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Vulnerability of a Behavioral Pattern of Miners in the Implementation of Strategies for Behavior in an Extreme Situation

V V Gryzunov¹, V F Mitreykin¹ and P A Peresypkina¹

¹FSBEI HE I.P.Pavlov SPbSMU MOH Russia, Saint-Petersburg, st. L.Tolstoy, 6-8, 197022, Russia

Abstract. The modernization of mining lowered the number of air-dust-methane mixture explosions, but specific value of fatal traumatism has increased threefold. Most of the miners' die from toxic gases poisoning in accidents, which means insufficient efficiency of personal protective equipment use. The cause of miners' death was inability to behave in 52% of cases. Excessive stress in miners' professional activity contributes the decline of self-control, forming disadaptive forms of behavior with characteristics of deviancy. Modelling escape to the surface using mine self-rescuers with chemically complexed oxygen among 84 individuals have had experienced protective equipment for respiratory tract has demonstrated that only 20% have covered the distance to the surface in estimated time. Strategy for solving the problems prevailed among this category of miners. The study was shut down for 80% of miners, and they had the strategy of avoiding the problems and support. Forming during respiration hyperoxygenated mixture with the help of mine self-rescuer helps forming circumstances for inadequate danger estimate and insecure behavior in extreme situation. Thus, miners' preparation for action at risk should be realized according to the strategies of behavior while respiration modelling using mine self-rescuer, providing breathing hyperoxygenated gas mixture.

1. Introduction

The increase of coal seams development by underground methods depth up to 500m, the growth of developed lava space and face output length complicate the security of mine-workers [1,2]. The part of dangerous mines with methane and coal dust explosions and rock strikes has increased from 28 to 51% [3]. Despite a decrease in the number of air-dust-methane mixture explosions, specific value of fatal traumatism has increased practically threefold [4]. According to forensic-medical evidence, 47 – 58% of miners died from composite and combined effect of damaging factors in an dust-gas explosion, and 33-80% of death cases are related to CO poisoning, which means insufficient efficiency of personal protective equipment for respiratory protection (PPEFRP) use in emergency situations. The current situation requires the necessity of behavior on solving the situation skills stability studying. To meet the challenge they developed the estimation pattern of people actions adequacy, who had an experience of using PPEFRP with chemically bonded oxygen on exertion.

2. Materials and Methods

84 people between the ages of 24 to 69 old were screened. These people have experienced the mine self-rescuers use and coal-mining operations. All the examining ones have been divided in 4 age groups (Figure 1), no medical contraindications to load test were established. The consent has been



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received by the test subjects. During the preliminary research 4,8% showed evidence of a slight external respiration function disorder.

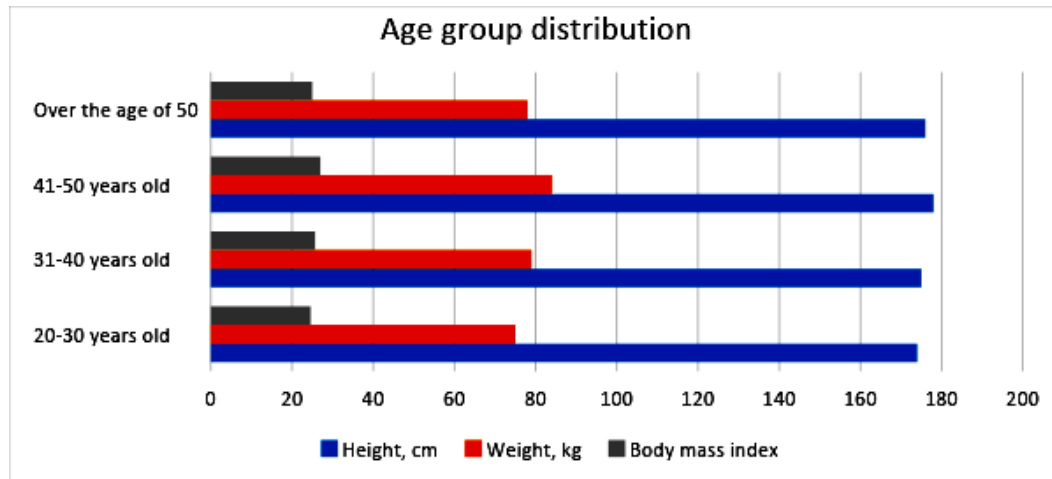


Figure 1. Basic anthropometric criteria of the test subjects.

All the examining ones were equipped special clothing, personal protective items of miners, and the respiration was implemented by PPEFRP with chemically bonded oxygen. The imitation of an physical activity during the escape to the surface from the mine danger zone was carried out with the help of Eger treadmill (Germany). Also the monitoring of central hemodynamic and external respiration functional status has been conducted. The distance of the passed way ranged from 24,5 to 70,4 m/min. 82% of the examining ones had the average physical activity in terms of energy consumption. Others had the physical activity reflecting hard and tough work, which required a periodic tension or rest decrease. It ranged from 623 to 1319 W/h. It should be noted that the route length in the advanced age group is 13,5% higher than the similar values in the age group from 20 to 30. However, the movement time doesn't essentially differ. (Figure 2).

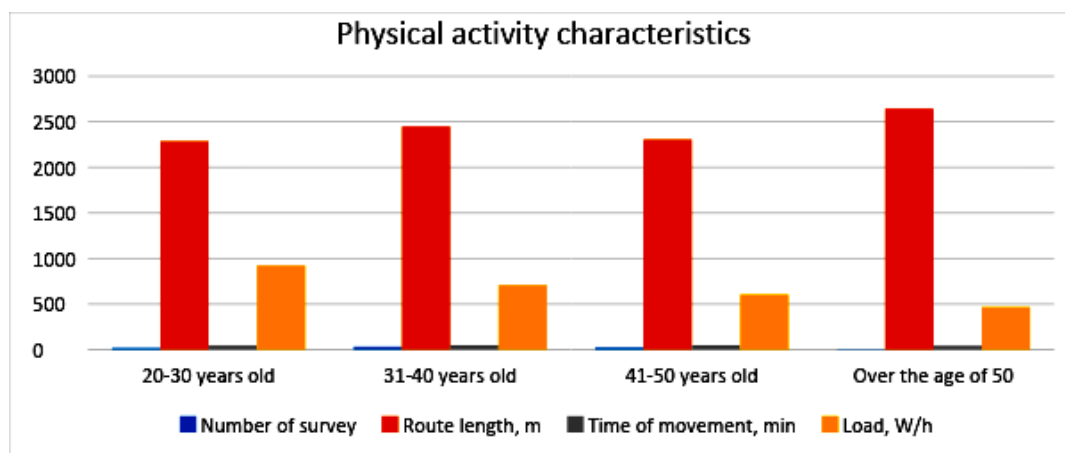


Figure 2. Age group distribution of physical activity.

Effective running time of test subjects in PPEFRP ranged from 33 to 87 min. Taking into account that adaptation capabilities of control behavior are implemented through arbitrary respiration regulation, 56% of the examining ones were analyzed to choose coping-strategy during overcoming

the difficulties, which reflects vulnerability of a behavioral pattern. To assess the control behavior strategies the «Coping Strategy Indicator» questionnaire was used.

3. Results

Out of the total number of test subjects only 20% escaped to the surface in estimated time, and 80% had the research been shut down in relation to the end of the resource (57%) or due to clinical evidence (23%). The denials of further research were due to increase in gas breathing mixture temperature, rise on respiration resistance, insufficient humidity of gas breathing mixture, which led to tickling and cough during breathing. Studies showed that the volume per cent of oxygen in breathing bag, when the mine self-rescuer was activated, reached its maximum value in 25-35 minutes and ranged from $96,0 \pm 1,19$ to $97,3 \pm 0,56$ at a barometric pressure of $770,5 \pm 1,70$ millimeters of mercury, suggesting the prevalence of normobaric hyperoxia in gas breathing mixture (Table 1). From the 15th minute the volume per cent of carbon dioxide started to raise, reflecting the emergence of a «breakdown point» of arbitrary external respiration regulation. Elevation of CO₂ initiated hyperventilation, thereby changing conditions of chemisorptive, diffusive, thermal and aerodynamic processed in regeneration cartridge.

Table 1. Evolution of volume percent of oxygen in gas breathing mixture.

Time, min	1	5	15	30	45	50	65	70
Volume percent of O ₂	$52,7 \pm 4,9$	$60,7 \pm 3,6$	$83,0 \pm 2,6$	$97,0 \pm 0,7$	$95,5 \pm 1,5$	$93,6 \pm 4,6$	$95,6 \pm 1,7$	$94,0 \pm 5,0$
Volume percent of CO ₂	$0,07 \pm 0,02$	$0,03 \pm 0,01$	$0,13 \pm 0,04$	$0,54 \pm 0,13$	$0,96 \pm 0,39$	$1,33 \pm 0,54$	$1,46 \pm 0,58$	-

Furthermore, breathing in and out resistance during physical activity ranged within minutes from $26,7 \pm 3,33$ millimeters of water, and in 30 minutes has reached $77,5 \pm 9,95$ millimeters of water and $85,0 \pm 9,06$ millimeters of water, respectively, reflecting the increase of aerodynamic breathing in and out resistance. However, exhalation resistance significantly exceeded inhalation resistance to 15th minute, due largely to addressing the breathing bag resistance force necessity. In 40 minutes the aerodynamic inhalation resistance ($107,5 \pm 23,8$ millimeters of water) and exhalation resistance ($97,5 \pm 17,8$ millimeters of water) reaches its maximum value and this area can be seen as peculiar «starting point», from where shutdown of test subjects from PPEFRP begins due to feeling of inhalation gas breathing mixture lack.

Taking into account different threshold of diversion of arbitrary respiration regulation for metabolic, one could speak of individual sensitivity to hyperoxia, defining the range of arbitrary respiration regulation. But arbitrary regulation reflects the highest level of behavioral adaptive activity, due to the strategy of action in addressing the challenging situation choice. This predetermined the necessity of control test subjects' behavior strategies studying with the help of «Coping Strategy Indicator» questionnaire by J.H. Amirchan. When analyzing coping-strategies all test subjects were divided into 2 groups. There were people who had fully undertaken engagements using mine self-rescuer in the first group; and there were test-subjects who had failed the physical activity test with the help of PPEFRP (Figure 3). In the overall structure of control behavior test subjects in the 1st group had the strategy of solving the problem, conducive to skills acquisition, been dominated. The strategy of avoiding the problem, aiming at the emotional discomfort decline, but not solving the problem, prevailed in the 2nd group. Thus, behavioral strategies can be seen as mental form of test-subjects' adaptation in extreme conditions.

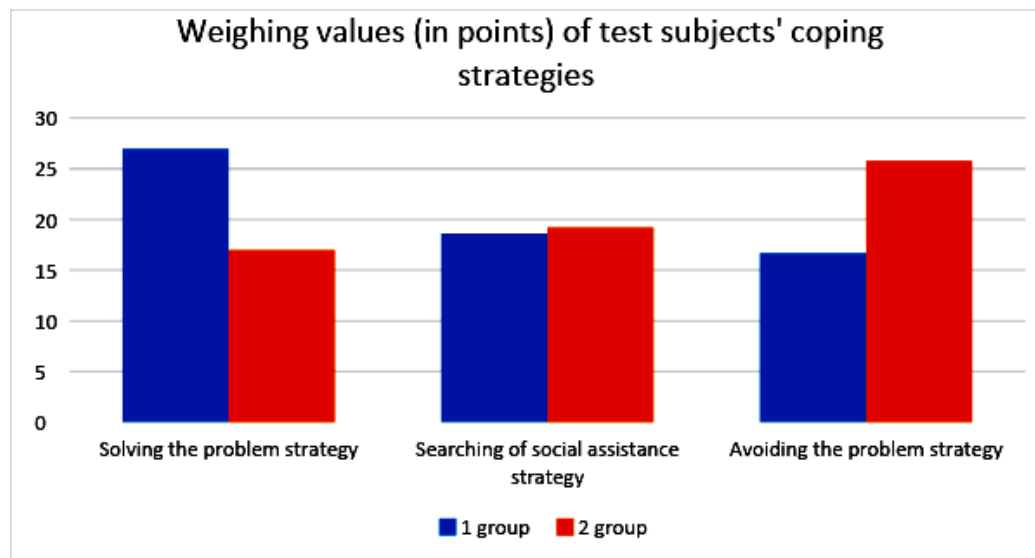


Figure 3. Test subjects' coping strategies distribution pattern.

4. Discussions

The analysis of the situation in the mining industry suggests that the profession of a miner social profile has acquired the traits of professional victimhood, owing to professional ambivalence, which contribute to miners sacralization [6]. The victimhood, which, on the one hand, acts as a condition, characterized by tension, anxiety, fear, concern, bad presentiments; and on the other hand – quality, implementing genetically determined program of vegetative neuroses, accompanied by depressive sense of yearning, panic, terror, impotence; forms a special «negative risk-induced adjustment». The current situation initiates the factors of professional deviation genesis, which are: daily activities replete with potential danger; industrial accidents, involving people deaths.

Besides, danger duality lies not only in the very extreme situation, but in people reluctance to prevent and eliminate by virtue of their psychophysiological peculiarities. Being in a complex situation, connected with high risk for health and life, often leads to the waning of psychological adaptation mechanisms and switching to non adaptive behavioral strategies. Arising condition decreases the success of extreme situation adaptation with the attendant:

- lack of miners' commitment to action in case of emergency;
- tolerance for colleagues' mistakes, technological malfunctions and their resources;
- self-confidence, initiating personality professional deviation, influence on supervisory and working environment.

Therefore, the choice of non adaptive behavior at risk strategies forms vulnerability, which can change workers' attitude towards personal security problems in the line of duty.

5. Recommendations

The current situation prejudices the necessity and feasibility of developing a system of miners respiration in PPEFRP with chemically bonded oxygen studying; because existing preparation for mine self-rescuer using complex do not fully meet modern requirements, connected with a person behavior in case of emergency.

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