Estimation of functional state and labour efficiency of shift workers in conditions of the Far North

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ABSTRACT

Objectives. Shift work is an expeditionary method, and it has become quite common for the maintenance of industrial process in the Far North. In spite of good equipment and a high professional standard of the medical personnel in the majority of northern enterprises, the level of morbidity tends to increase. The aims of our work were to evaluate the psychophysiological alterations in shift-workers during transit labour. Methods. Shift workers of "Gazprom" Public Corporation were examined in conditions of the Far North using psychological and physiological methods. Results. The morbidity of shift workers is higher than that of non-transit workers working in the same industries. Distinct changes of the functional condition of the cardiorespiratory system were discovered. While comparing shift workers of the Far North with workers of the Central regions of Russia we discovered an essential prevalence of isolated systolic hypertension (44.6 %) in the first group. It is established that an increase of anxiety level (situational and personal) is much more common in persons having haemodynamic signs of hypertension. For workers in intraregional shift work metabolic exchange disorders, and for workers in inter-regional shift disorders of immune resistance are typical. Conclusions. Our results have shown that shift work is accompanied by stress of regulatory and adaptable systems, a decrease of functional reserves and an increased morbidity and frequent relapses.

Key word: shift work, morbidity, hypertension, health, activity, mood, adaptation.

INTRODUCTION

Industrial development of sparsely inhabited regions in Russia and some other countries has made it necessary to transfer workers to remote regions with extreme climatic conditions for short periods of time, ranging from 2 weeks to 3 months and sometimes more. The largest oil and gas companies in Russia are planning to increase the percentage of shift workers (1,2). This is connected with the economical profits of such work.

The shift work method is accompanied by the following circumstances: forced social and psychophysiological discomfort; violation of a biological stereotype of vital functions; change of a habitual way of life and so on.

Transit labour (shift work) exposes individuals to deprivation of their habitual ecological environment (3,4). Besides that, the occupational hazard for "Gazprom" workers includes in-plant noise (about 100 decibel); various kinds of hydrocarbon dust or aerosols; general vibration of working equipment. Psychosocial variables are known to occupy a special place in the state of health in Arctic and Antarctic men (5-7). Different kinds of accidents and disasters have their impact on all the working staff, especially when their co-workers perish. Anxiety and fear of flights are reported by up to 30% of shift-workers. Physiological consequences of these translocations can be harmful when they are repeated (8-10).

Moreover, in our study and in others it has been revealed that, although incidents of industrial injuries can be reduced by special methods, morbidity increases when transit labour is used (11,12,13).
The aims of our work were to evaluate psychophysiological alterations in shift-workers during transit labour, to find some new methods and ways to organize the labour and rest of the inhabitants, and to work out a strategy aimed at preserving the health of the inhabitants on the Northern latitudes.

STUDY DESIGN AND METHODS

We studied two blocks of problems: a) problems of health and adaptation of people coming to live in circumpolar regions; b) shift-team method of labour organization. We tested inhabitants of the Arctic as well as transit workers: psychological status, physical work capacity, hormone-metabolic data, energy reserves, central and peripheral haemodynamics, psycho-emotional tension. An analysis of illnesses among oil enterprise workers was carried out in accordance with the illness charts.

Transit workers (240 gas industry workers, 19-50 years old) living in the European part of Russia and flying to work to the northern regions of Siberia (the distance covers about 4,000 km) were observed. Non-transit workers (40 men) of similar industry were taken as a control group. We have used:
- cardiopulmonary system EOS-Sprint of "ERICH JAEGER" company (Germany) connected to an IBM PS/AT and veloergometer "Hellige" and multi-canals cardio-monitor "Servomed" for control O2 and CO2 consumption;
- pulse-oximetry (Criticare, model 503) for measuring blood oxygen desaturation;
- We determined the blood cortisone and thyroxine levels with the help of the RIA method, contents of triglycerides and total cholesterol by standard techniques.

Psychological status was determined by the method of Taylor (14).

For estimation of parameters of central and peripheral haemodynamics an <APKO-8RITS> arteriovenous monitor was used (8 parameters of ABP, stroke volume and cardiac output, indices of myocardial contractility of the left heart ventricle, peripheral resistance, indices of arterial vessels' tone, etc.). The following parameters were estimated: systolic (SABP), diastolic (DABP), average (AABP), lateral (LABP), stroke (SABP), and pulse arterial blood pressure (PABP), minute volume of blood circulation (MVBC), stroke volume (SV), general peripheral resistance of vessels (GPRV), actual and working specific peripheral resistance (SPR), cardiac index (CI), volumetric output speed (VOS) and capacity of contraction of the left ventricle. When analyzing the indices received, the type of circulation (hypokinetic, hyperkinetic, eukinetic and mixed) and levels of arterial hypertension by the WHO classification (normal ABP, soft, moderate, severe and isolated systolic hypertension) were defined (15).

RESULTS

The morbidity of shift workers (Table I) is higher than that of people working in the same industries (data from Russian joint-stock company Gazprom). Morbidity with temporary disability is 65% higher, and states of psychoemotional stress appear 40%, and cases of premature retiring on a disability pension 51% more often.

One of the reasons for increased morbidity are adaptation – readaptation cycles repeated over and over again, which do not allow to form a long-term programme of adaptation, but change it by compensatory mechanisms. As a result, the psychophysiological mechanisms of functional regulation work with high tension, anxiety increases and functional reserves decrease (Figure 1), and hormone-metabolic indices go out of normal level (table II).

Taking into account the leading role of cardiovascular pathology in the total morbidity and professional disqualification (table III), we have given greater attention to estimation of parameters of general haemodynamics.

| Table I. The increase of morbidity of interregional shift personnel in comparison with the personnel living in the place of employment. |
|-------------------------------------------------|----------|
| Morbidity with temporary disability             | 70       |
| State of psycho-emotional stress                | 50       |
| Cases of premature retiring on a disability pension | 50       |
The analysis of parameters of central and peripheral haemodynamics received during the research has revealed that among the contingent surveyed persons with isolated systolic (44.6%) and soft (21.4%) hypertension prevail (Table IV).

At the same time we found a prevalence of isolated systolic (48.8%), and severe (17.1%) hypertension among men, while in women, alongside with soft (40%) and isolated systolic (33.3%) hypertension, we observed rather often a normal level of arterial pressure (20%). What especially attracts our attention is the excessively high number of women (100%) having haemodynamic signs of arterial hypertension from the age of 30 to 50.

The prevalence of isolated systolic hypertension in workers of the Far North also attracts attention, while in the Central regions of Russia persons with normal levels of arterial blood pressure and soft hypertension prevail.

We measured the general functional reserve of physiological systems using functional exercise ECG testing. It was ascertained that only 33% of all patients examined had conserved reserves of adaptation; furthermore, during the shift work we found a reduction in the quantity of workers with retained reserves of adaptation (from 6% up to 40%) concurrently with an increase of those with failure of adaptation reserves (about 5% up to 15%).

![Graph](image)

**Fig. 1.** Power work capacity, according to max O2 consumption during physical activity (black circles) and Anxiety Index dynamics by Taylor (white circles) in workers during full transit work rotation cycle (90 days work in the North after 30 days’ rest in the European part). Abscissa axis shows sampling at 10 days’ intervals, asterisks mean **p<0.01 comparing with 1st day.

### Table II. Metabolic indices in transit workers (type II).

| Metabolic indices | on the 10th day | on the 30th day | on the 60th day | on the 90th day |
|-------------------|----------------|----------------|----------------|----------------|
| Cortisol, nmol/l  | 630*           | 400            | 650**          | 550*           |
| Thyroxine, nmol/l | 115            | 117            | 125*           | 115            |
| Cholesterol, mmol/l | 4.1           | 3.8            | 4.8**          | 4.5*           |
| Triglycerides, mmol/l | 1.65*         | 1.35           | 1.45           | 1.4            |

** - p<0.01, * - p<0.05 comparing with control

### Table III. Reasons of workers’ mortality of oil-and-gas industry in the North in 1999 (Mortality % of all deaths).

| Cause of death                          | % of all deaths |
|-----------------------------------------|-----------------|
| Diseases of the cardiovascular system   | 35.6            |
| Blood diseases                          | 1.4             |
| Oncology                                | 19.4            |
| Diseases of the urinogenital system     | 1.5             |
| Other                                   | 15.4            |
| Diseases of the respiratory apparatus   | 0.4             |
| Traumas and poisonings                  | 23.7            |
| Diseases of the gastrointestinal tract  | 2.5             |

### Table IV. Distribution of the persons surveyed by level of hypertension.

| Level of hypertension        | all surveyed | men | women |
|-----------------------------|--------------|-----|-------|
| Isolated systolic hypertension | 44.6         | 48.8| 33.3  |
| Severe hypertension          | 12           | 17.1| -     |
| Soft hypertension            | 21.4         | 14.2| 40    |
| Moderate hypertension        | 10           | 9.9 | 6.7   |
| Normal                       | 12           | 10  | 20    |
Objective estimation of basic characteristics of functional condition: state of health, activity, mood, and also degree of fatigue were carried out using blank methods (SAM test: state of health, activity, mood). When carrying out estimation of basic characteristics of functional condition – state of health, activity, mood, and also degree of fatigue – it has been revealed that only 59% of the patients examined consider themselves as being absolutely capable of working, 41% consider themselves as being absolutely healthy, 23% as rested, and 45% as having desire to work (Table V).

**CONCLUSIONS**

Work in conditions of the Far North exerts a serious influence on the functional condition of a person’s organism and is accompanied by a stress of regulatory and adaptive systems, reduction of functional reserves and internal resources of an organism, and an increased morbidity or frequent relapse of already existing diseases. A major part of the adaptive mechanisms of an organism are changes of the functional condition of the cardio-respiratory system.

Adaptation is mainly based on compensatory mechanisms and on the increasing of sensitivity of nerve centres in regulation. There is no time for adaptation to develop on morphological level because of a lack of time. In shift workers such cycles are repeated over and over. We consider this state to be incomplete adaptation and think that it causes increased morbidity.

**Table V.** Basic characteristics of functional condition (state of health, activity) in rest time (240 persons).

| State of health          | %     | %     |
|--------------------------|-------|-------|
| Good state of health     | 46    | 54    |
| Absolutely capable of working | 59 | 41    |
| Absolutely healthy       | 41    | 59    |
| Rested                   | 23    | 77    |
| Wish for having a rest   | 55    | 45    |
| Having a strong desire to work |       |       |

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