# RISK ASSESSMENT PRACTICE IN HYGIENIC AND EPIDEMIOLOGICAL STUDIES

UDC 614.1/7:612.017
DOI: 10.21668/health.risk/2017.3.06.eng

## RESULTS OF PHYSIOLOGICAL ADAPTATION ASSESSMTN AND HEALTH RISKS FOR LABOR MIGRANTS FROM TAJIKISTAN

**M. Khodzhiev, N.F. Izmerov, I.V. Bukhtiyarov**

Scientific Research Institute for Labor Medicine, 31 Budennogo Av., Moscow, 105275, Russian Federation

*The paper focuses on the results of physiological research performed on 9 occupational groups of migrants who came to Moscow region of Russia from southern Central Asia republics. We studied adaptation processes characteristics in labor migrants as per cardiovascular system parameters and neuromuscular apparatus parameters. We revealed peculiarities in heart rate variability (changes in stress index S1, values of AMo, VLF spectrum power, PARS parameter) in migrants depending on neuro-emotional nature of working activity and muscular loads intensity. We detected apparent decrease in dynamometric parameters of endurance and maximum working capacity of arms muscles and backbones and legs muscles by the end of their working day. We created a procedure to determine an adaptation process stage under combined effects exerted by labor physical hardness and neuro-emotional intensity; unsatisfactory adaptation increases health disorders risks. We showed that long-term and intense impacts by factors determining labor process hardness caused occupational diseases of musculoskeletal system and peripheral nervous system. We revealed that as labor intensity grew working stress in a body also increased and it could transform into overstrain and occupational diseases evolvement (primary hypertension, ischemic heart diseases, and neurotic disorders). A distinctive feature is that men suffer from cardiovascular system pathologies more frequently while women tend to suffer from nervous system pathologies. In this relation, we should make separate predictions of occupational pathology probability depending on labor intensity level for males and females.*

*Adaptation processes optimization should include organization of rational work and rest regime, healthy lifestyle formation, improvements in medical aid for migrants.*

***Key words**: migrants, neuro-emotional nature of labor, muscular loads, адаптация, heart rate variability, healthy lifestyle.*

An issue of labor migration in Russia is determined, on the one hand, by necessity to at-tract additional labor force required for post-perestroika development of Russian economy and efficient use of human resources in all brunches of industries, agriculture, and communal services. On the other hand, citizens from former USSR republics (Central Asia) need to come to Russia searching for paid jobs; they come to various regions, including Moscow and Moscow region [12, 13] .

A concept of adaptation as a process of a



**Makhmadamin Khodzhiev** – Candidate of Medical Sciences, working for a doctor's degree (e-mail: amin.dok@mail.ru; tel.: +7 (968) 585-12-95).

**Nikolay F. Izmerov** – Member of the Russian Academy of Sciences, Doctor of Medical Sciences, Professor, Scientific Supervisor.

**Igor' V. Bukhtiyarov** – Director, Head of Laboratory for Labor Physiology and Preventive Ergonomics, Doctor of Medical Sciences, Professor, a Corresponding Member of the Russia Academy of Sciences (e-mail: niimt@niimt.ru; tel.: +7 (495) 365-02-09).

body getting adapted to the environment is widely used in biology and medicine. Examination of human adaptation to new environmental factors and health disorders have attracted attention of many researchers. A theory on sequence of adaptive shifts in a body under influence exerted by increased loads has been developed with-in general physiology and occupational physiology [1]. Sequence in adaptation processes evolvement involved sequencing of a certain stages in functional state; adaptation failure led to increased risk of pathologic disorders. N.A. Agadjanyan observed adaptation processes peculiari-ties occurring in adaptation to highlands and hypoxia, which became apparent in more efficient cardiovascular system responses in native Tadjiks in comparison with visitors [2]. S.G. Krivoshchekov studied how healthy migrants adapted to conditions in sub-polar regions (Middle Priobye) under ordinary and shift working regimes; as a result, a concept of human adaptation in the North was created [10]. Adaptation to a new place of living is known not to pass without consequences for one's health; adverse environmental factors and working process factors influ-ence bodies of labor migrants working in various RF regions. Yu.V. Moikin et al revealed chronic diseases exacerbation in Baikal-Amur Railroad builders who came from the south of Ukraine and Moldavia during their first months of staying on ecologically adverse territories of Siberia [8]. Substantial physical loads, both local and overall, which builders had to undergo were shown to result in occupational diseases of musculoskeletal system and neuromuscular system.

Adverse social and psychological conditions labor migrants work in are related to exces-sive requirements at a working place, to absence of any possibilities to participate in labor process adjustment (low control at a working place), and insignificant (very small) social support for labor migrants [7]. It can lead to stress at a working place [4, 17,18], and increased cardiovascular system diseases risk [14, 16, 19]. Occupational stress related to overexhaustion, central nervous system depletion, as well as functional overstrain, can cause neurotic disorders evolvement which are a significant part of psychological health issues [5].

Peculiarities of adaptation among various occupational groups of labor migrants have been attracting more and more attention in recent years; a new research trend in occupational physiology and occupational medicine is being formed and it is related to more profound insight into adaptation process which all aspects of our everyday life are involved in. Analysis of scien-tific literature has revealed that today there are not enough data on research on adaptation re-sponses to working processes peculiarities and to new social and psychological conditions in labor migrants as well as on their health risks analysis. And here labor intensity and peculiarities of specific working loads play a very important role in formation of a body functional state as they can vary greatly in case of each specific occupational group of labor migrants. It is especially vital in case of young people who come to Russia both as labor migrants looking for a job and as students who come from various Tajikistan regions to start their studies in HEE in the country capital.

Our research goal was to give scientific grounds for physiological peculiarities of Tadjiks migrants adaptation to industrial, social and psychological, and climatic and natural conditions in Moscow region; another goal was to work out activities aimed at providing social and medical support for labor migrants.

**Data and methods.** Research in industrial environments was performed on 6 occupational groups of men (builders-steelmen, builders-erectors, subway builders, road builders, vegetable warehouse workers, and vegetable market workers) and 3 groups of women employed in social sphere (housemaids, nurses, and child-minders) which were selected allowing for physical and neuro-emotional loads.

Students from Moscow Mining University and Tajikistan State Medical University who went into various sports (volleyball, futsal, free-style wrestling, box, taekwondo, and field shooting with handguns) took part in the research; they were 18-25 (21.5± 0.9). Our basic research periods were a training one and a period of competitions. Totally 139 people were examined.

Job analysis as per labor hardness and labor intensity was performed in conformity with Guidelines P 2.2.2006-05 [11]; physiological examinations included arm and backbone dyna-mometry, tremor measuring, determination of index of functional changes in circulatory system [9], and heart rate variability analysis as per conventional techniques [3,6,15].

**Results and discussion.** Physiological examinations of labor migrants were aimed at studying functional state of neuro-muscular system as being occupationally significant and making great contribution in providing reliability of work performed by the examined occupational groups. We detected decrease in dynamometric parameters of steelmen in a shift dynamics which became most apparent by the end of their working day. Thus, if hand muscles endurance lowered by 11.2% by a lunch break, then by the end of a shift that decrease became more drastic and amounted to 28.5% ($P \leq 0/05$), which was higher than physiological standards of a body strain in case of physical efforts; such physiological standards are equal up to 20% in case of general muscular loads.

The performed research revealed that a lunch break was not enough for the examined pa-rameters to recover. An integral dynamometry parameter, maximum muscular efficiency, also went down over a shift dynamics and this decrease amounted to 31.8% by the end of work in comparison with the data obtained when a shift just began. Such changes in dynamometry pa-rameters can be evidence that strain evolves in a neuro-muscular apparatus of arms and it is caused by physical hardness of work done. Together with decrease in dynamometry parameters hand tremor grew drastically (2.5 times). Thus, when a shift began a number of touches per 30 seconds amounted to 9.7± 1.16, but by a shift end it grew to 29.8 ± 2.13 touches ($P \leq 0.05$).

We should also note that work done by steelmen involves frequent maintaining uncom-fortable working postures (up to 50% of a shift), namely deep bendings; therefore, it was inter-esting to trace changes in dynamometry parameters of muscles supporting such postures. Strength reduced by 15.9%, endurance, by 25.6%, and integral parameter of maximum muscular efficiency, by 37.9%, by the end of work (Figure 1). So, we can conclude that strain and over-strain of neuro-muscular system caused by work evolves in steelmen (binders) over a shift dy-namics.

Data obtained via physiological research show that natural decrease in maximum efficiency of hand muscles develops in erectors over a shift dynamics; it reached 6.2% to static ef-forts by the end of work. Together with this decrease in maximum efficiency there was a fall in endurance by 9.0% by a lunch break, and by 14.5%, by the end of work. Calculated integral pa-rameter of maximum muscular efficiency also went down during a shift: by a lunch break it fell by 22.4%, and by the end of work, by 21.6% ($P \leq 0.05$). the described changes in dynamometry parameters can be evidence that strain evolves in neuro-muscular apparatus of erectors (binders)' arms and it is caused by a great number of local movements required in fastening building struc-tures with wire (binding).

Erectors' work involves preparing base surfaces, carrying panels over to a place of erec-tion, panels' strapping at storage places and other operations which require efforts by substantial groups of muscles. Research on efficiency and endurance of backbone muscles and legs muscles in a shift dynamics revealed there was decrease in backbones efficiency and endurance over a shift. Efficiency went down by 9.2%, endurance, by 21.8%, and in-

tegral parameters of maximum muscular efficiency, by 28.9%, by the end of work ($P \leq 0.05$), i.e., strain and overstrain devel-oped in workers' neuro-muscular system in a shift dynamics.

Such changes in dynamometry parameters can be evidence that strain and overstrain evolves in neuro-muscular apparatus and it is caused by physical hardness of work done. Mi-grants complained on pains in various parts of their bodies, including legs and arms muscles, and on overall fatigue, by the end of their working day.

Research of functional state of female migrants' neuro-muscular apparatus in a working day dynamics revealed that maximum efficiency of their right working arm tended to go down by the end of their work in comparison with the working day beginning. Endurance to static ef-forts decreased authentically by the end of a working day in comparison with its level at the be-ginning of it; decrease amounted to 29.3% in housemaids and nurses, and to 28.2% in child minders ($P \leq 0.05$).Statistically significant decrease in maximum muscular efficiency was detected already after 4 hours of work; by the end of a working day this decrease amounted to 31.0%, 28.9%, 31.0% of the initial level correspondingly.

Apparent static strain in lumbar muscles caused by performing work tasks in an uncom-fortable posture which involved bending by 45º was confirmed by negative dynamics in back-bone muscles dynamometry parameters in female migrants employed in social sphere. Maximum efficiency of backbone muscles in migrants working as housemaids decreased by 49.7% by the end of work; nurses, by 35.3%; child-minders, by 32.7% from the initial level ($P \leq 0.05$).

Detected changes in dynamometry parameters in a shift dynamics and graveness of phys-iological shifts prove that strain and overstrain evolves in neuro-muscular apparatus of arms and backbone muscles of labor migrants. First signs of strain occur already after 4 hours of work. By the end of work strain in neuro-muscular apparatus becomes quite apparent. The research results allowed us to determine a correlation between labor hardness and intensity and nature of changes in blood pressure and heart rate. Index of functional changes as-sessment and its average values over a shift proved that higher values of it were detected among steelmen who had greater workload. Thus, average values of functional changes index were equal to 3.09±0.07 for steelmen; 3.31±0.06 for erectors; 3.20±0.08 for subway builders; and 2.69±0.10 for vegetable market workers. We detected significant discrepancies between groups ($p \leq 0.05$). There was clear decrease in functional capabilities of a circulatory system and unsatisfactory adaptation evolvement in builders during stressful working hours. As market workers had significantly smaller workload we detected only functional strain evolvement in them.

Research on heart rate variability revealed authentic discrepancies in stress index (SI) pa-rameters in workers from various occupational groups depending on labor hardness category. As we can see from Figure 1, its values grew from 201.0±14.9 st.units in case of labor hardness cat-egory 3.1 (vegetable market workers) to 511.4±13.6 (steelmen) and 611.9±25.7 st.units (subway builders - tunnellers) in case of category 3.3. Seemingly, central regulation mechanisms became more active when autonomous circuit was suppressed in workers with labor of category 3.3 which indicated body physiological reserves were strained.

It was confirmed by significant decrease in summary cardiac intervals variability - SDNN - in subway tunnellers whose labor had 3.3 category of hardness. The parameter amounted to 41.6±2.01 msec against 59.87±1.55 msec y in market workers (labor hardness category 3.1). According to R.M. Baevskiy, the obtained data prove that parasympathetic section of vegetative nervous system becomes less active.

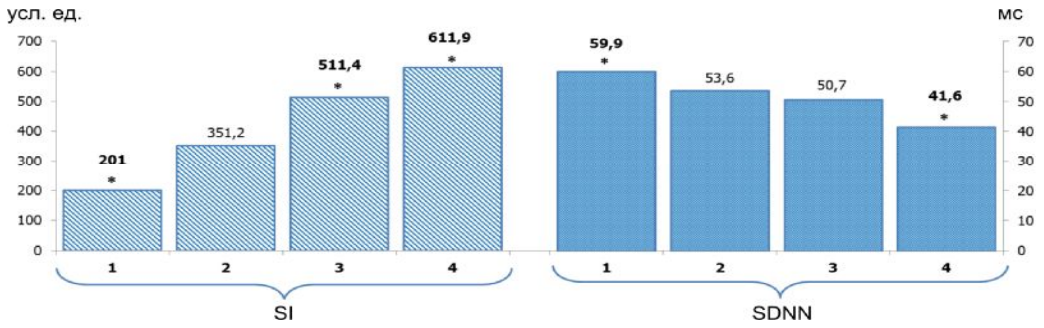


Figure 1 - Stress index parameters (SI) and total heart rate variability (SDNN) in labor migrants from various occupational groups depending on labor hardness category: 1 – vegetable market workers (category 3.1); 2 – road builders (category 3.2); 3 – steelmen (category 3.3); 4 – subway-builders - tunnellers (category 3.3). * $p<0.05$ – statistically significant changes in comparison with group 1

Index of centralization - IC - was also quite informative as we analyzed research results for workers with different physical loads (Figure 2). The obtained results coincide with changes in autocorrelation function parameter and prove there is increase of central mechanisms in heart rate regulation when labor hardness is high. Analysis of heart rate frequency characteristics re-vealed apparent increase in spectrum power of very low frequency (VLF) component in builders and subway builders with simultaneous increase in heart rate (to 91.5 beats/min), which proved sympathetic activation was high.

Regulatory systems activity parameter (PARS) revealed substantial strain in adaptation mechanisms of labor migrants. Thus, it varied from 4.74±0.54 – 5.85±0.64 st.units in female migrants employed in social sphere. It indicated that apparent strain in regulatory systems evolved and it was related to active mobilization of protective mechanisms including increased activity of sympathico-adrenal section. The obtained PARS values in Mosmetrostroy (subway) builders (6.21±0.82 points), and erectors (6.0±0.90) allowed to rank body functional state among regulatory systems overstrain (Table1).

This state is characterized with inefficient protective mechanisms unable to provide ade-quate body response to impacts exerted by working process factors and working environment. In this case excessive regulatory systems activation in not supported by relevant functional reserves.

To determine circulation regulation type (hypokinetic, hyperkinetic, or eukinetic one), we compared obtained values of blood minute volume and peripheral resistance with the standard values of the said parameters [2]. Our research results allowed us to reveal prevalence of hyper-kinetic circulation type in labor migrants. And here minute volume was higher than proper minute volume by more than 10%; peripheral resistance was more than 10% lower than its standard value. Hyperkinetic (cardiac) circulation type means greater heart output (blood minute volume) together with lowered peripheral resistance. Some migrants had eukinetic regulation type which was accompanied with certain decrease in peripheral vascular resistance. And in this case devia-tions of blood minute volume and peripheral resistance from their standard values were within ±10.0%.

Individual analysis of peculiarities in hemodynamics allowed us to determine per cent distribution of people with different circulation types as per examination groups (Table 2). The biggest share of people with unfavorable hypokinetic type of hemodynamics was detected in mi-grants working at big construction sites in Moscow and in Mosmetrostroy (subway construction): 36.9 ± 6,8% and 39.3 ± 9.2% correspondingly.

There were a lot of people with hyperkinetic type of circulation regulation in these migrants groups; their number in group I amounted to 34.2 ± 6.5%; in group II, 32.1 ± 8.8%. The obtained results prove there is more apparent instability in cardiovascular system functioning in migrants and it coincides with heart rate variability results.

So, performed research revealed that adverse functional changes evolved in labor migrants and they proved there was overstrain in neuro-muscular apparatus in workers; bodies. As working period grows longer, evolving stress in certain body system can cause risks of patholog-ical disorders. Basing on big database containing information on examined workers with various occupations, including builders, we calculated probability of occupational pathologies evolve-ment in musculoskeletal system and peripheral nervous system depending on working process hardness. It was detected that if labor had 3.2 or 3.3 hardness category, pathologies evolvement probability amounted to 17.1-37.0% cases which meant physiological-hygienic optimization of labor was required.

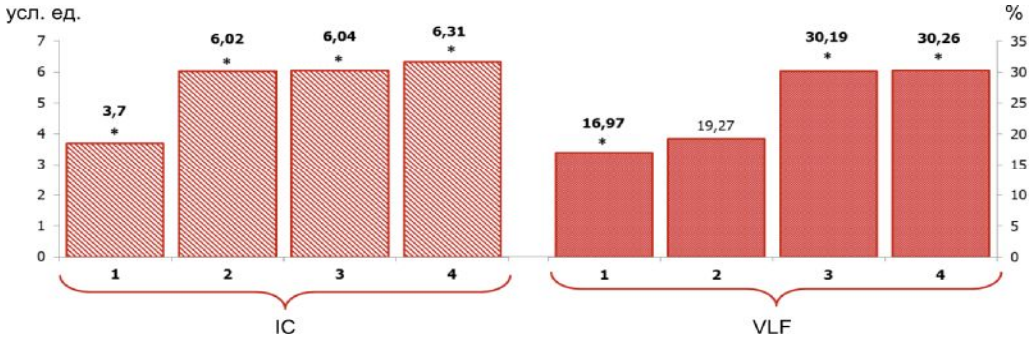


Figure 2 - Centralization index parameters (IC) and relative spectrum power of very low fre-quency component (VLF%) of heart rate variability in labor migrants from various occupational groups depending on labor hardness category: 1 – vegetable market workers (category 3.1); 2 – road builders (category 3.2); 3 – steelmen (category 3.3); 4 – subway builders - tunnellers (cate-gory 3.3). * p<0.05- statistically significant changes in comparison with group 1

Table 1

Certain parameters of heart rate variability in migrants from various occupational groups

| Parameters | Groups | | | | | | | | | $p < 0,05$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Steelmen | Erectors | Subway builders | Road builders | Vegetable warehouse workers | Vegetable mar-ket workers | Employed in social sphere | | | |
| | | | | | | | Housemaids | Nurses | Child-minders | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| SDNN, мс | 50,70 ± 1,61 | 41,72 ± 1,86 | 41,60 ± 2,01 | 53,56 ± 1,91 | 56,81 ± 1,57 | 59,87 ± 1,55 | 52,52 ± 1,65 | 48,88 ± 152 | 50,44 ± 2,17 | $p_{2-6,3-6}$ |
| SI, conv. units | 511,4 ± 13,6 | 546,4 ± 23,5 | 611,9 ± 25,7 | 351,2 ± 25,8 | 255,9 ± 17,9 | 201,0 ± 14,9 | 389,0 ± 15,6 | 451,5 ± 19,6 | 357,7 ± 20,4 | $p_{1-6, 2-6, 3-6, 4-6, 5-6, 6-7, 6-8, 6-9}$ |
| CCO | 6,85 ± 0,24 | 6,29 ± 0,81 | 5,68 ± 0,92 | 5,50 ± 1,80 | 5,99 ± 1,42 | 2,98 ± 0,31 | 4,36 ± 0,79 | 4,62 ± 0,92 | 5,39 ± 1,03 | $p_{1-6, 2-6, 3-6, 6-9}$ |
| TP, мс$^2$ | 1946,9 ± 147,5 | 1188,9 ± 155,6 | 1468,0 ± 175,3 | 1853,9 ± 250,3 | 2339,8 ± 176,1 | 2739,6 ± 197,7 | 2122,7 ± 202,1 | 1829,8 ± 219,4 | 1978,0 ± 179,1 | $p_{1-6, 2-6, 3-6, 4-6, 6-8, 6-9}$ |
| HF, % | 17,20 ± 1,95 | 18,46 ± 1,60 | 17,15 ± 0,90 | 23,45 ± 2,11 | 21,89 ± 2,44 | 50,22 ± 4,50 | 39,0 ± 2,86 | 27,15 ± 2,27 | 29,31 ± 1,27 | $p_{1-6, 2-6, 3-6, 4-6, 5-6, 6-8, 6-9}$ |
| VLF, % | 30,19 ± 2,42 | 30,69 ± 1,78 | 30,26 ± 2,04 | 19,27 ± 1,25 | 28,39 ± 2,58 | 16,97 ± 1,89 | 22,14 ± 2,17 | 20,78 ± 1,50 | 21,80 ± 1,92 | $p_{1-6, 2-6, 3-6, 5-6}$ |
| IC, conv. units | 6,04 ± 0,61 | 7,58 ± 1,11 | 6,31 ± 0,95 | 6,02 ± 0,85 | 6,0 ± 1,02 | 3,70 ± 0,91 | 5,18 ± 0,60 | 5,29 ± 1,01 | 5,59 ± 0,70 | $p_{1-6, 2-6, 3-6}$ |
| PARC, conv. un | 5,57 ± 0,79 | 6,0 ± 0,90 | 6,21 ± 0,82 | 5,56 ± 0,69 | 4,88 ± 0,42 | 4,05 ± 0,62 | 4,74 ± 0,54 | 5,29 ± 0,71 | 5,85 ± 0,64 | $p_{3-6}$ |

Table 2

Results of research on circulation type in migrants from various occupational groups

| Circulation type | Examined group | | | | |
|---|---|---|---|---|---|
| | Steelmen and erec-tors | Subway tunnellers | Road build-ers | Vegetable warehouse workers | Market workers |
| | 1 | 2 | 3 | 4 | 5 |
| Hyperkinetic | 34,2 ± 6,5 | 32,1 ± 8,8 | 49,0 ± 8,7 | 42,8 ± 6,1 | 54,1 ± 7,4 |
| Eukinetic | 28,9 ± 7,1 | 28,6 ± 8,5 | 27,2 ± 11,5 | 40,8 ±11,1 | 37,0 ± 12,4 |
| Hypokinetic | 36,9 ± 6,8* | 39,3 ± 9,2* | 23,8 ± 9,9 | 16,4 ± 4,4 | 8,9 ± 9,2* |

*p ≤0.05 in comparison with the 5th group (market workers)

Functional sample with fixed respiration rate (FRR6, FRR12) was aimed at detecting physiological reserves of cardiovascular activity and adaptation reactions of a human body. When respiration frequency was equal to 10 cycles per minute (FRR6), there was increase in power of high frequency waves (HF) within 0.15 - 0.25 Hz range, and it was shaped as a narrow high-amplitude wave. Most researchers considered it an effect of vagus nerve stimulation.

When respiration was less frequent and deep - 5 cycles per minute (FRR12), we detected authentic fall in heart rate variability, mode amplitude, S1 and parameters with characterized respiration waves. And at the same time authentic increase in SDNN appeared. Growth in power of low frequency waves (LF) with respiration which was 5 cycles per minute frequent was shaped as high amplitude peak within 0.05 - 0.15 Hz range.

We used samples with fixed respiration rate and revealed 2 basic reaction types which didn't depend on sex or place of permanent residence. The first type reaction was characterized with the situation in which increase in body regulatory systems stress occurred at FRR6 with the following decrease at FRR12. The second reaction type was characterized with gradual decrease in stress level at FRR6 and FRR12.

The performed spectral analysis revealed that changes in relative values of spectrum components during sampling of cardiorespiratory system with FRR were characterized with au-thentic increase in a spectrum high frequency component (HF) at FRR6 and its suppression at FRR12; decrease in low-frequency spectrum component (LF) at FRR6 and increase at FRR12.

Cardiovascular system response to a functional sample with fixed respiration rate in Tadjiks migrants is lowered in comparison with Russians living in Moscow region. It also proves that their adaptive reactions have certain physiological peculiarities depending on climate and geographic conditions of highlands in a donor country which make for increase blood saturation with oxygen and increase in cardiac muscle contractility.

We analyzed the results of research on competition stress as per heart rate variability in students representing various groups of professional sportsmen. Comparative analysis of heart rate variability parameters obtained before and after competition loads revealed slight changes in cardiovascular system responses in all the examined groups.

The greatest changes occurred in stress index SI in all groups except shooters; responses to competition loads were similar but with excessive appearance. Pre-start level of regulatory system stress was different both in individual sportsmen and in different kinds of sports.

The lowest SI before competitions was detected in volleyball players and football players, i.e. sportsmen from team sport games. But in case of sports where success depended on a sportsman' individual efforts, i.e. in fighting, SI before competitions was substantially higher.

The highest SI values, both before and after competitions, were detected in boxers

which probably was due to this kind of sport being rather extreme.

We gave grounds for a body adaptation under joint impacts exerted by labor hardness and intensity as per results of physiological research on representatives from various social groups (labor migrants, male and female students - professional sportsmen). The obtained results allowed us to justify determination of stages in adaptation as per results of analyzing correlations between working process factors and physiological parameters (dynamometry parameters and parameters of body vegetative provision).

Analysis of correlations between physical hardness of labor and its neuro-emotional in-tensity and physiological parameters of neuro-muscular system and cardiovascular system al-lowed us to rank them. Central place in this system belongs to labor hardness; other parameters as per their ranks are set as follows: working posture ( is statistically significantly related to physiological parameters in 93.3% of cases), static load (80.0%), labor intensity (73.3%), and emotional load (66.7%).

Research results helped us to give grounds for quantitative assessment of strain evolving in body adaptation responses due to physical labor and neuro-emotional labor which included calculation of decrease in neuro-muscular apparatus parameters (% of shift from initial state), and changes in average monthly values of cardiovascular system parameters (deviations from standard and proper values in %).

We applied regression analysis of data on changes in adaptation which occurred in great number of workers by the end of their working shift as per neuro-muscular system and cardio-vascular system parameters; it allowed us to derive a formula for determining level of strain in body adaptation responses (an application for a patent is completed). we determined stages in adaptation process of a worker's body in working process: self-regulation (optimal strain), activa-tion (allowable strain), mobilizations of 1,2, or 3 degree (overstrain of 1, 2, or 3 degree).

Long-term and intense impacts of factors determining labor hardness causes occupational diseases of musculoskeletal system and peripheral nervous system. Analysis of data obtained during physiological-clinical research allowed to reveal dependence between frequency of occu-pational diseases evolving in peripheral nervous system and musculoskeletal system of workers from the examined occupational groups and labor hardness (in conformity with working condi-tions class as per P 22.2006-05); the dependence is described with a log0linear regression equation.

Physical labor with local muscular loads, for example, erectors' work, involves completing a great number of small stereotype hands movement (from 4,000 to 130,000 per a shift), and it determines nature and depth of functional shifts and pathological disorders. Multiple regression analysis revealed there was a positive correlation ($P < 0.01$) between: a) a number of movements per shift and neuromuscular system fatigue in workers ($r = 0.96$); b) a number of movements per shift and frequency of occupational diseases evolving in peripheral nervous system and musculoskeletal system ($r = 0.92$); c) neuro-muscular apparatus fatigue and occupational pa-thology frequency ($r = 0.72$).

We calculated dependence between occupational diseases frequency and labor hardness category allowing for local muscular load; our calculation revealed that if labor hardness category was 1 (optimal) and a number of local movements per a shift didn't exceed 20,000, occupational diseases (pathological disorders in peripheral nervous system and musculoskeletal system) occurred in rare cases (up to 2%); if labor had 2 category (40,000 movements), pathologies oc-curred in 2-13% cases. But if labor category was 3 (hard labor, up to 60,000 movements) occupational diseases occurred in 13.1-20.0% cases; category 3.2. (more than 60,000 move-

ments), 20.1-28% cases; category 3.3, more than 28% cases.

Examination of physical labor related to regional and overall muscular loads revealed that labor process factors determining labor hardness (weight of cargos which workers had to lift and move, dynamic and static loads, number of movements, period of staying in physiologically non-rational postures etc.), were different in different occupational groups. Complex physiological-clinical research revealed close correlation between evolving neuro-muscular system fatigue as well as nature and depth of pathological disorders in peripheral nervous system and musculo-skeletal system and physical loads. Results of multiple linear regression analysis revealed there was an authentic ($P< 0.001$) correlation between examined physiological parameters and impacts exerted by above-mentioned labor process factors; correlation coefficient with muscular endur-ance amounted to + 0.79; electrobiological muscular activity during work + 0.92; heart rate + 0.88.

We calculated dependence between occupational diseases frequency (retrospective analy-sis of 2,318 cases) and labor hardness category allowing for regional and overall muscular loads; it helped us to derive a regression equation. We can see from this equation that if labor category is 1 (optimal) occupational diseases probability didn't exceed 6%. If labor category was 2, patho-logical disorders frequency didn't exceed 17.0% of cases. In case of hazardous (hard) labor (category 3.1) occupational diseases occurred in 17.1-28% cases; category 3.2, 28%: category 3.3, more than 36% cases.

As integral parameter of labor intensity grew, overall working strain in workers' bodies increased substantially and it could result in overstrain and consequently in occupational diseases. We performed correlation analysis on the example of several occupational groups searching for correlations between a share of workers who had certain general somatic pathologies and labor intensity. We revealed high direct correlation between integral parameter value and a share of people with the following pathologies: primary hypertension, ischemic heart diseases, and neurotic disorders (total number); i.e., the higher labor intensity was the greater risk of the said pathologies evolvement occurred. Regression analysis performed by us revealed that this de-pendence was given as a logarithmic equation regardless of a pathology detected.

Results of clinical examination performed on these occupational groups proved that the higher labor intensity was the greater share of people with this or that pathology was detected. Thus, primary hypertension was detected in 6.0-6.6% of women with 2 category of labor intensi-ty; in 9.77-13% of women with 3.1 labor intensity (in 10.77-18.9% of men); in 17.3-21.6% in women with 3.2 labor intensity (in 27.0-27.3% of men). Ischemic heart disease was correspond-ingly detected in 0.9-3.2% of women with 2 labor intensity; in 1.1-4.3% women with 3.1 labor intensity (in 8.0-8.4% of men); in 10.3-11.2% of women with 3.2 labor intensity (up to 32.5% of men). the same regularity was detected as per total number of neurotic disorders: 18.9-31.7% in case of 2 labor intensity; 44.7-45.4% in case of 3.1 labor intensity (12.1-24.2% males); 50.9-69.6% in case of 3.2 labor intensity (up to 34.3% males). A distinctive peculiarity is that men tend to have higher % of cardiovascular system pathology, and women, nervous system patholo-gy, and it coincides with data taken from literature. In this respect, prediction of occupational pathology evolvement depending on labor intensity should be done separately for women and men. Calculated probabilities (in %) of occupational pathologies practically fully coincide with the data of complex occupational analysis and physiological-clinical research.

We created scientifically grounded recommendations on medical and social support for la-bor migrants: educational activities, occupational selection and occupational orienta-

tion; rational work and rest regimes; motivation to pursue healthy lifestyle; medical and diagnostic activities; additions to legal regulations for labor migrants.

**Conclusions.** We proved that a heart rate variability parameter when combined with functional samples was quite informative for characterizing peculiarities of regulation by vegetative functions and stress level. Nature of strain in body regulatory systems as per heart rate variability parameters depends on working process peculiarities, climatic and geographic conditions, stressful situations of social and occupational genesis related to social and psychological life of labor migrants.

Activity of sympathetic section of regulation in labor migrants revealed that adaptation strain syndrome as per physiological parameters became apparent through changes in heart rate variability: various levels of SI stress index related to great physical (muscular) loads and neuro-emotional loads; evident increase in spectrum power of very low-frequency component (VLF) with simultaneous increase in heart rate. We determined stages in a body functional state and adaptation stages as per regulatory systems activity parameter (PARS) (optimal strain was equal to 1.19±0.28 points; allowable strain was equal to 40.5±0.62 points; overstrain was equal to 6.21±0.82 points).

Detected discrepancies between native Russians and Tadjiks migrants in the following parameters: overall heart arte variability parameter SDNN, correspondingly: (63.76± 2.80) and (56.25±1.62) msec; very low frequency spectrum component VLF: (14.51± 0.81) and (19.54±2.94) %; low frequency spectrum component LF: (50.61±1.72) and (35.38±2.10) % con-firm that biological adaptation is directly determined and it was formed as a result of long-term historical process.

Our comparative and physiological research allowed us to reveal that adaptation process developed basing on various mechanisms: increase in spectrum components power or increase in information processing period or information transfer rate; it is proved by data on dynamics of periods of waves with different frequency during a test with fixed respiration rate. We applied functional samples with fixed respiration rate and it allowed us to reveal that Tadjiks migrants regardless of their sex tended to have smaller range of fluctuations in heart rate variability pa-rameters during respiratory testing which was the evidence of efficiency of cardiovascular system response to a test with fixed respiration rate.

The created standards of physical development allowing for sex and age helped to give physiological grounds for standard requirements to organization of a student's workplace under contemporary conditions involving educational process computerization as it could increase effi-ciency and preserve students' health. Our examination of personal features and temperament peculiarities revealed discrepancies in heart rate variability parameters in students with different extroversion and introversion levels. These discrepancies were authentic increase in SI and mode amplitude and decrease in SDNN, TP, and LF as extroversion grew. We created and gave scientific grounds for quantitative assessment of 5 strain stages in a worker's adaptation to a working process which were related to combined impacts exerted on a body by labor physical hardness and neuro-emotional intensity: self-regulation stage (optimal strain), activation (allowable strain), mobilization of 1,2, or 3 degree (overstrain of 1,2, or 3 de-gree).

Health disorders prevention aimed at preserving migrants labor potential requires devel-oping medical and social support program which allows for functional restructuring of body physiological regulatory mechanisms which corresponds to a stage of 2- and 3- adaptation pro-cess mobilization degree.

## References

1. Agadzhanyan N.A. Ekologicheskaya fiziologiya: problema adaptatsii i strategiya vyzhivaniya [Ecological physiology: adaptation issues and survival strategy]. *Ekologo-fiziologicheskie problemy adaptatsii: materialy Kh mezhdunarodnogo simpoziuma* [*Ecological and physiological adaptation issues: materials of X international conference*]. Moscow, 2001, pp.5–16 (in Russian).

2. Agadzhanyan N.A.. Shabatura N.N. Bioritmy, sport, zdorov'e [Biorhythms, sport, health]. Moscow, Fizkul'tura i sport, Publ., 1989, 208 p. (in Russian).

3. Bukhtiyarov I.V., Matyukhin V.V., Rubtsov M.Yu. Professional'nyi stress v svete reali-zatsii global'nogo plana deistvii po zdorov'yu rabotayushchikh [Occupational stress in light of who global plan of action on workers' health implementation**]**. *Mezhdunarodnyi nauchno-issledovatel'skii zhurnal*, 2016, no.3, pp. 53–55. Doi: 10.18454/IRJ.2016.45.014 (in Russian).

4. Baevskii P.M., Ivanov G.G. [i dr.]. V pomoshch' prakticheskomu vrachu. Analiz variabel'nosti serdechnogo ritma pri ispol'zovanii razlichnykh elektrokardiograficheskikh si-stem: metodicheskie rekomendatsii [For a practitioner's assistance. heart rate variability analysis with the use of various electrocardiographic systems: methodical guidelines]. *Vestnik aritmologii*, 2001, no. 24, pp. 65–87 (in Russian).

5. Izmerov N.F., Lipenetskaya T.D., Matyukhin V.V. Stress na proizvodstve kak vazhnaya so-stavlyayushchaya problemy psikhicheskogo zdorov'ya v obshchestve [Stress at a working place as an important component of psychological health in a society]. *Rossiiskii psikhiatricheskii zhurnal*, 2005, no. 2, pp. 12–16 (in Russian).

6. Instrumental'nye metody issledovaniya serdechno-sosudistoi sistemy: cpravochnik [Instrumental techniques for cardiovascular diseases research: reference book]. In: T.S. Vinogradova, ed. Moscow, Meditsina, Publ., 1986, 416 p. (in Russian).

7. Moikin Yu.V.. Yushkova O.I.. Belitskaya L.A.. Ivanov V.V. K voprosu o fiziologicheskoi adaptatsii stroitelei, pribyvshikh iz yuzhnykh raionov strany k usloviyam Vostochnogo uchastka BAM [On an issue of physiological adaptation of builders who came from the southern regions to participate in construction of the Eastern section of Baikal-Amur Railroad]. *Adaptatsiya cheloveka v razlichnykh klimato-geograficheskikh i proizvod-stvennykh usloviyakh: materialy 111 Vsesoyuznoi konferentsii* [*Adaptation of a man in various climatic and geographic conditions and working conditions: Materials of 111 USSR conference*]. Ashkhabad, 1981, pp. 38–40 (in Russian).

8. Kalinina S.A. Rol' psikho-sotsial'nykh faktorov v formirovanii professional'nogo stressa u rabotnikov s razlichnoi stepen'yu napryazhennosti truda [The role of psychological and social factors in establishment of professional stress of workers with different labor intensity]. *Vestnik Tverskogo Gosudarstvennogo Universiteta. Seriya Biologiya i ekologiya*, 2007, no. 6, pp. 44–49 (in Russian).

9. Optimizatsiya funktsional'nogo sostoyaniya organizma v fizkul'turno-ozdorovitel'nom tsentre promyshlennogo predpriyatiya: metodicheskie rekomendatsii [Optimization of a body functional state in a physical training and health center of an industrial enterprise: Methodical guidelines]. In: R.M. Baevskoii, ed. Moscow, 1988, 23 p. (in Russian).

10. Krivoshchekov S.G., Neshumova T.V., Razumenko A.A., Tataurov Yu.A. Osobennosti energo-obmena i effektivnosti myshechnoi raboty u cheloveka pri adaptatsii [Peculiarities of energy metabolism and muscular work efficiency in a man during adaptation]. *Kosmicheskaya biologiya i aviakosmicheskaya meditsina*, 1989, no. 1, pp. 62–66 (in Russian).

11. R 2.2.2006-05. Rukovodstvo po gigienicheskoi otsenke faktorov rabochei sredy i trudovogo protsessa. Kriterii i klassifikatsiya uslovii truda [Guidelines on hygienic assessment of working process factors and working environment factors. Working conditions criteria and classification]. Moscow, Federal'nyi tsentr gigieny i epidemiologii Rospotrebnadzora,Publ., 2005, 142 p. (in Russian).

12. Trudovaya migratsiya i voprosy zdravookhraneniya: materialy «kruglykh stolov» [Labor migration and issues of public healthcare: Materials collected at "round tables"]. Moscow, Byuro Mezhdunarodnoi Organizatsii po Migratsii v Moskve, Publ., 2010, 56 p. Available at: http://moscow.iom.int/russian/publications/trudmigrac_and_zdravoohranenie-mod2.pdf (18.06.2017) (in Russian).

13. Tyuryukanova E.V. Zhenshchiny-migranty iz stran SNG v Rossii [Female migrants from the CIS countries in Russia]. Moscow, MAKS Press, Publ., 2011, 125 p. (in Russian).

14. Belkic K., Landsberqis P.A. Is job strain a major source of cardiovascular risk. *Scand. J. Work Environ. Health*, 2004, vol.30, no. 2, pp. 85–128.

15. Theorell T., Perski A., Akershtedt T. [et al.]. Changes in job strain in relation to changes in physiological state. *Scand. J. Work Environ. Health*, 2013, vol. 14, pp. 189–196.

16. Heart rate variability. Standards of Measurement, physiological interpretation and clinical use. *Circulation*, 1996, vol.93, pp. 1043–1065.

17. Kivimak M., Leonon-Arjas P. Work stress and risk of coronary mortality: prospective cohort study of industrial employees. *British Medical Journal*, 2002, no. 3, pp. 857–863.

18. Levi L. Stress and distress in response to psychosocial stimuli. *Acta. Med. Scand*, 1972, vol.191, no. 528, 166 p.

19. Weder Alan B., Schock Nicholas J. Adaptation, algometry and hypertension. *Hypertension*, 1994, vol.24, no.2, pp. 145–146.

*Khodzhiev M., Izmerov N.F., Bukhtiyarov I.V. Results of physiological adaptation assessmtn and health risks for labor migrants from Tajikistan. Health Risk Analysis, 2017, no. 3, pp. 48–59. DOI: 10.21668/health.risk/2017.3.06.eng*

Received: 31.07.2017
Accepted: 19.09.2017
Published: 30.09.2017