

## Prevalence and estimation of the occupational risk of the musculoskeletal disorders in workers of aluminum potrooms

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**Abstract:** The aim of this research is to investigate the role of the occupational risks in the development of pain syndromes of the locomotor system in workers employed in basic workplaces at aluminum potrooms, basing on the periodic health screenings data. It has been determined that working under the conditions of toxic fluorides-related exposure and athletic overexertion increases the risk of the upper arm pain syndrome development 4.3 fold. The maximum relative risk (108.2) has been revealed in the workers of such kind of professions having the length of employment upper 20 years and suffering simultaneously from cervical osteochondrosis and pulmonary diseases.

**Keywords:** prevalence, etiological fraction, occupational risk, pain syndrome, spine, extremities, fluorides, athletic overexertion.

The most severe consequence of intensive exposure to fluorides is skeletal injury with initial injury of spongy bones (pelvis and spine) and calcification of the ligaments, followed by involvement of the long bones in the disease. These radiological-morphological abnormalities are the diagnostic criteria and have been made the basis for classification of skeletal fluorosis [5, 6]. A number of studies demonstrated similar events with occupational exposure to fluorides and with endemic fluorosis.

Diagnostics of occupational fluorosis, according to the domestic classification, is designed following the principle of syndromology and based upon the aggregate of nonspecific dysfunction of internal organs and bone and joint abnormalities [2], being confirmed by an extremely subjective visualization technique developed in the 60s of the past century. The difficulties of objective diagnostics of skeletal fluorosis consist of the fact that radiography is unable to detect less than 30% changes in bone density, and pain syndromes (osteoarthralgias) may not restrict the patient's functional abilities.

There is no doubt that the entire clinical syndromology related to the bone and joint abnormalities is nonspecific and depends upon a number of causes, the primary ones being the extent of exposure and individual differences related to the functional activity of the detoxication and eliminating systems.

Undoubtedly, the similarity of the clinical manifestations of occupational chronic intoxication and endemic fluorosis is caused by affinity of fluorides towards calcified structures [3]. However, exposure not only to fluorides but also to other adverse industrial factors, such as hard physical labor, thermal emission, electromagnetic fields and dust loading, persists in the principal workers' occupations at the electrolysis workshops (pot operators, anode operators). These

factors may potentiate the adverse toxic effect of fluorides, thus increasing the risk of development of nonspecific abnormalities of the musculoskeletal system, and contribute to earlier and more advanced development of skeletal fluorosis.

Investigation of the cause-effect relationships and assessment of occupational risks as related to the multi-etiological diseases of the musculoskeletal system has certain difficulties:

1. Experimental modeling of the diseases of the shoulder girdle and extrapolation of the results are difficult, though it does not prevent investigation of certain key elements of pathogenesis.
2. Specification of the physiological and hygienic parameters characterizing the regional adverse exposures of various parts of the spine, joints, and muscles, both in the setting of overexertion and in the setting of physical inactivity, is insufficient.
3. The issues of quantification of the proportion of occupational exposure in the diseases of the musculoskeletal system remain underinvestigated as well.

Based on the aforesaid, the object of the present study was to investigate the role of the occupational risk factors in development of pain syndromes related to the musculoskeletal system in the population of workers with primary occupations at the electrolysis plant of an aluminum factory using the results of periodical medical examinations.

**Materials and methods.** Analysis of occurrence of the lumbo-ischialgia syndrome was carried out on the basis of data from the periodical medical examinations (PME) of 903 workers and employees of the Urals Aluminum Plant, and investigation of the occurrence and professional risk factors of the pain syndromes related to the shoulder girdle was carried out using the results of the PME of the workers at the Bogoslovskiy Aluminum Plant. The primary study

group was comprised of the workers of the principal occupations at the electrolysis workshops (pot operators and anode operators) with similar technological processes and labor conditions. The primary adverse occupational factors are: concentration of the fluorides in the air of the working zone is 4 – 12 fold, exceeding the M.A.C. for the maximum one-time concentrations (hydrofluoric gas, soluble and insoluble fluorine salts), general and regional muscle overexertion (class 3.2), thermal and electromagnetic emission.

The control groups were comprised of 281 persons working in the environment of increased exposure to fluorine at the same workshop but having no physical overexertion (operators and foremen), as well as the workers of accessory services (151 persons) that had no relation to the “hazardous” adverse factors (engineers, services and sections managers, economists, etc.). One more (the 4<sup>th</sup>) group comprised of the manual laborers from other industrial enterprises of Sverdlovsk Region that had no exposure to the toxic factors (locksmiths, molders) was selected for investigation of the epidemiology of the pain syndromes related to the shoulder girdle. The laborers examined at the medical examination using the neurological and orthopedic testing were comparable in age and length of employment.

The term “shoulder pain syndrome” (SPS) was used in the study as a common term for various diseases of the shoulder girdle. The present term, analogous to the “total shoulder pain, T-SP” introduced by S. Ueno in 1999, is mostly appropriate for epidemiological investigations, since it is often difficult to distinguish between various neurological and orthopedic diseases in the setting of the PME, in absence of diagnostic equipment.

In the course of complaints collection at the PME, the subjects were questioned: “Does it hurt in the lumbar area and leg and (or) cervical and shoulder area at the present moment?”, “Did it hurt in the lumbar area and leg and (or) cervical and shoulder area over the past year?” Both mandatory parameters (gender, age, length of employment) and accessory parameters considered to be risk factors (labor conditions, concomitant diseases of the internal organs) were registered in the patient assessment records. Based on the parameters collected in the course of the PME and entered into the Excel software, absolute, relative (RR) and attributive risks were estimated, and the etiological fraction (EF) and assessment of the strength of correlations between health and labor was carried out (E. I. Denisov, 2006) [1].

Spearsman’s rank correlation coefficient and phi coefficient were estimated to detect the degree of impact (correlation strength), as well as rank correlations, with the following selection of the strongest correlations.

**Results and discussion.** A significant excess in occurrence of the vertebrogenous pain syndromes of the lumbar area was discovered in the first and second groups (74.5 and 71.2%), where the workers experience physical overexertion as compared to the third group (35.1%), where the exposure to the adverse industrial factors is absent.

Lumbalgia and lumbo-ischialgia prevailed in the structure of lumbar pains in the first and second groups. The same relation (prevalence in the first two groups) was discovered by the separate analysis of lumbalgia (56.5 and 54.1 versus 30.5) and lumbo-ischialgia (4.2 and 5.7 versus 0.7). Analysis of the occurrence parameters revealed a tendency towards increase in occurrence of the lumbo-ischialgia syndrome along with increase of the length of employment in the 1<sup>st</sup> and 2<sup>nd</sup> groups, while no tendency of this kind was discovered in the 3<sup>rd</sup> group.

Estimations of the etiological fraction revealed that 71.4% cases of the lumbo-ischialgia syndrome discovered in the 1<sup>st</sup> group were related to the exposure to physical overexertion and toxic effect of fluorides, and 63.6% in the 2<sup>nd</sup> group (fluorides only), which confirms a very high grade of correlations between the health disorders and labor [1]. It should be noted that the occurrence values of the dorsalgia syndromes in the group of workers being exposed to the toxic effect of fluorides only are practically similar to the values discovered in the group of persons working in the setting of exposure to fluorides and physical overexertion.

The highest SPS occurrence values were registered in the 1<sup>st</sup> group (physical overexertion and toxic effect of fluorides) – 32.9% (CI 28.6 – 38.0), and the lowest ones in the 3<sup>rd</sup> group (physical overexertion) 6.9% (CI 6.52 – 9.04). The discovered data provide evidence that the occurrence and etiological fraction in the 3<sup>rd</sup> (physical overexertion) and 4<sup>th</sup> (absence of “hazardous” industrial factors) groups are practically similar. The largest proportion of patients with shoulder pain (42.9%) is observed in the group of persons working for more than 20 years and exposed to fluorine and physical overexertion.

The absence of a difference between the SPS occurrence values in the group of physical overexertion and the group with no exposure to the adverse industrial factors requires a separate analysis. On one hand, it is a known fact that both physical overexertion and physical inactivity produce an impact on the development of the diseases of the musculoskeletal system. Besides that, not only the direct toxic effect of fluorides but also the indirect effect caused by the diseases of internal organs (visceropathies) may contribute to the accelerated development of degenerative and dystrophic abnormalities of the articular and periarticular structures and formation of shoulder pain syndrome.

Estimation of the etiological fraction revealed that relative risk of SPS development is the highest in the first group, as related to the 4<sup>th</sup> group (5.67) and the 3<sup>rd</sup> group (5.24), while the etiological fraction made up 77.5 and 78.7%, respectively, which is evidence of a very high correlation grade between the health disorders and labor conditions, in this particular case the impact of a combination of factors: physical overexertion and the toxic effect of fluorides.

Analysis of the SPS occurrence with concomitant visceral diseases demonstrated higher values in the group of patients with the diseases of the bronchopulmonary system (24.8%), which was slightly higher than the value for the group of the cervical degenerative disk disease (23.4%) and more than twice exceeded the values for the groups of patients with the cardiovascular diseases (13.9%) and with the diseases of the gastrointestinal tract (13.2%). At the same time, the relative risk of SPS development is statistically significantly higher in the group of patients with the degenerative disk disease (7.0) than in other groups.

The highest value of the SPS occurrence is observed in the group of workers with a high length of employment (more than 20 years), being exposed to fluorine and physical overexertion (pot operators, anode operators) – 42.9%, the value for those with the length of employment of 10 – 9 years (sic) being 32.7%. At the same time, patients of these groups present mostly with bilateral pain syndrome, which is more typical for arthritis of the acromioclavicular joint. Both physical overexertion and toxic effect of fluorides contribute to the development of this particular form of the disease of the shoulder joint. The potentiating (additive) effect of these factors may perhaps be judged based on the data obtained.

Analysis of the SPS occurrence in relation to the presence of concomitant diseases demonstrated the highest values in the workers of the first group that had concomitant cervical degenerative disk disease – 57.9% (CI 50.5 – 65.3) and the second group – 41.46 (CI 25.7 – 57.2).

Maximal risk of SPS development was observed in the workers with the highest age and length of employment (20 workers) of the 1<sup>st</sup> group that had concurrent cervical degenerative disk disease and diseases of the bronchopulmonary system – 108.2 (CI 60.79 – 99.21). This value was also high in the group of workers with the length of employment of 10 – 19 years – 103.16 (CI 53.5 – 98.7) and in the workers with a low length of employment – 99.21 (CI 19.2 – 102.3). In this particular case, the risk was estimated in relation to the group with the length of employment of

less than 9 years that was not exposed to any adverse industrial factors and had no concomitant diseases.

The analysis demonstrated a minor strength of correlation with the shoulder pain syndrome for all concomitant diseases except cervical degenerative disk disease, where the strength of correlation was medium, however, statistically significant in all cases.

**Conclusions.** 1. *Labor in the setting of the toxic effect of fluorides and physical overexertion (pot operator and anode operator occupations at the aluminum plants) increases the risk of development of the shoulder pain syndrome 4.3 fold.*

2. *Risk of the SPS development in these workers having the length of employment exceeding 20 years and concurrent cervical degenerative disk disease and diseases of the bronchopulmonary system increases significantly and makes up 108.2 (CI 60.79 – 99.21).*

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