

CRITERIA OF OCCUPATIONAL FITNESS FOR WORKERS OF COAL PRODUCTION EXTREME PROFESSIONS

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In recent years issues of personal suitability for specific workplace (or career suitability) using complex methodological approaches were widely discussed in various fields of economy. This included studies of individual properties of neural system, personality, mental processes, cortico-subcortical relationships, autonomic responses, which characterize the degree of stress imposed upon a human's body. Specific working conditions in coal mines, characterized by a complex of unfavorable factors, place increased demands on psychofunctional conditions of miners' bodies. Certain general properties of body should be studied and be critically important for selection of extreme profession. Intensification of industrial production, growth requirements for quantity and quality of work and level of training brings stricter requirements of professional competences. Competences are especially important for those occupations in which the discrepancy between physiological capacity of a body is associated with potential health damage and life threatening risks. We have developed criteria for suitability applicable to the preparation of young professionals to work in extreme conditions of the coal production. Use of a complex psychophysiological indicators of professional competence of body work, will increase efficiency, reliability and enable trouble-free carrier. The most informative psychophysiological parameters are Breathing capacity, Capacity of forced breathing, Maximal volume speed, Maximal ventilation of lungs, Systolic arterial pressure, Diastolic arterial pressure, Frequency of systole, Reactive uneasiness and Individual uneasiness.

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Introduction

A number of industrial enterprises, during the last years, have experienced an enormous growth. These enterprises have introduced new production technologies. For this reason, the labor in modern medicine is facing problem of occupational suitability (or career suitability). The complex methodological approaches, in medicine, include study of properties of individual neural system, personal features of individuals, mental processes, corticosubcortical interrelations and vegetative reactions. This also includes the individuals' tension, degree of organisms, and energetic "price" of performed work (Makarenko, 1991; Moykin, 1994; Sudakov, 1998). The establishment of worker's optimum conformity, both by a state of physical and psychological health, is main task of professional success and reliability. The discrepancy between a person's specific features either physical or mental and features required for specific workspace could be a source of worst consequences (Eliseev, 1994).

Intensification of coal production with introduction of new technologies and the equipment puts forward a pressing need to prepare qualified workers to do production tasks in extreme conditions of an underground coal mining. The failures of labor activity are not only considered as consequence of his or her psychophysiological status. We may assume that psychophysiological functions are professionally significant. Successful learning and adaptation is impossible without further development of psychophysiological functions (Ismailova, 2001).

The purpose of this work is to develop psychophysiological criteria to define workers' professional suitability in extreme conditions of underground coal mining. The criteria will be based on ability to achieve organisms' noise stability and functional reliability of workers considering influence of physical and psychoemotional pressures.

Methods of research

We formed several groups of examinees (126 miners and 44 workers of operator service in coal mines, the middle age of workers was 38.9 ± 1.4 and 37.2 ± 1.8 years; work experience was 17.6 ± 1.5 and 14.6 ± 1.5 years). This provides professional experience and information capacity for the brain's high parts to accept emergency decisions, including foreseeing, and expectation. 35 pupils, from trade-union schools at age of 17-18 years, were also included in the analysis.

A commission of experts analysed the effectiveness of miners' professional work. These experts were the members of collective coal producers. These experts characterized the level of social activity of each worker. The intergroup relations of workers were examined by these experts. The experts found that 90% of workers showed professionalism, working capacity, responsibility, and carefulness in accident-free work and successfulness in their work tasks. We have discovered that frequent changes of work assignments had resulted in unsatisfactory adaptation to working conditions. There was a loss of valuable experience, specific knowledge and furthermore a reduction in working capacity of the worker.

Questionnaire and psychological testing was used to estimate workers' organism group type. The individual reactions were found to depend on performance during labor tasks. Researchers studied individual properties of neural system, features of personal, mental processes, corticosubcortical interrelations, reactions and energy providing systems to adjudge psycho-physiological status of examinees. The received results are processed by means of correlation and regression analyses. Reliability was tested by Student criterion (t).

Results of research

The results of questioning have shown that industrial environment and professional work influenced psychological status of the workers. We have found that, in the opinion of 54.2 % workers, quality of doing labor task depended on a high quality of difficultness and working tensions. About 45.8% examinees blamed the industrial environment to be a bad factor to influence quality of doing labor tasks. The intensity of peculiarities, subjective perception and duration of labor are also a bad factor. These factors can cause a noticeable decrease in worker's capacity by decreasing the tolerance, sensitivity of functional weakness, and regulative system.

The psychophysiology test showed that the greatest prevalence of uneasiness was found in miners. About 65% of interrogated workers worked with lower performance. A rod symptom of a mental

tension was high degree of reactive tension, higher force and mobility of neural processes that defined base functional level which underlies success, reliability and accident-free performance of an activity.

The action of industrial information coupled with formation of various shifts from parameters of adaptive mechanisms has potential impact on psycho-physiological status of operator service workers. The intellectual tension in addition to complex emotional loading, in the working conditions, promotes a limbic-cortical systems tension. It is responsible for integrative function of CNS, and it, particularly, provides such functions as: memory, attention and thinking.

The parity of balance of the basic neural process in cortical part of visual analyzer changed in all of the examined miners due to insufficient level of light on workplace and absence of daylight. Decrease in activity of acoustic perception in miners is linked to an intensive workload.

Influence of production negatively influences miners' working capacity that leads to physiological changes and displacement of a psychological structural balance. These data are in the basis of success, reliability and accident-free work of miners, as activation of brain hemispheres does not cause success of adaptation, but provides reserve opportunities, high plasticity, ease of centers involvement in forming interfaced dominant foci of excitement and inhibition.

Activity of operators organisms' information-operating structures depend on the condition of analyzer (acoustic, visual) systems. So, their high sensitivity was provided with formation in organism's cyclic correlations by the regime of expecting excitement reverberation. The prominent feature was prevalence of switching character function, which provides checking an acting stream of sensory information, comparison of all data at acceptance of the further operative actions.

Parameters of attention and of visual analyzer's throughput abilities at examined miners did not differ significantly as per simple test performance, and test with switching attention. When miners were working with success, concentration and attention stability was monitored, and also quality of tests performance for volumes definition of short-term semantic (acoustical) and mechanical (visual) memory on verbal, sign-symbolical and spatial elements of information is considerably above ($p < 0.05$), than at miners less successfully coping with work.

The tension of subsystems of an organism information-operating structures at operators' professional work was showed by mobilization of a brain cognitive functions in due to concentration of attention functions (growth of attention parameter), activity of figurative-spatial memory (FSM) parameter, with increase in frequency of brain's throughput ability (S); all this proceeded on a background of decrease in parameters of short-term and long-term memory, an index of attention.

Preservation conditions of workers' intellectual high levels of working capacity from coal producing enterprises testified about structure flexibility and sufficient reliability of mnemonic functions allowing them to adapt to various stimulation. Fast reaction to the changed situation is revealed at presentation of various physical and psychological loadings or pressures, best ability to process the received information and speed of acceptance measures on elimination of the reasons leading to various unexpected situations.

Miners' vegetative maintenance test of intellectual loading was defined by various types of hemodynamic systems reaction: miners successfully working by vascular, at miners less successfully coping work by heart type, at operators by balance displacement on homeostatic level to side of raising ergotrop influences with formation of more rigid connections. This tendency lead to an

uneconomical costs of lost reserve opportunities of an independent contour and as forecasted further promoted destabilization of a rhythm. Close positive correlated connections of absolute capacity parameters with parasympathetic neural system markers are directed on creation of more economic regime of heart working. This can be seen as an adaptation of their organisms' individual sensitivity in a process of balancing optimum interaction by independent and central contours of management.

Results of psychophysiological research revealed that the degree of successfulness of task mastering depend on complex process of individual adaptation the neuro-regulative mechanisms included various physiological reactions which specificity was defined by character of influencing factors extremeness. Thus, the same level of adjustable parameters were reached at the examined persons due to non-uniform changes of different parts of regulation system, an ambiguous condition of functioning systems.

During adaptation to working conditions a miners' organism developed a plenty of functional interrelations to choose the optimal variant of reaction to action of "physical" and "neural-emotional" factors of the industrial environment.

The essence of formation of workers' professional suitability from coal-mines consisted in association of physiological functions which are taking part during labor activity and providing adaptation of their organism to production conditions. Character and features of functional system activity, that is quality of formed professional suitability, depend on an initial level of separate professionally significant qualities. As can be seen on Table 1, psychophysiological results show complex of professional-significant qualities and of workers' organism functions related to coal production.

For workers of basic tasks from collieries it is necessary to consider these professional-significant qualities: as force and mobility of neural processes, a level of neurotism, stability of attention, short-term mechanical memory and recognizing the sign-symbolical information, muscular force, parasympathetic vegetative structure.

Process of adaptation to continuity and processes periodicity therefore expanded in a range of protectively-adaptive opportunities of miners organisms. We have found, that during professional work of workers from coal production after a primary tension of regulative structures steady adaptation was formed and lead to optimal functioning providing optimal balancing of their work energy.

Thus, isotropic function of a myocardium, as a rule, increased, the general peripheral resistance of vessels decreased, we reconstructed pattern of breath, and balance of inhibition and exciting processes of central neural system was established. We discovered that in 82.5 % examined miners phase of steady adaptation reached 13-15 years.

Table 1: Parameters of professional-significant qualities and of an of workers' organism functions from coal production, (M \pm m)

Indexes	Miners	operators
Vegetative dysfunctions, a.u.	14.4 \pm 1.8	16.0 \pm 3.5*
Kirido's vegetative index , %	- 9.1 \pm 1.2	-6.3 \pm 0.8*
Individual uneasiness, ball	42.1 \pm 0.9	44.1 \pm 1.1*

Power of neural processes, a.u.	1.2±0.03	0.9±0.01**
Asymmetry of neural processes, a.u.	1.1± 0.7	1.4 ±0.5*
Latent period of visual-motor reaction	324.9± 6.7	313.9±8.7*
Number of non-adequate reactions on light stimulus	6.2± 1.8	6.4± 1.9**
Stability of attention, ball	6.6±0.3	6.3± 0.5*
Acoustic memory, ball	6.1± 0.1	7.6 ±0.1**
Visual memory, ball	4.7± 0.2	5.2 ±0.1*
Power of left hand, kg	47.4± 1.2	53.8±1.1*
Note: * p < 0.05; ** p < 0.01 reliability between groups Source: Authors		

Adaptation in conditions of increased functional loadings at influence of physical factors proceeded due to increase in speed of energy consumption by inclusion of the available compensating mechanisms. Each functional system of an organism possessed certain liability, enabling to change condition to adequately influence by certain level of elements integration.

Therefore, the degree how factors influence a system, was estimated using correlation structure, characterized either by its regrouping, or strengthening of communications (the quantity of intersystem communications increased 1.3 - 2.5 times).

Received results of correlation analysis show that at age of 30-39 years the miners reached their peak of professional working capacity due to an optimum mode of homeostatic regulation. At the same age there was a differentiation of workers by a level of adaptable potential and size of functional reserves. The features of physiological parameters describing a level of nonspecific cerebral activity and a condition of vegetative reactions depend on mental adaptation and success of miners' professional work. The level of central neural system activity defined qualitative specificity of working person's regulative mechanisms.

It is established, that separate functions cannot characterize possible efficiency precisely and professional work of individual worker. We have reviewed the most informative indexes of psychophysiological parameters from 128 analyzed parameters of an organism's leading systems functional condition (see Table 2).

The revealed most significant indexes of psychophysiological parameters have formed the basis for development of professional suitability criteria. We use linear regression to estimate model parameters (each worker's psychophysiological parameters). So the goal is to forecast professional suitability (PS) using the following model:

$$PS = 1,8xL - 0,5xFNP - 0,3xF - 0,2xS + 0,4xSA + 0,3xCA + 2,8xVM + 5,5xAM - 80,4,$$

where: *L* – a level of neurotism, a ball; *FNP* – force of neural processes, a.u.; *P* – power of left hand, kg; *S* – staying-power of the right hand; *SA* – stability of attention, a ball; *CA* – concentration of attention, a ball; *VM* – visual memory, a ball; *AM* – acoustic memory, a ball.

Table 2: Fluctuations ranges of the most informative indexes of psychophysiological parameters, defining professional suitability of workers from coal production

No.	Indexes	Size of indexes
1	Breathing capacity, % from FBC	89- 90
2	capacity of forced breathing out ₁ ,% from FCFB ₁ ,%	85-88
3	Maximal volume speed, % from FMVS	75-77
4	Maximal ventilation of lungs, % from FMVL	76-85
5	Systolic arterial pressure	100-130
6	Diastolic arterial pressure	60-90
7	Frequency of systole, in ¹ /min	66-80
8	Reactive uneasiness, ball	35-44
9	Individual uneasiness, ball	35-44
10	Speed of reaction, (ms) a) simple on sound signal acoustic motor reaction AMR b) difficult on visual signal visual motor reaction VMR c) difficult on signals of various colors VMR	< 330 < 340 < 660
11	Force of neural processes (chronoreflexometria) 40/90	0,84-1,30
12	Mobility of neural processes, Gc	>26
13	Audimetria, on waves (Gc): a) from 125 till 2000 b) from 4000 till 8000	from < 5 to < 10 from <10 to <35
14	Concentration of attention (Anfimov's test), % a) index of throughput ability of visual information, simple b) index of information process speed, complex	> 45 < 50
15	Memory capacity , %	> 30
16	Short-term acoustic memory	> 7
17	Short-term visual memory	> 6
18	Brightness	> 1,3 x10 ⁻⁶
19	Sensitivity of brightness, E	from 5 to 6,0
20	Power of hands, (kg)	> 35

21	Staying power of hands, (s): a) 50% from maximal power b) 75% from maximal power	 >70 > 32
22	Index of tremor,(a.u): a) static b) dynamic	 >0,14 >0,29
Source: Authors		

The estimation of the presented model is lead by Fisher's factors ($F = 362.1$) and discrimination ($D = 97.2$), showing high importance and reliability of developed model. Coefficient of determination $R^2 = 0.974$. The regresses received by means of equation ball estimations of predicted professional suitability for each worker were compared with the received integrated parameter which was result of multiplication of average ball estimation to corresponding size of weight factor.

In estimation of professional suitability it is necessary to consider the following: if, a predicted point is above the worker's integrated parameter, this worker should be carried to group "suitable" and if, below, he is carried to the group "conditionally suitable".

For the persons recognized "suitable" for underground works, it is necessary to use differentiated criteria of an estimation of an organism's basic systems functional condition to which increased requirements during labor activity. Measurement of professionally important functions and qualities should be conducted during preliminary medical examination and then every 3 years based on the decision of the employer. Properly organized professional selection will promote increase of labor productivity of miners while decrease in disease and a traumatism.

Establishment of professional routes' parameters which change of trades in 33.6 % cases with the most harmful and dangerous working conditions were carried out will allow revealing in due time persons of "group of risk" during preliminary and periodic medical examinations. Realization of schemes of professional routes and recommendations on protection by time alongside with use of an individual protection methods will allow to protect health of thousands of those working on the enterprises in the coal industry of Central Kazakhstan.

Conclusion

On a basis of workers' professional work success are basic individual psychophysiological characteristics: small force of neural system, mobility of excitation, an average level of lability, prevalence of excitation processes over inhibition, which defined sensitivity (excitability) of managing and energy providing systems, causing safety at high level while maintaining working capacity and health.

The estimation of operators' brain cognitive functions has shown that the leading functions are functions of attention, figurative-spatial memory and throughput of a brain. Worker's ambiguity of perception is caused by influence of adverse factors of coal production. Possibly, not only due to character of such industrial activity, but also by individual comprehension and the attitude to it.

An estimation of an organism's individual psychophysiology based on operator service and mines and a degree of worker's conformity to professional requirements is defined not only by learning, but also

by features of psychological adaptation of an organism to adverse complex production factors. Creation of professional suitability forecasting system will promote for wide implementation in various fields of economy.

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