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Evaluation of Mood and Anxiety in Pilots Undergoing Simulated Gravitational Pooling of Blood in the Lower Part of the Body

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Abstract

Introduction: The main aim of the study was to assess mood and anxiety level in military pilots and cadets undergoing examination using the lower body negative pressure (LBNP) method. There can be found many research works on subjects' well-being during MRI procedures in the literature. Similarly to MRI tube, an LBNP device requires a fixed position of the body and limits the ability of movements as the patient's lower body has to be placed in an underpressure chamber. However, the authors of this paper did not find any reports on mood and anxiety of people being examined using the LBNP device.

Materials and Methods: The study involved 38 healthy pilots and cadets of the Polish Air Force Military Academy. Mood and anxiety level were assessed just before and after the LBNP test using psychological questionnaires, such as UMACL and STAI.

Results and Discussion: Hedonistic tone and energetic arousal were significantly higher and anxiety level was significantly lower when the test was ended in comparison to the state before the survey ($P<0.05$). There were no significant differences in tension arousal before and after the test ($P > 0.05$).

Conclusion: The results indicate that specialized training equipment can in some way affect subjects' well-being due to its design.

Keywords: Mood; Anxiety; LBNP Chamber; Simulator Training; Pilots

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Abbreviations

LBNP: Lower Body Negative Pressure

Introduction

The aim of the study was to evaluate mood and anxiety level in military pilots and cadets being examined by means of the LBNP apparatus. It was assumed that the examination may cause negative feelings in subjects such as tension, anxiety and fear due to the specific construction of the simulator and the fact that the subjects had to deal with this device for the first time. Taking into account different research on pilots during real flights described in the literature [1], in this paper the authors present the results of studies carried out in simulated flight conditions using the LBNP method-based system.

A lower body negative pressure (LBNP) chamber equipped with a tilt table is used for research and training of military pilots and cadets of the Polish Air Force Academy (PAFA) to evaluate body tolerance on ischemic hypoxia and orthostatic stress causing hypotension.

The method of reducing pressure around the lower part of the body, i.e. the LBNP test, has a long tradition in space and aviation medicine [2-4]. The primary element of every LBNP system is a chamber in which the underpressure is generated and the lower part of the subject's body (usually from the waist area down) remains inside the chamber during the examination. Therefore, the apparatus simulates gravitational pooling of blood in the lower abdomen and extremities and is an example of equipment which substantially restricts movements of the examined person and this can be a source of discomfort or bad mood. Similarly to the MRI tube, the LBNP chamber forces motionless, lying body position, and thus significantly reduces freedom and possibility to make movements by the subject. Although research works on subjects' well-being, including the experience of tension, anxiety and symptoms characteristic of claustrophobia, during MRI

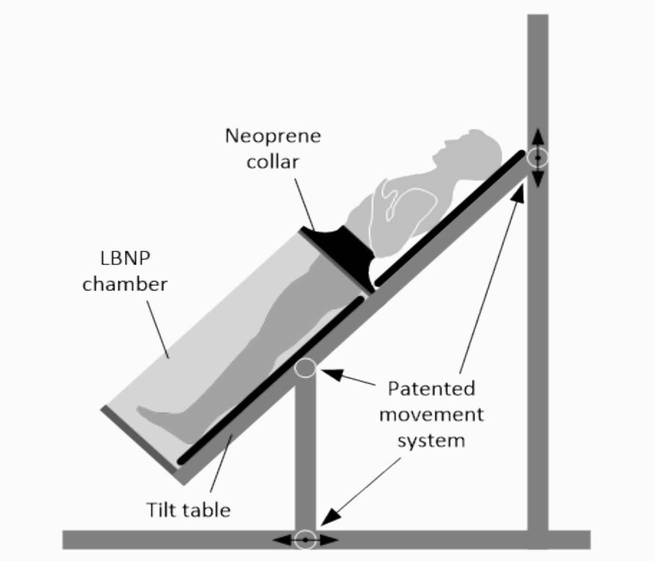

Figure 1: The main elements of the research and training LBNP system.

procedures can be easily found in the literature [5-10], the authors of this paper did not find any reports on mood and anxiety of pilots being examined using the LBNP method.

Materials and Methods

Subjects

The studies were conducted on a group of 38 military pilots and the PAFA's cadets including 5 women and 33 men. The subjects were healthy, aged between 22 and 25 years old (M = 23.61, SD = 0.64). The pilots, i.e. flight school adepts shortly after graduation, and the cadets took part in the studies voluntarily. They were informed in detail on the purpose and nature of the studies using the LBNP apparatus and expressed their consent before participating.

The study protocol was approved in advance by the Ethics Committee reviewing biomedical research (Decision No. 18/2015).

Procedure

The study of mood and anxiety was conducted twice, i.e., just before and immediately after leaving the LBNP apparatus, i.e., approx.1-2 minutes before and after the whole LBNP test including two sessions, according to the repeated measurement scheme. The whole research based on the LBNP method was purposed to assess the changes in physiological parameters, including cardiovascular and cerebral oxygenation indicators, in response to two types of stimuli, i.e., reduced pressure around the lower part of the body (the LBNP component) and verticalization of the body known as the orthostatic test (the ORTHO component). Thus, the ORTHO-LBNP simulator by *ETC-PZL Aerospace Industries*, Poland, was consisted of the underpressure chamber and the tilt table, whose drive system has been registered in the Patent Office of the Republic of Poland [11]. A schematic illustration of the simulator is shown in Figure 1.

The whole study included two sessions. In the first of them cardiovascular responses and the efficiency of cerebral functions under LBNP conditions were recorded. The subject was remaining in a fixed supine position, whereas the value of pressure inside the chamber was decreasing reaching -100 mmHg. In the second session the physiological parameters were observed both under reduced pressure and orthostatic stress. The subject was being fixed in a supine position, while the position of the tilt table was changing from -40° to +70° and pressure was decreasing from 0 to -60 mmHg.

Table 1: Basic distribution parameters of variables measured by the UMACL and the STAI before and after the LBNP test in the group of pilots (N = 38).

Testing moment	Variable	Distribution parameters				
		M	SD	Me	Min	Max
Before the LBNP test	TH	36.63	3.38	37.50	27	40
	PN	10.82	2.29	10.00	9	18
	PE	34.08	4.76	35.00	21	40
	Anxiety state	26.66	5.79	26.50	20	45
	Anxiety trait	25.71	4.05	25.50	20	35
After the LBNP test	TH	37.53	2.60	38.50	32	40
	PN	10.74	2.02	10.00	9	17
	PE	35.71	4.16	37.00	25	40
	Anxiety state	24.84	4.35	24.00	20	33

M – mean, SD – standard deviation, Me – median, Min – minimal value, Max – maximal value, TH – hedonistic tone, PN – tension arousal, PE – energetic arousal.

Equipment

The mood of the pilots before the LBNP examination and after leaving the apparatus was studied using the UWIST Mood Adjective Check List (UMACL) in Polish adaptation by E. Goryńska [12]. The questionnaire is designed to assess mood defined as an affective experience of moderate duration, i.e. at least a few minutes, not connected with the object or related to a quasi-object, and including three dimensions, such as tension arousal, energetic arousal defined as energy for action and hedonistic tone associated with a feeling of pleasure/unpleasantness.

To evaluate the pilots' level of anxiety before and after the LBNP test, a Polish version of the State-Trait Anxiety Inventory (STAI) by C. D. Spielberger, J. Strelau, M. Tysarczyk and K. Wrześniewski was used [13]. The questionnaire enables for assessing anxiety felt at the moment in response to a given situation, which is defined as a transitional state. The inventory also examines the intensity of anxiety treated as an internal disposition, i.e. trait, which means a relatively constant feature.

Statistical analysis

Statistical analysis of the results was carried out using IBM SPSS version 24. The Shapiro-Wilk test was used to assess normal distribution of the results. Due to the failure to meet the assumptions of normality of distributions, the results of psychological questionnaires obtained before and after the examination were compared using a non-parametric Wilcoxon signed-ranks test.

Results and Discussion

The analysis of Shapiro-Wilk test showed deviations from the normal distribution of all psychological variables assessed before and after exposure to the LBNP test ($P < 0.05$). Basic distribution parameters of the UMACL and the STAI scores are presented in Table 1.

Possible range of scores for each scale in the UMACL and STAI questionnaires is from 10 to 40 points for hedonistic tone, from 9 to 36 points for tension arousal, from 10 to 40 points for energetic arousal, and from 20 to 80 points for anxiety as a current state and trait [12,13]. According to the data shown in Table 1 it can be summarized

Table 2: The Wilcoxon signed-ranks test results for three mood dimensions and anxiety state assessed before and after the LBNP test.

Statistics	Variables measured before and after the LBNP test			
	TH	PN	PE	Anxiety state
Z	-2.06	-0.17	-3.31	-3.23
W	87.00	132.50	80.00	62.50
P	0.039	0.864	0.001	0.001

TH – hedonistic tone, PN – tension arousal, PE – energetic arousal, Z, W – statistics of the Wilcoxon signed-ranks test, P – significance level.

that the subjects received high scores in the hedonistic tone scale and energetic arousal scale, whereas low scores appeared in the tension arousal scale. Such a pattern of mood indicates a well-being and can be defined as a good mood.

With reference to anxiety, the average scores for both anxiety considered as a current state caused by the experimental situation and as a relatively constant trait, were low.

The analysis of Wilcoxon signed-ranks test revealed statistically significant differences in relation to mood in its two dimensions, i.e. hedonistic tone and energetic arousal, when assessed before and after the LBNP exposition ($P < 0.05$). Also the indicators associated with anxiety state before and after the exposition showed statistical significance in the Wilcoxon test ($P < 0.05$), as presented in Table 2.

A certain dynamics of mood and anxiety in the pilots participated in the experiments can be found on the basis of the data presented in Table 1 and Table 2. The results indicate significantly higher levels of hedonistic tone and energetic arousal manifested in the subjects after the experimental procedure in relation to the initial state before the test ($P < 0.05$). According to the sten scale, in which 1–4, 5–6 and 7–10 are regarded as low, medium and high scores, respectively, it can be said that approx. 79% of the subjects received a high score on a hedonistic tone scale before the experimental session, whereas such a result achieved approx. 95% of them after ending the session. Similarly, in case of energetic arousal approx. 63% and 71% of the pilots obtained a high score on this scale before and after the examination, respectively.

The pilots exhibited higher anxiety before the test when compared to the state after leaving the apparatus ($P < 0.05$). One of the subjects received a high score on the anxiety state scale before the test, whereas no one got a high score on this scale after the exposition, i.e., 92% of the subjects obtained a low score, and 8% of them were distinguished by a medium score.

There were no statistically significant differences in tension arousal scale in the group of pilots before and after the LBNP test ($P > 0.05$), thus this dimension of mood remained stable before and after the experimental exposure.

Conclusion

In general, the average results obtained in the studied group in the UWIST Mood Adjective Check List and in the State-Trait Anxiety Inventory (Table 1) indicate a well-being, positive mood and low anxiety level in the pilots during the LBNP experiment. This means that a completely new experimental situation, including the first contact with the research and training simulator, causes neither tension nor reductions of mood.

However, there can be observed some dynamics of mood and anxiety in the pilots during the experiments. As shown earlier, the subjects obtained significantly higher results in the hedonistic tone scale, and thus felt more pleasure and satisfaction, after leaving the apparatus ($P < 0.05$). Moreover, higher scores in the energetic arousal scale after the exposition mean more energy for action ($P < 0.05$). After the test, there was also a significant decrease in the level of anxiety ($P < 0.05$). Hence, it can be summarized that the subjects manifested less energy to act and worse mood, i.e., they experienced less pleasure, as well as higher anxiety state before the experiment when compared to the condition after leaving the LBNP apparatus.

The obtained results show that carrying out experimental studies with the use of the simulators, which restrict movements and force a specific body position can cause at least minor changes in mood and well-being of the subjects. Our studies may indicate that training equipment and simulators used in aviation and space medicine can in some way affect mood and well-being of the pilots. Confined space worsens the pilot's comfort during the examination or training and therefore when interpreting physiological parameters acquired from the pilot's body at that time, possible impact of stress and tension on them should be taken into account. However, in order to improve comfort and well-being of the subjects, one might consider the possibility of increasing the size of the LBNP chamber so that the pilot could freely move his legs during the examination. A good solution for the relaxation of the subjects may also be a suitable arrangement of the room where the study is conducted, involving the appropriate choice of wall colors, e.g., shades of green, or wallpapers, e.g., views of the forest, as it is often done in the newly built rooms for MRI diagnostics. In addition, ambient lighting and relaxing music could be helpful for relaxation and mood enhancement of study participants [14,15,16].

It should be emphasized that the lower body negative pressure method is not only used in the field of aviation and space medicine, but it is also well-known by physiologists who utilize its backgrounds in clinical trials for investigation of haemodynamic responses to the shifts of physiological fluids in the head-legs direction [17]. Therefore, in the clinical area where various types of simulators are used, it would be worthwhile to consider different psychological factors, e.g., anxiety level, as well as people's comfort, and their potential relevance to the results obtained.

Considering the above, it is very important to respect the principles of ergonomics when developing concepts and constructing all kinds of research and measuring systems and devices for carrying out studies involving people, as well as when modernizing the already produced ones. The proposition of some authors to implement virtual prototypes during the design phase in the product development process to support human factors and ergonomics evaluation could be a good solution in designing all research simulators [18]. It should be highlighted, however, that it has been said a lot about ergonomics in the context of workplaces so far [19-22], while the authors of this work did not manage to find any research simultaneously devoted to ergonomics of the research equipment, e.g., simulators, and the subjects' well-being. Meanwhile, this topic is of great importance to ensure people participating in different experimental research comfort and consequently reduce unnecessary tension and stress and therefore should be undertaken by researchers from various fields of science. The presented paper can be an inspiration to carry out such research.

Further works will include a compilation of subjective indicators of mood and anxiety, based on self-report methods, i.e. questionnaires, and physiological parameters, which will provide more objective information on body stimulation and stress during the experimental research. It is also planned to evaluate whether changes in mood and anxiety are related in any way to different physiological effects of the LBNP test, mainly referred to cardiovascular system and cerebral functions.

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