



TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering  
Vol. 64, Issue Special I, January, 2021

## A LONGITUDINAL STUDY ON WORK RELATED EARLY WEAR

Raluca Maria IORDACHE, Viorica PETREANU, Delia Cristina MIHĂILĂ

**Abstract:** This communication briefly presents the results of a longitudinal study conducted for 3 years on a group of electricians working at power lines (at height and on ground) and in power stations to detect possible signs and symptoms of a reversible physical and mental health, of a reduced ability to work, of occurrence of risky behaviors in the activity, which highlight the existence of a possible risk of early wear of the personnel, in relation to the activity carried out and the specific work related risks. Based on a multidimensional, multifactorial ergonomically approach of the problems, the study aimed to: (a) determine a system of exposure indicators and biological response to the action of the identified risks / risk factors; (b) establish a procedure for long-term monitoring of the physical and psychophysiological capacities and health of personnel; (c) establish measures to reduce risk factors for the health and safety of personnel, to preserve health and working capacity during working life. In its development, the study aimed to evaluate some indicators of the physical, psychophysiological and mental capacities of the personnel, capacities involved in carrying out work tasks in specific working conditions; the study also aimed to evaluate neuropsychic effort and analysis of physical and mental health. The study emphasized the occupational risk factors which can contribute, together with the extra-occupational and individual factors, to the etiological-pathogenesis of the investigated personnel' possible illnesses and the necessary measures in the OSH organization policy.

**Key words:** ergonomic risk factor, occupational biological exposure indicators, long-term monitoring of the physical and psychophysiological capacities and health, chronological wear, work related early wear.

### 1. INTRODUCTION

An important role in ensuring Occupational Safety and Health (OSH) is played by the early detection of signs and symptoms of reversible physical and mental health disorders, reductions in work capacity, the appearance of deficient, risky behaviors in activity that could be related to a possible risk of premature /early wear.

The process of wear is inherent with age, it is a complex process involving changes in the structure and functions of the body because of the entanglement of genetic, living and work environment factors, and which must be seen separately from the defects of disease. Wear can be approached in three ways: chronologically, physiologically and psychologically [1].

Chronological wear is defined by anatomical, physiological, psychological, pathological changes (nervous, muscular, digestive, renal, cardiovascular, respiratory, osteo-muscu-

loskeletal system, epidermis, visual and auditory analyzer, immune system, decreased performance in some mental and psychophysiological capacities) [2; 3; 4; 5; 6].

As life duration and the number of adult persons increased during the last century, the perspective of an ageing workforce became very important [1; 7] the idea of social and individual utility/use of work activity for this category of persons has drawn the attention of scientific community as follows: on one hand, the problem of the ageing employees' role played in the productive work and services of the society; on the other hand, the question of the eventual influence of work on individual's physiological wear process raised for consideration and if positive, under what conditions the work activity intervenes as an ageing/wear precocious producing factor. However, the uppermost idea in the scientific area should be that the ageing employees are not a group of population to be

globally retired, but useful employees for the specific work and realizing a better life standard of all society members [7; 8; 9]. The decrease in performance is influenced by many factors and that is why it is difficult to determine the age/early wear effect in this decrease [10].

As the workforce ages and the length of active life increases, the detection of possible early wear and the remedy of the matters that could cause it, would ensure a better use of this high-power stations' workforce, but would also ensure its safety and health [8; 9].

A decreased performance is influenced by numerous factors and it is difficult to detect the role of early wear in this process. The following aspects should be studied: (a) the role of harmful occupational factors that directly determine premature aging and the decline of health in the case of occupational diseases or of those related to the profession; (b) sanogenic, prophylactic and therapeutic measures in relation to both occupational and geriatric pathology; (c) control and prevention of early wear.

This article presents partial results from a longitudinal study carried out on a group of electricians working at electric lines (at height and on ground) and in high power stations and has the following objectives:

- Determination of a system of exposure indicators and biological response to the action of identified risk factors;
- Establishing a procedure for long-term monitoring of the physical and psychophysiological capacity and health of the investigated personnel;
- Establishing measures to reduce health and safety risk factors and to preserve the health and working capacity of the personnel during working life.

## 2. METHODS

### 2.1. Measures

A complex and multidimensional methodology using ergonomic methods and techniques has been used [11]. The study premise is related to the situation of the human operator in a complex system whose parts are interconnected and in which the influence of

work on health must be analyzed in a holistic approach. The following methods have been used:

- Technical organizational and psychophysiological analysis of the activity;
- Analysis of working conditions;
- Analysis of specific occupational risks and biological response to the action of identified risk and workload factors;
- Evaluation of occupational effort;
- Analysis of physical and mental health.

The investigations should include (like the stages of the research scenario):

- Measuring of somatic-metric indexes (corporal mass index), joint mobility indexes for the scapula-humeral, humeral-ulna, knee and dorsal-lumbar vertebral column articulations; segmental force indexes for palmar, scapula-humeral and lumbar flexor muscles and calculating the global index reported to the subject weight;
- Astrand test for assessing aerobic physical effort;
- Cardiovascular functional tests (Teslenko, Cramptom, Harvard and Ruffier);
- Exploring some visual functions: binocular visual acuity, simultaneous vision, phoria and relief vision, post-obliteration adjustment, chromatic vision (using Rodatest Ergovision);
- Study of psychophysiological capacities (using Digital Tachistoscope) and general personality traits (using personality inventories, e. g. Freiburg Personality Inventory);
- The neuropsychic load (through the work task indicators and the subjective assessment indicators of individual workload: TLX-NASA);
- analysis of physical and mental health state and the psychological stress level (using questionnaires, analysis of medical documents etc.);
- The indicators were monitored for a period of three years on the same group of participants from the investigated personnel categories through two annual assessment, in winter and summer, to early identify the eventual wear phenomena.

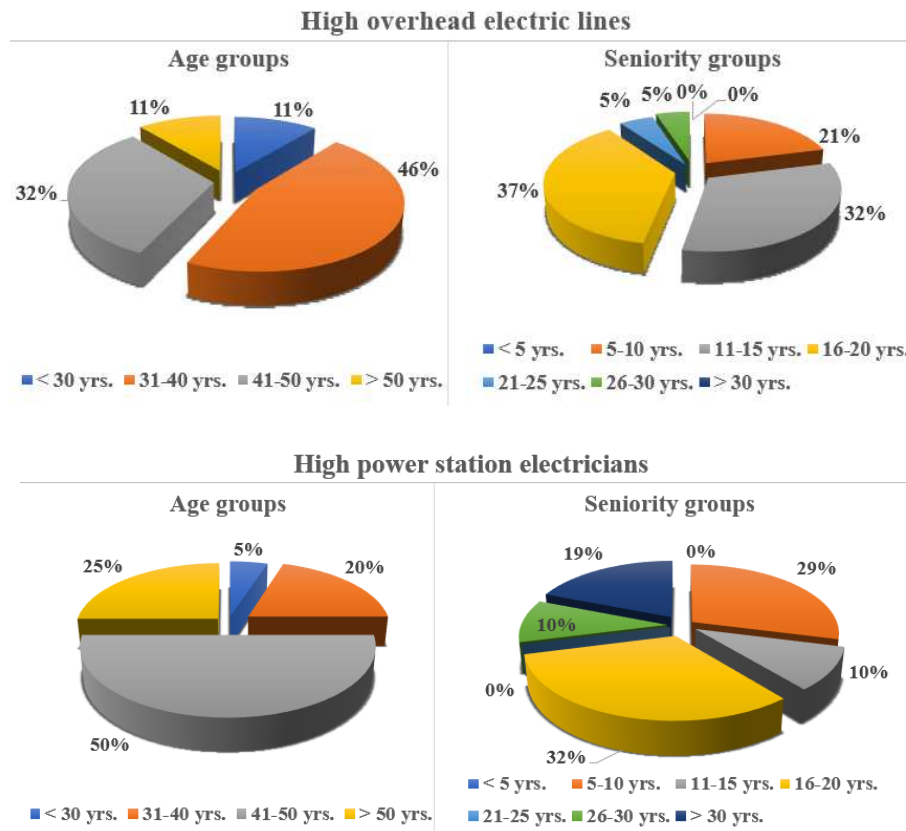


Fig. 1. The research sample demography

## 2.2 Participants in the research

Group involved in the study: 40 subjects, average age of 42.26 years old, average total work seniority: 23.68 years and the present workplace seniority (with specific occupational exposure): 16.63 years (see Fig. 1).

## 3. RESULTS

### 3.1. The first research stage

The activities carried out by the investigated personnel are complex and characterized by a high level of responsibility, are performed both on the ground and at height (in the case of electricians working at electric lines) and performed in high power stations. The personnel are subject to the accumulation of risks/risk factors for occupational injury and illness: mechanical, electrical, chemical, thermal, specific to the work environment, ergonomic and psychosocial risks. They can have effects specific to each type of risk or can result in the production of multiple injuries when several risks are combined. There is no work accident

that does not cause psychological consequences at the same time, the somatic impact being always doubled by a psychological impact. The existence of occupational risk and overload factors is a health risk and is reflected in the evolution of physical and psychological capacities and in personnel morbidity.

The following findings of the research were achieved. From the point of view of the body mass index, 13 obese and 17 overweight subjects were registered, respectively 78% of the total investigated group. Only eight subjects were normal weight, compared to 12 subjects at the entrance to the study. The proportion of those who exceed normal body mass remained very high, during the three years of investigation, in all age groups.

Excess weight is a predisposing factor for cardiovascular (hypertension) and metabolic (diabetes) disorders. It is necessary to pay more attention to this aspect by implementing awareness and information programs about a healthy diet, not only finding of diseases in the controls for health surveillance [12; 13].

It is noted low joint mobility, especially in the dorsolumbar spine (objectified by the abdominal flexion index), in the bilateral knee joint, and in the humero-ulnar joint (elbow). Upon entry into the study, all subjects had normal mobility in the humeral joint. At the last assessment, only two subjects had normal mobility, the rest of the electricians showing impaired mobility. At the level of the knee joint, there is a gradual deterioration of mobility, compared to the time of entry into the study. The mobility of the dorsolumbar spine has remained low throughout all stages of the study.

Strength indicators (palmar flexors, scapulohumeral force) remained low as does the

overall strength index referred to weight. An annual decrease in the number of subjects with strength indicators with normal values has been observed.

Effort capacity was decreased in approximately 35% of cases. Regarding the cardiovascular tests the following results have been obtained. The results from static tests (Teslenko and Crampton tests as seen in Fig. 2 ad Fig. 3) have correlated with the current health of the subjects, being influenced by the associated morbidities (obesity, hypertension). In the long run, they have had no predictive value for the detection of certain diseases.

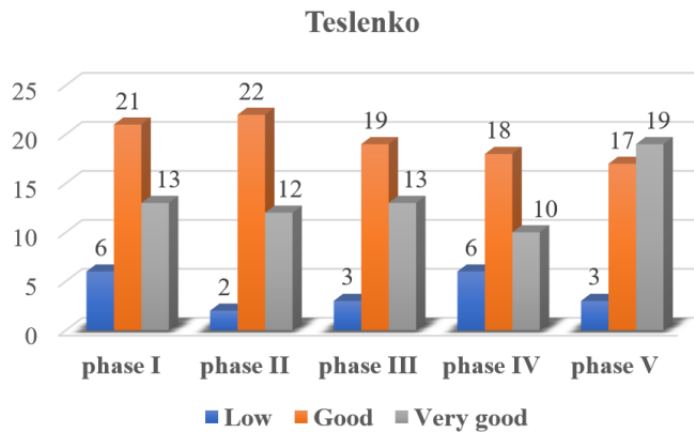


Fig. 2. The research results of Teslenko test

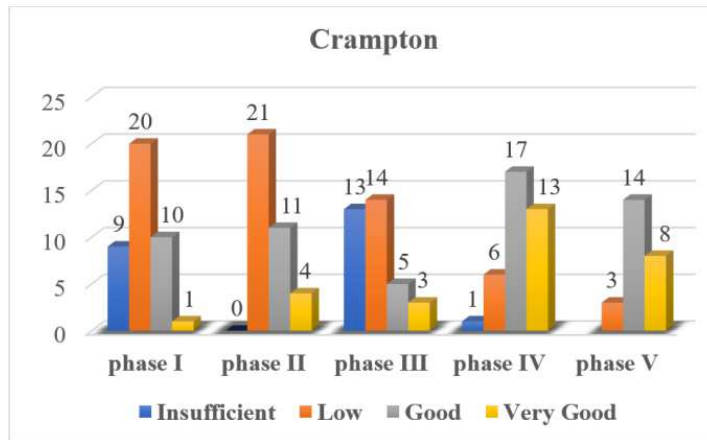


Fig. 3. The research results on Crampton test

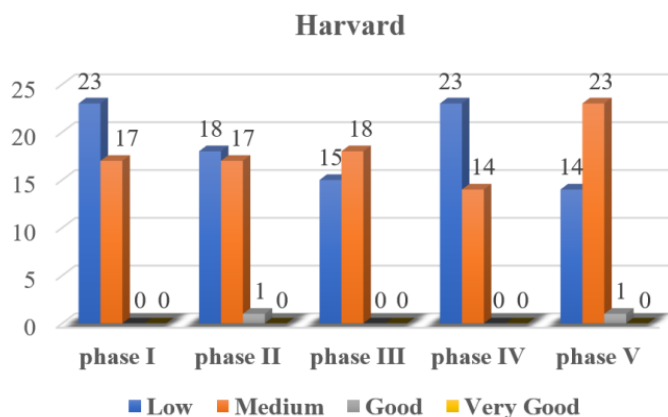


Fig. 4. The research results on Harvard test

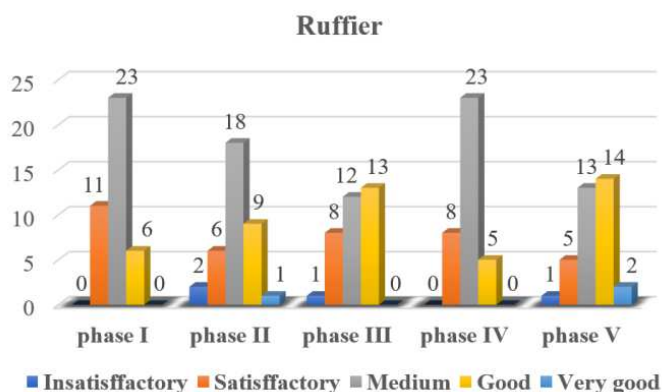


Fig. 5. The research results of the Ruffier index

The results from Harvard test (Fig. 4) has reflected the health of the subjects. Pre-existing conditions (hypertension, diabetes, obesity) have correlated with poor / average results.

Among the cardiovascular tests involving dynamic physical exertion, the Ruffier index has shown a decrease in the number of subjects whose values of pulse and systolic and diastolic blood pressure returned to rest values, after three to five minutes of exertion during dynamic tests, reflecting a decreasing capacity of adaptation of cardiovascular functions. Half of the subjects who did not registered a return to normal pulse and blood pressure at the beginning of the study, in the following years were diagnosed with hypertension or had high normal blood pressure values at regular medical examination. Thus, the alteration of the cardiovascular response to dynamic physical exertion may precede the appearance of important cardiovascular changes.

From the evaluation of the sense of balance, of the stability of the orthostatic position, there were significant changes in the levels of abilities of the same individual from one stage to another, in terms of increasing, reducing and returning to the previous level. No constant or significant reduction has been observed for the installation of the wear state.

In contrast, from the investigation of visual functions and health, a lower level of sense of balance (even if not below average), still coexisted with the following disorders: deficiency of the various components of binocular vision, the need for optical correction, obesity or overweight, reduced mobility in the knee joints, high blood pressure, hearing loss. These dysfunctions can be signs, signals for early wear and tear, they appear because of the demands of the activity and of the conditions in which it takes place, but also against the background of individual vulnerabilities.

Depending on the length of seniority at the current workplace, the following results were recorded:

- For electricians under 10 years of seniority, the proportion of healthy subjects is 33% (4 electricians out of 12). The following conditions were diagnosed: hypertension (2 cases), blood pressure values above the normal limit (1 case), hearing loss (4 cases), obesity (3 cases);
- In the 11-20 years of seniority group, about half of the subjects were clinically healthy (9 electricians out of 20). The following health problems were found: 3 cases of hypertension, 6 cases of borderline hypertension, type II diabetes in one case, 9 cases of obesity (grade I or II), one case of scoliosis;
- In the group with more than 21 years of seniority, there is a healthy subject. The following conditions were registered: 4 cases of hypertension, 3 cases of borderline blood pressure, 1 case of type II diabetes, obesity in 4 subjects, 1 case of hearing loss, pain in the spinal area in 2 cases.

From the health analysis of all the electricians (both types of discussed categories), it has been noted a similar way of distribution of the diagnosed diseases with the lots. Their incidence increases with age, but they are also found in young employees, which is a signal for early wear.

### **3.2. The second research stage**

Regarding the psychophysiological capacities and mental health of the investigated personnel, the following results have been achieved and they are analyzed in the following section. The results of the evaluation of the general personality traits have indicated, in most cases, balanced personalities, without accentuated personality tendencies that generate inappropriate or maladaptive behaviors in the occupational activity or in the extra-professional life. The evaluation of the sensory-perceptual and cognitive capacities and of the qualities of the simple and complex motor skills reveals the following aspects:

- In the case of sensory - perceptive capacities, analyzing the evolution between the stages of investigations, we could see that most subjects ( $\approx 70\%$  - group of electricians working on power lines, respectively  $75\%$  - group of electricians working in high power stations) have maintained relatively constant capacities from one stage to another. Moreover, there are cases of evolution in a positive sense, hence improvement of these sensory-perceptive and cognitive capacities;
- In terms of psychomotor capacities, a relative maintenance of levels could be observed in most subjects ( $\approx 60\%$  - group of electricians working on power lines, respectively  $62\%$  - group of electricians working in high power stations), both in the case of reaction time to visual as well as auditory stimulus.

The cause of these evolutions can be attributed both to the relative knowledge of the test (it may be a certain degree of cognitive and motor “learning”, which allows “updating” performance when meeting the stimuli in the test), but also to the involvement when participating in study (hence, a higher level of intrinsic motivation of the subjects). No significant correlations could be established between the situations of decreased level of sensory – perceptual, cognitive and psychomotor capacities and the age or seniority of the investigated subjects.

Regarding the analysis of the workload, it should be noted, however, the existence of certain factors at which the level of risk has increased. Hence, these factors are qualifying as stressors. Thus, in the case of electricians working on power lines, factors such as “imposed work pace”, “time constraints”, “professional requirements (mental and physical)”, “responsibilities and dangers” have registered increases in the level of risk, even towards an increased level in some cases. For electricians working in high power stations, there have been increases in “operator overload” and “responsibilities and dangers”, coupled with a decrease in “independence in carrying out the activity”. The evaluation of the factors generating psychic stress has highlighted the increase of the activity demand, of the

constraints and limitations, as well as of the responsibilities in relation to the safety of one's own person, other people and equipment, in the case of both categories of electricians. The evaluation of mental symptoms (Questionnaire for the Evaluation of Occupational Stress) has highlighted, in the case of both groups investigated, the fact that the subjective symptomatology is within normal limits, that the symptoms accused by the subjects has not exceeded the average level, being therefore psycho-pathologically insignificant. Regarding the state of mental health (PSI - Ilfeld), it was found that there are no subjects with significant psychopathological symptoms, so we refer to a state of comfort and mental health.

### **3.3. The third research stage**

Based on the obtained data, a procedure for monitoring the physical and mental health of personnel has been carried out and a risk identification/assessment grid that may generate possible early wear and tear of employees has been developed.

Measures like reducing the level of physical activity, activity optimization, adaptation of the work environment, development of skills (learning, training, improvement), work stress management; constant concerns for improving working conditions, integration of ergonomic and psychosocial risk management in general OSH management at the organization level, have been suggested.

## **4. CONCLUSIONS AND DISCUSSION**

The ergonomic risk factors are pertinent as well as occupational biological exposure indicators and are reflected in the health state, especially in the presence of cardiovascular and musculoskeletal disorders. The study emphasized the compatibility of the present personnel with their position and workplace as for the health state perspective. The present levels of the investigated physical and physiological functions and capacities represent a reference level for future surveillance of electricians' performance.

Some occurring variations may depend on both the current state of the individual and the

evolution of abilities over time, so they must be monitored over longer periods of time, in order to identify the general trend of their evolution. From the point of view of physical health, there is an increased incidence of obesity, hypertension and diabetes, not influenced by age group, which may signal early wear. By comparing the health conditions with the results achieved at the control group of electricians, the following can be stated. First, there has been a similar structure and proportion of the types of diseases; a significant number of cases of untreated or incorrectly treated hypertension were registered. Second, there has been a significant number of subjects with blood pressure values at the upper limit of normal. Thus, the measurement of blood pressure after the night shift or when returning from the field, after interventions (sustained physical effort), could record values at the upper limit of normal. For the optimal determination of the blood pressure values, we have suggested that the medical control should be performed after granting a rest time following the night shift or the interventions carried out in the field.

The assessment of psychophysiological and mental capacities showed higher levels than average for most of the studied subjects and constant levels of the sensorial perceptive and cognitive demands in the different stages of the study. In addition, the occupational risk/stress factors together with other extra-occupational and individual factors could intervene in the etio-pathogenesis of some diseases of the investigated personnel.

The longitudinal surveillance of the health state, the levels of different physical, physiological and mental functions and capacities, the general personality traits, emphasized the relationship between the work (under all aspects) and the health state, have offered the possibility for a more judicious assessment on occupational exposure to accident and ill health risk factors and allowed the early detection of the reversible disease/decrease of capacities. The surveillance of personnel health state has been correlated to the specific occupational risk factors and legislation requirements. The aim of this study was achieved by knowing and understanding the

actual workplaces, operations, demands, work conditions and the human response to all these work demands.

## 6. REFERENCES

- [1] Green, A. E., Labour Market Trends, *Skill Needs and the Ageing of the Workforce: A Challenge for Employability?*, Local Economy, 18(4), 306-321, 2003.
- [2] Carter, D. R., Beaupré, G. S., Wong, M., Smith, R L., Andriacchi, T. P., Schurman, David J., *The Mechanobiology of Articular Cartilage Development and Degeneration*, Clinical Orthopaedics and Related Research, 427, S69-S77, 2004.
- [3] Charnes, N., *Ageing and Human Performance*, Human Factors: The Journal of the Human Factors and Ergonomics Society, 50(3), 548-555, 2008.
- [4] McEwen, B., *Sex, stress and the hippocampus: allostasis, allostatic load and the aging process*, Neurobiology of Aging, 23(5), 21-939, 2002.
- [5] Najjar S. S., Scuteri A., Lakatta E. G., *Arterial Aging. Is It an Immutable Cardiovascular Risk Factor?*, Hypertension, 46, 454 – 462, 2005.
- [6] Toma, I., *Medicina muncii*, Editura SITECH, Craiova, 2004.
- [7] Ilmarinen, J. E., *Ageing workers*, Occup Environ Med, 58, 546, 2001.
- [8] Gáspárik, A.I., Ábrám, Z., Ceana, D., Sebesi, S., Farcas, D., Gáspárik, A. C., *Shortages of Doctor-Patient Communication. Teaching Patients to Communicate Effectively*, Procedia - Social and Behavioral Sciences, 142, 376-379, 2014.
- [9] Farcas, D.M., Sachelarie, L., Burlui, A., Suteu, C., *Is a support group important in improving the quality of life and well being in patients with osteoporosis?*, International Journal of Medical Dentistry, 23(3), 169-174, 2019.
- [10] Harper, S., Marcus, S., *Age-Related Capacity Decline: A Review of some Workplace Implications*, Ageing Horizons, 5, 20-30, 2006.
- [11] Petreanu V., Iordache R.M., *A research perspective concerning work related early wear*, The European Proceedings of Social & Behavioural sciences, 601-608, 2016.
- [12] Papadakis, M.A., Mcphee, S.J., *Current medical diagnosis and treatment*, Mc Graw Hill Education, 2019.
- [13] Masters, B. R., *Harrisons's Principles of Internal Medicine*, two volumes and DVD. Eds: Dan L. Longo, Anthony S. Fauci, Dennis L. Kasper, Stephen L. Hauser, J. Larry Jameson and Joseph Loscalzo, McGraw Hill, 2012.

### Un studio longitudinal asupra uzurii premature în muncă

Aceast articol prezintă rezultatele unui studiu longitudinal efectuat timp de trei ani pe un lot de electricieni care lucrează la înălțime și în instalații sub tensiune pentru a depista posibile semne și simptome cu caracter reversibil ale stării de sănătate fizică și mentală și care pot conduce la apariția unor comportamente riscante în activitate. Scopul cercetărilor a fost de a evidenția existența unui posibil risc de uzură prematură a personalului, în relație cu activitatea desfășurată și riscurile profesionale specifice. Bazat pe o abordare metodologică multidimensională, multifactorială a problemelor ergonomice, studiul a evidențiat factorii profesionali de risc care pot contribui, alături de factorii extraprofesionali și individuali, la etio-patogeneza posibilelor afecțiuni ale personalului investigat și măsurile necesare în planul politicii de sănătate și securitate în muncă la nivel organizațional.

**Raluca Maria IORDACHE**, PhD, Senior Researcher, National Research and Development

Institute for Occupational Safety and Health “Alexandru Darabont”, Ergonomics Department, iorraluca@yahoo.com, Blvd. Ghencea no. 35A, sector 6, Bucharest.

**Viorica PETREANU**, eng., Senior Researcher, National Research and Development Institute for Occupational Safety and Health “Alexandru Darabont”, Ergonomics Department, vioricapetreanu@yahoo.com, Blvd. Ghencea no. 35A, sector 6, Bucharest.

**Delia Cristina MIHĂILĂ**, MD, National Research and Development Institute for Occupational Safety and Health “Alexandru Darabont”, Ergonomics Department, diacris8@gmail.com, Blvd. Ghencea no. 35A, sector 6 Bucharest.