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Trends in the Incidence of Arterial Hypertension and its Association with 24-Hour Shift Work in the Enterprises of the Circumpolar Region

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Abstract. Work in the Arctic and a circumpolar region is associated with great risks for workers. In these regions there are a cold, strong wind, darkness during the polar night, constant light in the summer during the polar day and other factors. As a rule, the majority of employees works in shifts. The company organizes a 24-hour work schedule in shifts. Adverse weather conditions are superimposed on working conditions on shifts and cause nervous tension for workers. Nervous breakdowns can cause an exacerbation of cardiovascular diseases. We assumed that during shift work in the circumpolar region workers develop Arterial Hypertension. During the year we have been examining 2 groups of employees of a mining enterprise: 697 employees who worked 15/15 days in shifts, including night shifts, and 768 employees who worked in 5/2 days at 8-hour working day. Statistical processing of the initial data showed there are statistically significant differences in systolic pressure between people having two various working conditions. These differences have not been found for diastolic pressure.

1. Introduction

Global climate change of the planet, along with such threats to international security as a nuclear disaster, terrorism, cybercrime, environmental and financial and economic crises are a new challenge to humanity at the turn of XX–XXI centuries [1].

In the Arctic conditions, a person is influenced by a complex of factors such as low temperature, fluctuations in the geomagnetic and electric fields, atmospheric pressure etc. Their impact degree can be different depending on the climatic and geographical features of the area, especially, taking into account existence of local climate zones with particular nonlinear patterns within the same quasi-homogeneous climate region [2]. However, the listed factors are not equivalent to the human body. It was historically established that initial attention was paid to the impact of cold on a human body. Only in the second half of the last century, researchers drew attention to the effects rendered by other factors.

Currently, a human is believed to be affected not only by cold but many other factors. Basically, it includes working conditions. Most often, people work in the Arctic on mining operations: oil, gas, coal, diamonds, and others. This production is associated with a high level of noise (figure 1). Noise creates a great load on the Central nervous system in combination with cold, twenty-four-hour darkness during the polar night and twenty-four-hour light during the polar day, limitation of working and personal space.





Figure 1. Work of heavy-load transport.

Development of the Arctic is most often done in shifts, which is characterized by a large physical load on a body due to the high intensity of work. Work is conducted in a twenty-four-hour mode in shifts so that production does not stop. The alternation of day, evening and night shifts upsets the natural rhythm of human life.

An effect of the specific stimuli complex causes the functional reconstruction of the cerebral cortex and subcortical vegetative centers. Reactions of a body through the subcortical centers and hypothalamus involve humoral components of regulation: hormones, metabolites, adrenergic and cholinergic neurotransmitters, vitamins, etc. All this call forth the reconstruction of body structural elements at different levels (organism, system, organ, tissue, cellular, molecular levels) and in a certain sequence depending on the stages of adaptation.

People entering conditions in the Arctic for the first time, experience a set of symptoms called syndrome of neurosis [3]. Its appearance means the tension of the adaptive mechanisms. The main clinical manifestation of the syndrome of neurosis is the anxiety of varying severity, from a state of psychological discomfort to the neurotic level of anxiety. The alarming state affects the cardiovascular system to a large extent [4]. This tension could be significantly reduced if an employee had the opportunity to have a good rest. Work in the night shift causes an upset of body biological rhythms. A person gets insomnia, which does not allow him or her to rest normally. All of this leads to a variety of human diseases, including hypertension.

The International community in the circumpolar region is anxious about human's adaptation problem in the Arctic. A major accomplishment of the Arctic Human Health Initiative (AHHI) and the International Polar Years (IPY) was the increased attention to human's health issues in the Arctic within the Arctic Council. This resulted in the formation of the Sustainable Development Working Group Arctic Human Health Experts Group during the Norwegian Chairmanship (2006-2009) and a subsequent commitment of the Arctic Council to pursue human health as a priority during the Danish Greenlandic chairmanship 2009-2010 [5].

Despite these initiatives and scientists' efforts the current condition of the regional climatic system and regional ecosystem still can't be "approximated" from the nearest past 5-10 years [6,7]. Consequently, losses from uncollected data on monitoring of human condition become irreplaceable

for scientific understanding of the evolution of its regulations as well as research of their collection and storage becomes highly popular [6].

That determines the strategic direction of research within the development of the Northern (Arctic) Federal University named after M. V. Lomonosov (NARFU) scientific and educational project “Arctic biomonitoring laboratory” [8].

This study aims to create software and conduct a research to reveal lapses from a statistical state, what is considered as a good base for a statement of a problem about Arctic’s climate influence on the peculiarities of human adaptation to the circumpolar region conditions.

2. Study population and methods

2.1. Study design

The study was conducted in a mining company (figure 2). Some of the company's employees work full-time for 5/2 days, 8 hours a day. The other part of workers works in shifts of 12/12 hours 15/15 days, including night shift. Data for the study were collected during annual inspections of employees at the beginning and at the end of the period 2016-2017. There was no interference in an operating mode.



Figure 2. Work in a mine.

2.2. Study population

During the year we examined 2 groups of employees of the mining enterprise: 697 employees who worked 15/15 days in shifts, including night shifts, and 768 employees who worked in 5/2 days at 8-hour working day.

We measured systolic and diastolic pressure at the beginning and at the end of the annual period during the preventive examination of employees. We removed those workers, who had the serious cardiovascular disease, from the initial sample: hypertension and coronary heart disease. In addition, we removed all the indications in which workers had no significant changes in blood pressure at the beginning and end of the period.

In the final sample of 957 people 2 groups were formed according to systolic pressure: group V — 481 workers working in shifts, and group E — 476 employees with single-shift. We included 586 men (263 in group V, 323 in group E) and 371 women (218 in group V, 153 in group E) in these groups.

In the final sample of 710 people 2 groups were formed by diastolic pressure: group V — 350 workers, working in shifts, and group E — 360 worker with single-shift operating conditions. We included 441 men (198 in group V, 243 in group E) and 269 women (152 in group V, 117 in group E) in these groups.

2.3. Health outcomes

Blood pressure and heart rate were measured twice using a semi-automatic device Omron® S1 HEM-4030-RU with additional control by a mechanical sphygmomanometer. Measurements were carried out in a sitting position.

Employees were asked to refrain from smoking and drinking alcohol for a day before the study and physical activity for at least half an hour.

Workers working on a rotational basis were subjected to surveys including questions on status and satisfaction with the operating conditions.

2.4. Statistical methods

The following statistical methods and criteria were used in this research:

1. Preliminary preparation of data for processing was carried out to check for the presence of extreme values, construction of distribution diagrams, testing for normality using the Shapiro-Wilk test.
2. The dependence of the compared samples was proved by means of correlation analysis with the construction of dispersion diagrams, calculation of the correlation coefficient ρ -Spearman (for abnormal distributions).
3. Comparison of samples using the nonparametric test of signed-rank Mann-Whitney for comparing dependent samples was performed.
4. Control comparison of samples was done using Student's t-test to compare dependent samples.

3. Experimental results

The obtained results were downloaded from the database in MS Excel 2010 [8], in the same program numerical graphs were built, after which the data were processed in the statistical package IBM SPSS Statistics 20 [9].

We have generated 4 sample data: ART_S1 - systolic pressure at the beginning of the period, ART_D1 - diastolic pressure at the beginning of the period, ART_S2 - systolic pressure at the end of the period, ART_D2 - diastolic pressure at the end of the period. We have compiled descriptive statistics on these samples.

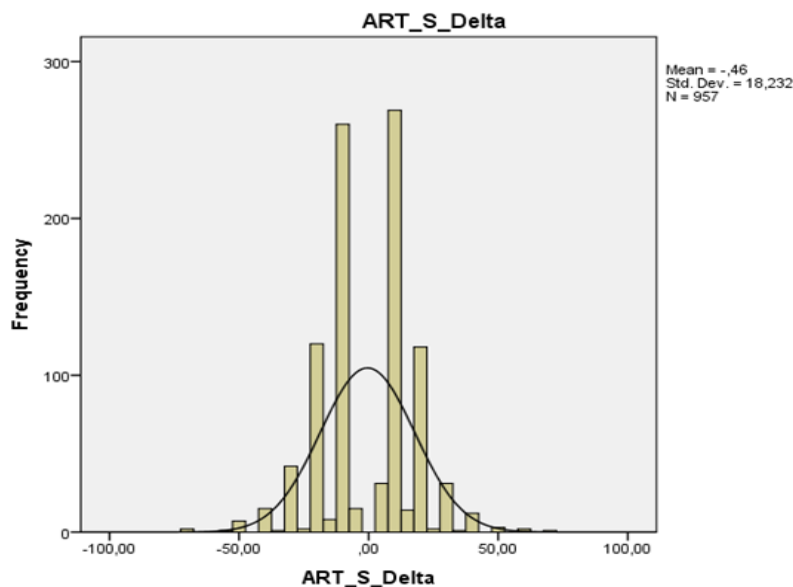
The samples were fairly homogeneous (table 1). Skewness index is above normal. We fulfilled an additional research on the normality of the distribution. Shapiro-Wilk test with an error probability of 5% rejected the null hypothesis of the normality of the distribution of the original data. Since the distribution is not normal, we cannot apply parametric criteria. We decided to modify the original data. We have compiled an additional table, which included data on the difference between the pressure at the end of the period and at the beginning of the period and created 2 samples: ART_S_Delta — change in systolic blood pressure, ART_B_Delta — change in diastolic blood pressure. We removed all data having no changes from the samples. In addition, we clarified the diagnoses of employees and removed all employees, who had cardiovascular diseases at the beginning of the period, from the samples.

Then, the resulting samples were tested for normal distribution again. According to the graph shown in figure 3, it is clearly seen that the distribution differs from normal. Shapiro-Wilk test with an error probability of 5% also rejected the null hypothesis of the normality of the original data distribution.

Table 1. Descriptive statistics.

<i>Parameter</i>	ART S1	ART D1	ART S2	ART D2
The average	125.02	80.12	124.75	80.19
Std. Error of Mean	0.40	0.23	0.38	0.24
Median	120	80	120	80
Mode	120	80	120	80
Std. Deviation	16.07	9.43	15.28	9.63
Variance	258.35	88.90	233.35	92.66
Skewness	3.48	2.64	3.76	12.23
Std. Error of Skewness	0.12	0,12	0,12	0,12
Kurtosis	1.42	0.80	1.39	1.62
Std. Error of Kurtosis	0.06	0.06	0.06	0.06
Interval	140	80	130	130
Minimum	90	60	90	60
Maximum	230	140	220	190
Sum	205650	131805	205214	131907
Score	1645	1645	1645	1645
Reliability level (95.0%)	0.78	0.46	0.74	0.47

We have identified ART_S_Delta and Art_v_delta by 2 groups: group V is workers working in shifts, and group E is workers with the single-shift mode.

**Figure 3.** Distribution diagram (systolic pressure).

We have decided to apply the Mann-Whitney test, which can be applied to nonparametric data. We put forward a null hypothesis that between the two operation modes: namely, shift method with a shift operating, and operating without shifts (that is operating during a day) there are no differences that lead to an increase in blood pressure.

The Mann-Whitney test for systolic pressure with a 5% probability rejected the null hypothesis (table 2, figure 4). Thus, we can conclude that there are differences in the area of systolic pressure between the shift method and the operating during a day. Additional analysis showed that the shift

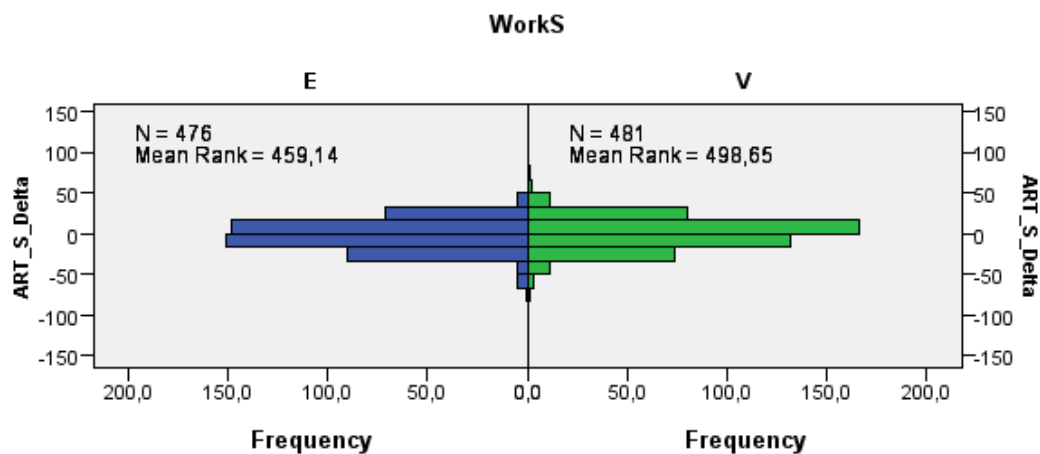
method led to a pressure increase in 58% of cases during the study period, that means that patients have hypertension.

Table 2. Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of ART_S_Delta is the same across categories of WorkS.	Independent-Samples Mann-Whitney U Test	,024	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Independent-Samples Mann-Whitney U Test



Total N	957
Mann-Whitney U	123 930,000
Wilcoxon W	239 851,000
Test Statistic	123 930,000
Standard Error	4 175,234
Standardized Test Statistic	2,264
Asymptotic Sig. (2-sided test)	,024

Figure 4. Results of the Mann-Whitney test for systolic pressure on the hypothesis of differences in single-shift operation (E) and 24-Hour Shift Work (V).

The Mann-Whitney test for diastolic pressure with a 5% probability did not reject the null hypothesis. Thus, we can conclude that there is no difference in the area of diastolic pressure between the shift mode and operating during a day.

We additionally conducted studies on systolic and diastolic pressure to identify differences in the influence of the shift method on the work of men and women, but with a 5% probability, we can conclude that no differences were found. Our study coincides with the study [10] on the impact of shift work but does not coincide with the study on gender differences.

4. Discussion

Interviews with employees revealed the main reason why they choose to work in shifts with 24-hour work. This is because of high wages.

At the same time, they note the negative aspects of such work:

- Physically hard work
- A complex schedule of work and rest (work for 2 weeks, then the same period of rest at home).
- Psychological problems associated with work and rest in a small team in a narrow space.
- A permanent work in conditions of almost permanent darkness in the polar night and under conditions of constant illumination during the polar day negatively affects employees.
- Monotonous, poorly balanced diet.

All of the mentioned above causes nervous overload, which leads to the load on the cardiovascular system, and, consequently, to hypertension.

Our studies have not refuted the hypothesis about the possible consequences of 24-hour shift work which implies the onset of hypertension among employees. We believe that the method of changing the work of shift workers proposed in [11] can be taken as a model in the Arkhangelsk region.

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