated that occupational vibration and prolonged static-dynamic overload may induce degenerative and demyelinating changes in peripheral nerves and spinal roots. However, limited information exists regarding the neurophysiological characteristics of afferent somatosensory dysfunction in miners with vertebrogenic pathology.

The aim of the present study was to investigate changes in afferent somatosensory conduction pathways in miners with chronic vertebrogenic lumbosacral pain syndrome using electrophysiological methods.

**Materials and Methods. Study Design.** A cross-sectional clinical and neurophysiological study was conducted among miners employed in underground mining enterprises of the Karaganda industrial region.

**Participants.** The study included 225 miners aged 30–52 years with more than five years of occupational underground experience. All participants had clinically confirmed vertebrogenic pathology of the lumbosacral spine associated with chronic pain syndrome.

The control group consisted of 41 healthy individuals without occupational exposure to vibration or heavy physical workload and without neurological disorders.

**Clinical Classification.** Patients were divided into three groups according to the severity of pain syndrome:

- Group 1: mild reflex-tonic pain syndrome (n = 83);
- Group 2: moderate reflex-tonic and radicular pain syndrome (n = 46);
- Group 3: severe chronic pain syndrome (n = 19).

#### **Neurological Examination**

All participants underwent: neurological assessment, clinical examination of sensory and motor function, evaluation of reflex activity, assessment of pain localization and intensity.

#### **Electrophysiological Methods. Electromyography**

Electromyographic examination was performed using 4- and 8-channel electromyographs. Functional activity of agonist, antagonist, and synergistic muscle groups was assessed.

### **Somatosensory Evoked Potentials**

Somatosensory evoked potentials were recorded using the “Neurosoft” neurophysiological system.

Electrical stimulation of the tibial and median nerves was performed with registration from: brachial plexus region, cervical spinal level, frontal cortical region, somatosensory cortical projection areas.

The following SSEP parameters were analyzed: amplitude, latency, interpeak intervals.

The components studied included: N22, N30, P38, P46.

**Statistical Analysis.** Statistical processing was performed using Microsoft Excel and StatPlus software. Quantitative variables were expressed as mean  $\pm$  standard deviation. Student's t-test was used to determine statistical significance. Differences were considered significant at  $p < 0.05$ .

**Results. Clinical Findings.** The predominant symptom among examined miners was chronic lumbosacral pain radiating into the lower extremities. More severe clinical manifestations were observed in workers exposed to combined static overload and vibration.

Patients with severe pain syndrome demonstrated: reduced mobility, impaired reflex activity, muscle weakness, sensory disturbances in the lower extremities.

EMG examination revealed decreased functional activity of agonist and antagonist muscles, particularly in patients with chronic radiculopathy. Disturbances of neuromuscular excitability were most pronounced in severe forms of disease.

### **Somatosensory Evoked Potentials. Amplitude Characteristics**

A progressive increase in amplitudes of spinal and cortical SSEP components was observed with increasing pain severity.

**Table 1. Amplitude Characteristics of SSEP Components**

| Component                                           | Control       | Group 1         | Group 2           | Group 3              |
|-----------------------------------------------------|---------------|-----------------|-------------------|----------------------|
| N22 ( $\mu$ V)                                      | $1.1 \pm 0.5$ | $0.74 \pm 0.01$ | $2.54 \pm 0.02^*$ | $3.45 \pm 0.03^{**}$ |
| N30 ( $\mu$ V)                                      | $0.8 \pm 0.3$ | $0.59 \pm 0.06$ | $2.48 \pm 0.04^*$ | $3.39 \pm 0.05^{**}$ |
| P38 ( $\mu$ V)                                      | $2.4 \pm 1.5$ | $1.94 \pm 1.0$  | $3.5 \pm 0.09^*$  | $4.1 \pm 0.08^{**}$  |
| P46 ( $\mu$ V)                                      | $2.3 \pm 1.3$ | $2.0 \pm 0.81$  | $3.7 \pm 0.9$     | $4.5 \pm 0.6^*$      |
| * $p < 0.05$ ; ** $p < 0.01$ compared with control. |               |                 |                   |                      |

Increased amplitudes reflected hyperactivation of spinal and cortical sensory structures associated with chronic nociceptive stimulation.

### Interpeak Intervals

**Table 2. Intervals Between SSEP Components**

| Interval     | Control     | Group 1      | Group 2      | Group 3      |
|--------------|-------------|--------------|--------------|--------------|
| N10–N13 (ms) | 7.65 ± 1.04 | 12.34 ± 2.44 | 15.2 ± 2.01* | 19.8 ± 2.3** |
| N13–N20 (ms) | 8.36 ± 1.56 | 15.63 ± 2.38 | 18.6 ± 3.2*  | 20.4 ± 3.1** |
| N20–N30 (ms) | 16.1 ± 1.55 | 28.0 ± 3.15  | 32.3 ± 2.56* | 37.1 ± 1.9** |

\* p < 0.05; \*\* p < 0.01 compared with control.

Significant prolongation of interpeak intervals indicated slowing of impulse conduction along ascending spinal pathways and brainstem sensory structures.

### Latency Characteristics

**Table 3. Latency of SSEP Components**

| Component | Control    | Group 1     | Group 2     | Group 3      |
|-----------|------------|-------------|-------------|--------------|
| N22 (ms)  | 22.1 ± 2.2 | 36.2 ± 6.1  | 42.1 ± 4.9* | 51.3 ± 5.4** |
| N30 (ms)  | 29.8 ± 2.8 | 41.2 ± 3.9* | 49.6 ± 4.1* | 60.5 ± 5.7** |
| P38 (ms)  | 38.3 ± 3.3 | 43.8 ± 4.8  | 52.6 ± 3.7* | 63.9 ± 4.2** |
| P46 (ms)  | 46.4 ± 3.2 | 49.1 ± 4.0  | 54.3 ± 3.4* | 71.2 ± 6.7** |

\* p < 0.05; \*\* p < 0.01 compared with control.

The most pronounced latency prolongation was observed in miners with severe pain syndrome, indicating dysfunction of peripheral sensory fibers and central conduction pathways.

**Discussion.** The present study demonstrated significant neurophysiological abnormalities in miners with chronic vertebrogenic lumbosacral pathology. The obtained findings support the concept that occupational exposure contributes to dysfunction of both peripheral and central somatosensory systems.

The observed increase in SSEP amplitudes combined with prolonged latency and interpeak intervals reflects the development of central sensitization mechanisms. Chronic nociceptive stimulation appears to induce hyperexcitability of spinal and supraspinal neurons, resulting in persistent pain perception.

Particular involvement of 1α-afferent fibers and the H-reflex arc suggests that occupational vertebrogenic pathology affects proprioceptive regulation and sensori-

motor integration. Additionally, dysfunction of  $1\beta$ -fibers and motor pathways indicates combined sensory and motor impairment.

The severity of electrophysiological disturbances strongly correlated with clinical manifestations, suggesting that SSEP analysis may serve as an objective diagnostic tool for evaluating progression of vertebrogenic pain syndrome.

Long-term exposure to vibration and static-dynamic overload likely contributes to demyelination, impaired axonal conduction, and chronic neuroinflammatory changes in peripheral nerves and spinal roots.

These findings are consistent with modern theories of chronic pain pathogenesis emphasizing the role of deafferentation and central nervous system plasticity in occupational neurological disorders.

**Conclusion.** Occupational exposure in miners is associated with progressive dysfunction of afferent somatosensory pathways and development of chronic vertebrogenic pain syndrome.

Neurophysiological disturbances involve: peripheral sensory fibers, spinal conduction systems, supraspinal sensory structures,  $1\alpha$ - and  $1\beta$ -afferent pathways.

Somatosensory evoked potentials provide objective markers for assessing severity of vertebrogenic pathology and may improve differential diagnosis, treatment monitoring, and occupational health evaluation.

Further investigations are required to develop preventive strategies aimed at reducing neurophysiological consequences of occupational exposure in miners.

## References

1. Hartvigsen J., Hancock M. J., Kongsted A. et al. What low back pain is and why we need to pay attention // *The Lancet*. – 2018. – Vol. 391, No. 10137. – P. 2356–2367. – DOI: 10.1016/S0140-6736(18)30480-X.
2. Foster N. E., Anema J. R., Cherkin D. et al. Prevention and treatment of low back pain: evidence, challenges, and promising directions // *The Lancet*. – 2018. – Vol. 391, No. 10137. – P. 2368–2383. – DOI: 10.1016/S0140-6736(18)30489-6.
3. Cohen S. P., Vase L., Hooten W. M. Chronic pain: an update on burden, best practices, and new advances // *The Lancet*. – 2021. – Vol. 397, No. 10289. – P. 2082–2097. – DOI: 10.1016/S0140-6736(21)00393-7.
4. Raja S. N., Carr D. B., Cohen M. et al. The revised International Association for the Study of Pain definition of pain: concepts, challenges, and compromises // *Pain*. – 2020. – Vol. 161, No. 9. – P. 1976–1982. – DOI: 10.1097/j.pain.0000000000001939.

5. Woolf C. J. Central sensitization: implications for the diagnosis and treatment of pain // *Pain*. – 2011. – Vol. 152, No. 3, Suppl. – P. S2–S15. – DOI: 10.1016/j.pain.2010.09.030.
6. Latremoliere A., Woolf C. J. Central sensitization: a generator of pain hypersensitivity by central neural plasticity // *The Journal of Pain*. – 2009. – Vol. 10, No. 9. – P. 895–926. – DOI: 10.1016/j.jpain.2009.06.012.
7. Cruccu G., Aminoff M. J., Curio G. et al. Recommendations for the clinical use of somatosensory-evoked potentials // *Clinical Neurophysiology*. – 2008. – Vol. 119, No. 8. – P. 1705–1719. – DOI: 10.1016/j.clinph.2008.03.016.
8. World Health Organization. WHO guideline for non-surgical management of chronic primary low back pain in adults in primary and community care settings. – Geneva : World Health Organization, 2023.
9. International Organization for Standardization. ISO 2631-1:1997. Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements. – Geneva : ISO, 1997.
10. European Agency for Safety and Health at Work. Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU. – Luxembourg : Publications Office of the European Union, 2019.
11. GBD 2021 Diseases and Injuries Collaborators. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021 // *The Lancet*. – 2024. – Vol. 403. – P. 2133–2161.

**ӨНДІРІСТІК ФАКТОРЛАРДЫҢ БЕЛ-СЕГІЗКӨЗ ОМЫРТҚАСЫНЫҢ  
ВЕРТЕБРОГЕНДІК ПАТОЛОГИЯСЫ БАР ТАУ-КЕН  
ЖҰМЫСШЫЛАРЫНДАҒЫ АФФЕРЕНТТІК СОМАТОСЕНСОРЛЫҚ  
ЖОЛДАРДЫҢ ЖАҒДАЙЫНА ӘСЕРІ**

**Фазылова М-Д. А<sup>1</sup>.**

<sup>1</sup>«Еңбек гигиенасы және кәсіптік аурулар ұлттық орталығы» КеАҚ (100017, Қазақстан Республикасы, Қарағанды қ., Мұстафин к. 15, e-mail: info@naoncgt.kz)

1. Фазылова М-Д. А., м.ғ.к., «Еңбек гигиенасы және кәсіптік аурулар ұлттық орталығы» КеАҚ, кәсіптік неврология бөлімінің меңгерушісі, Қарағанды қ., e-mail: mangaz\_dana@bk.ru

**Тұжырым**

Мақалада бел-сегізкөз омыртқасының вертеброгендік патологиясы бар 225 тау-кен жұмысшысындағы афференттік соматосенсорлық жолдардың жағдайын зерттеу нәтижелері ұсынылған. Электромиография және соматосенсорлық шақырылған потенциалдар көмегімен ауырсыну синдромының күшеюіне байланысты перифериялық және орталық сенсорлық өткізгіштіктің бұзылыстары анықталды. Өндірістік факторлардың ұзақ уақыт әсер етуі соматосенсорлық жүйелер дисфункциясы мен орталық сенситизацияның дамуына ықпал ететіні анықталды. Соматосенсорлық шақырылған потенциалдар вертеброгендік ауырсыну синдромының ауырлығын объективті бағалау үшін қолданылуы мүмкін.

*Түйін сөздер:* тау-кен жұмысшылары, вертеброгендік патология, соматосенсорлық шақырылған потенциалдар, созылмалы ауырсыну синдромы, кәсіптік аурулар, афференттік жолдар.

## **ВЛИЯНИЕ ПРОИЗВОДСТВЕННЫХ ФАКТОРОВ НА СОСТОЯНИЕ АФФЕРЕНТНЫХ СОМАТОСЕНСОРНЫХ ПУТЕЙ У ГОРНОРАБОЧИХ С ВЕРТЕБРОГЕННОЙ ПАТОЛОГИЕЙ ПОЯСНИЧНО-КРЕСТЦОВОГО ОТДЕЛА ПОЗВОНОЧНИКА**

**Фазылова М-Д. А<sup>1</sup>.**

<sup>1</sup>НАО «Национальный центр гигиены труда и профессиональных заболеваний» (100017, Республика Казахстан, г.Караганда, ул.Мустафина 15, e-mail: info@nao.ncgt.kz)

1. Фазылова М-Д. А., к.м.н., заведующая отделением профессиональной неврологии, НАО «Национальный центр гигиены труда и профессиональных заболеваний, г.Караганда, e-mail: mangaz\_dana@bk.ru

### **Резюме**

В статье представлены результаты исследования афферентных соматосенсорных путей у 225 горнорабочих с вертеброгенной патологией пояснично-крестцового отдела позвоночника. С использованием электромиографии и соматосенсорных вызванных потенциалов выявлены нарушения периферической и центральной сенсорной проводимости, выраженность которых увеличивалась по мере усиления болевого синдрома. Установлено, что длительное воздействие производственных факторов способствует развитию дисфункции соматосенсорных систем и центральной сенситизации. Показатели соматосенсорных вызванных потенциалов могут использоваться для объективной оценки тяжести вертеброгенного болевого синдрома.

*Ключевые слова:* горнорабочие, вертеброгенная патология, соматосенсорные вызванные потенциалы, хронический болевой синдром, профессиональные заболевания, афферентные пути