

Lateralization of Brain Function Evaluation with Rotating Shift Workers to Handle Applied Problems of Occupational Psychology in the Arctic

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Abstract. Both cerebral hemispheres take turns to adjust to extreme conditions of rotating shift work in the Arctic. As a result of chronically uncompleted acclimatization and tensed adaptive processes, the right hemisphere is mainly active which triggers some characteristic differences in higher mental functions and activation of vegetative reactions. To evaluate possible research methods for lateralization of brain function with rotating shift workers, handle one of the applied problems of occupational psychology which was working out certain work and rest regimen (WRR), time-to-time survey for shift workers (n = 76) using Activatiometer was conducted. The shift workers carried out oil and gas extraction based on field work (WRR formula 12 12/52 + 52) and field rotating shift work (WRR formula 12 12/24 + 24). Statistically significant ($p \leq 0.001$) right hemisphere activation with shift workers is found predominant both during the day time and rotation period monitoring regardless of type of shiftwork management (TSM) used. Reduction of the total cerebral cortex activation can serve as a marker indicating body reserves wearing off with shift workers, ending of working efficiency period, and hence duration of rotating shift period, which can be used to develop optimal WRR in the Arctic.

1. Introduction

The need for intensive industrial development of the Arctic territories of the Russian Federation involves, inter alia, human resources to be attracted from other regions, and, consequently, various types of shiftwork management [6,14,15,16] to be used. Despite the fact that the rotating shift work is regulated by the Labour Code of the Russian Federation, which stipulates terms of work management, workload and many other requirements related to the efficiency of achieving the expected results and compliance with hygienic standards developed on the basis of numerous studies, the occupational hazard level and loss of health of rotating shift workers in the North are above acceptable limits [4,5,17,18].

2. Problem statement

One type of psychograms compiled to optimize work and rest regimen is characterized by defining the most labile psychological functions, the dynamics of which serves to indicate weaknesses in shiftwork management [1,11,12,13]. It is known that both cerebral hemispheres take turns in acclimatization process. However, as a result of chronically uncompleted acclimatization, the original dominant cerebral hemisphere becomes subdominant due to emotiogenic activation of the right cerebral hemisphere

[3]. This leads that the diencephalon causes hypercorticalism and a relative raise of insulin level compared to left-handers and ambidextrous, which indicates that the pituitary-adrenal system is tensed and the acclimatization process is untenable. [7,8,9,10].

3. Research questions

Since uncompleted acclimatization is common for rotating shift workers, there is a reason to believe that the stagnant activation of the right cerebral hemisphere affecting the diencephalon causes vegetal, humoral and endocrine control disorders which, in turn, define the duration period of stable efficiency, and hence rotation period for shift workers.

4. Purpose of the study

Taking into consideration the above data, it was important to evaluate a possibility to use research results of lateralization of brain function with shift workers to handle the applied problems of occupation psychology - to work out optimum work and rest regimen.

5. Research methods

To this end, time-to-time survey was conducted for shift workers ($n = 46$) who worked on field work basis (WRR formula $12 \times 12 / 52 + 52$); and shift workers ($n = 30$) who worked on field rotating shift work basis using the WRR formula ($12 \times 12 / 24 + 24$). All workers tested were apparently healthy males aged 39.6 ± 3.6 years, each of them was checked five times during rotating shift periods. To make the recorded data objective as much as possible, the research was carried out using Activatiometer (Acceptor Association, Y.A. Tsagarelli, PsyD) [19,20,21]. Mathematical analysis of the obtained results upon completion of cohort prospective studies was implemented using statistical package SPSS 13.0. After checking the correctness of the distribution over Shapiro-Wilk test criterion to compare the average values of the quantitative trait during rotating shift period (i.e., three or more dependent groups) not subject to normal distribution, the K-Related-Samples Nonparametric Test (t. Friedman) was applied followed by a pairwise comparison using Two-Related-Samples Test (t. Wilcoxon) and Exact test. The results were presented as median (Md), 25 and 75 percentiles. Critical level of significance (p) was taken equal to 0.05 [2] in this research.

6. Findings

The obtained data being analyzed revealed a statistically significant ($p \leq 0.001$) predominance of right cerebral hemisphere activation with rotating shift workers, both during the day time and rotating shift period. The number of workers with the predominance of right cerebral hemisphere activity was slightly decreasing towards the middle of rotating shift period, increased again to its completion, following the polynomial dependence ($y = 4.878x^2 - 21.951x + 87.805$; $R^2 = 1$), which made it possible to consider the midpoint of the rotating shift period as a less stressful period of the working cycle (Table 1). Absolute values of activatiometry with shift workers have undergone one-way changes in the direction of decreasing of cerebral hemispheres activation, more noticeable towards the ending of rotating shift period.

Table 1. Indicators of activatiometry with field shift workers during working cycle (Md (25; 75 percentile), n = 46).

Indicators	Beginning of shift -I	Midpoint of shift -II	Ending of shift -III	Magnitude-p
Activatiometry on the right	28.0* (24.0;33.0)	26.5* (22.4;33.0)	26.2* (23.5;29.5)	p2-3 = 0.053 p1-3 = 0.014
Activatiometry on the left	26.0 (21.1;33.0)	24.1 (18.3;28.6)	23.1 (16.8;28.4)	p1-3 = 0.048
Stereotypic activity indicator of brain function lateralization,%	-3.0 ((-10.0);1.0)	-8.0 ((-12.5);2.0)	-5.0 ((-7.5);1.5)	
Stereotypic activity indicator of psychoemotional state background	52.0 (43.8;63.5) rf/o = 0.073	50.9 (42.2;58.7)	49.7 (40.0;56.1) rf/o = 0.079	p1-3 = 0.105
Optimal psychoemotional state optim	50.0 (50.0;52.0)	52.0 (50.0;53.0)	52.0 (50.0;53.0)	

Note: * - p < 0.001 - predominance of right cerebral hemisphere activation.

The increase of right cerebral hemisphere activity was registered during the working cycle on days 13-14, 18-19 and 25-26 of rotating shift period, which was synchronized with similar changes in the activity of the left cerebral hemisphere. These processes were taking place against the background of high total cerebral cortex activity. The right cerebral hemisphere activity reached the highest level in the middle of working shift exceeding the activity of the left cerebral hemisphere by 8%. Starting from 30th-35th day of working shift, there was a decrease in the total activation of the cerebral cortex reaching its minimum value on 51st day of working shift. At the same time, weak changes in the activity of the left cerebral hemisphere were found, which could indicate the activation of acclimatization mechanisms to enable compliance with the general mechanism of body and intensity system for influencing environmental factors and work activity in extreme conditions of the Arctic region of the Russian Federation. The given results suggest that the decrease in the indicators of activatiometry indicates the depletion of body functional reserves with the workers being tested, the end of stable efficiency and, consequently, the duration of rotating shift period (30-35 days).

Any kind of human activity takes place against the background of a particular mental (psychoemotional) state (PS). Optimal PS contributes to efficiency, mental activity, energy, minimal latent reaction time. The deviation of PS from the optimal in any direction is associated with the decrease in the efficiency and functioning of the body [18,20,21]. The number of shift workers who had their optimal PS registered during the working shift was increasing, following the linear dependence ($y = 8.5366x + 40.65$; $R^2 = 0.8547$), and the number of hyperarousal decreased from 24.4% at the beginning, to 4.9% by its completion ($y = -9.7561x + 33.333$; $R^2 = 0.9796$). Warming-up period at the initial stage of the working shift, associated with hyperarousal of PS with more than a quarter of workers, was presented by inadequate reactions, excessive nervousness in relations between people, the potential for accidents during productive activities due to nervous breakdowns. The shift workers had fluctuations of mood records, outburst of petulance associated with the imbalance of brain functional activity. A group of shift workers, with lower psychoemotional tonus was quite representative. At the beginning of the rotating shift period, this cohort was 22% of the working shift, and starting from 30th-35th day, their number increased to 24.4%, following the dependence ($y = 1.2195x + 21.138$; $R^2 = 0.75$), which indicates increasing lassitude caused by monotony of work processes, the fifth part of shift workers were suffering from the first decade during rotating shift period.

When oil producing companies used field rotating shift work, during the 24 hours shift, the activity of the right cerebral hemisphere also significantly prevailed over the activity of the left cerebral hemisphere ($p < 0.001$). At the same time, there was a progressive increase in the value of activation for

both the right and the left cerebral hemispheres from the beginning of rotation period to its completion (Table 2).

Table 2. Indicators of activatiometry for oil workers during field rotating shift period (Md (25; 75 percentile), n = 30).

Rotating shift period Indicators	Beginning-I	Midpoint-II	Ending-III	Magnitude-p
Stereotypic activity characteristic of brain lateralization on the right	9.8 * (8.6;15.8)	11.8* (6.6;14.6)	15.0* (9.5;20.5)	p2-3 = 0.053 p1-3 = 0.042
Stereotypic activity characteristic of brain lateralization on the left	9.2 (7.0;11.2)	9.3 (6.6;12.5)	11.3 (7.3;16.6)	p1-3 = 0.060
Stereotypic activity indicator of PS factor.	64.2 (52.5;85.5) rf/o = 0.001	60.3 (37.0;77.1)	68.7 (46.0;102.8) rf/o = 0.010	
The optimal individual PS	52.5 (48.0;60.0)	52.0 (48.0;60.0)	52.0 (48.0;60.0)	

Note: * - $p < 0.001$ - predominance of right cerebral hemisphere activation.

The values of activity-stereotypical indicator of PS exceeded optimal individual values at the beginning and at the end of rotating shift period. The analysis of the obtained results showed that optimal PS was achieved by 12th-14th days of rotating shift period by 35.7% with oil workers, followed by a decrease ($y = -13.333x^2 + 52.381x - 15.714$; $R^2 = 1$) of the number of persons with this level of PS by 21.4% at the end of rotating shift period. A significant increase of shift workers being in a state of psychoemotional tension at the initial stage of shift period could be associated with the separation from habitual living conditions, taking a flight to the place of work and its beginning (up to 5-6 days from arrival). A similar change in emotional reactivity towards the ending of shift period (20-23 days) testified to the increasing level of tension of productive activity before shift changeover against the background of intensive exhaustion of functional body resources during this period. As a result, it is necessary to provide some rest or high psychopharmacological rehabilitation of psychoemotional tension during the first and final weeks of rotating shift period.

7. Conclusion

Thus, the decrease in the total activation of cerebral cortex can serve as a marker indicating the depletion of the functional reserves of the body during rotating shift period, the ending of stable efficiency, and hence duration of rotating shift period, which can be used to develop optimal work and rest regimen in the Arctic. In addition, the assessment of psychoemotional tension during shift period will allow to provide a prompt complex of correctional intervention of medical and psychological nature.

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