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ORIGINAL ARTICLE

PREVALENCE OF ABNORMAL SPINAL FINDINGS IN ASYMPTOMATIC CANDIDATES FOR MILITARY PILOTS

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Introduction: Spinal degenerative disease is a serious health problem in industrialized countries and is increasingly common among young adults. The aim of the study was to evaluate the frequency of occurrence of specific abnormalities in magnetic resonance imaging (MRI) results of the spinal column in young, asymptomatic candidates for piloting schools, taking into account their qualifications for training in supersonic airplanes based on medical opinion.

Methods: The research material consisted of the results of an MRI exam of the spines of 181 people aged 19 to 20, who were declared to be incapable of training in high-maneuverability airplanes by the military aviation-medical commission, solely or inter alia on the basis of such tests.

Results: The following were found: 72 hernias, 44 bulgings, 66 dehydration of spinal discs, 107 Schmorl nodules, 24 angiomas and 51 spinal bends. Single hernias were more than twice as frequent as the bulgings, the frequency of multiple hernias and bulgings was similar and the frequency of multiple Schmorl nodules was more than twice as high compared to that of multiple hernias and bulgings in conjunction. Their number and location in the spine were presented.

Figures: 1 • **Tables** 2 • **References:** 26 • **Full-text PDF:** http://www.pjambp.com • • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

Discussion: The study discusses the scale of the problem with regard to the data found in literature and the medical opinions – the piloting (including ethical–medical) aspect of the reported irregularities. The need to develop criteria for acceptable standards regarding changes in the MRI of the spinal column among candidates for training in high-maneuverability airplanes was indicated, taking into account not only their type, but also the degree of intensity.

Keywords: MRI, spinal degenerative disease, supersonic pilots

INTRODUCTION

Spinal degenerative disease is a serious health problem in industrialized countries. It is estimated that there is an 80% risk of spine pain during human life [16]. On the other hand, significant discrepancies between the results of neuroimaging tests on the spine and clinical symptoms are highlighted. They describe a significant degree of structural changes, which were not accompanied by any clinical symptoms [2,8,23]. Magnetic resonance (MRI) was selected as the test of choice from among the neuroimaging methods.

It allows for depicting the structures both of the spinal cord, the nerve roots and the intervertebral discs. Its sensitivity is comparable to that of invasive myelography [13].

This study has been inspired by numerous, in recent years, cases of medical disqualification of young adults - candidates for the Polish Air Force Academy (PAFA), exclusively or, inter alia, due to changes found in the routine, preliminary MRI spinal column test. The scale of the problem and its medical aspect concerning future specific exercise training (for better +Gz acceleration tolerance and proper performance anti-G straining maneuvers) was discussed.

AIM OF THE STUDY

The aim of the study was to evaluate the frequency of occurrence of specific abnormalities in MRI results of spinal column in young, asymptomatic aviation school candidates, taking into account their medical qualifications for training in high-maneuverability airplanes.

MATERIAL AND METHODS

The research material consisted of the results of MRI tests of the spines of 181 subjects aged 19 to 20, including 156 men (86.1%) and 25 women, who were declared by the military aviation-medical commission to be incapable of training in high-maneuverability airplanes at the PAFA, solely or inter alia on the basis of such tests. These subjects were selected from among 423 candidates (representing 42.8%) examined in the Military Institute of Aviation Medicine, in 2014-2016.

RESULTS

The abnormalities found in the MRI of the spinal columns of the tested persons were of the following nature: hernia, bulging, dehydration of intervertebral discs, Schmorl nodes (SN), spinal bends and angiomas in its stems. The type of changes, their number and percentage of people with these changes was shown table 1.

Tab. 1. Frequency of occurrence of specific changes in spinal column MRI in 181 young adults aged 19 to 20.

Type of changes in spinal column MRI	Number of patients with specific changes	Percentage
Scoliosis/bending	22	12.2
Lordosis	20	11.0
Kyphosis	9	5.0
Schmorl nodules	107	57.5
Dehydration	66	36.5
Bulges	44	24.3
Hernias	72	43.1
Angiomas	24	13.3
other *	4	2.2
Total	**368**	

* damage to the end-plates or nerve root cysts

The higher toll of changes in the MRI of the spinal column compared to the number of patients with these abnormalities is due to the fact that most of the subjects were affected by more than one change. The number of single and multiple bulges, hernias and Schmorl nodules (SN) detected among men (M) and women (W) was shown in table 2.

Tab. 2. Frequency of occurrence of single/multiple bulges, hernia and Schmorl nodules in the studied group.

BULGES	Single Total=21		Multiple Total =23	
	W	M	W	M
	2	19	3	20
HERNIAS	Single Total=27		Multiple Total=25	
	W	M	W	M
	4	43	4	21
SCHMORL NODULES	Single Total=10		Multiple Total=97	
	W	M	W	M
	1	9	10	86

W- women, M-men

Single hernias were more than twice as frequent as the bulgings, the frequency of multiple hernias and bulgings was similar and the frequency of multiple Schmorl nodules was more than twice as high as that of multiple hernias and bulgings together.

In 44 persons, a total of 80 bulges were found, while in 72 persons 115 hernias were found. The number and location of these in specific spine sections are shown in fig.1 .

It is worth noting that the localization of the hernia and bulges affected almost the entire spine, while it was found most frequently on L4/L5 and L5/S1 levels, less frequently on Th5 to Th8 and C5 to C7 levels, and they were not found at all in the spine sections C2/C3, C7/Th1, L1 to L3. Most of the SN (about 60 %) were located in the thoracic spine section.

DISCUSSION

Thanks to many years of research and development of science, the impact of extreme flight conditions on the human body is relatively well known. At the same time, thanks to the progress of medical technology, the diagnostics of the state of health of candidates for pilot training has become more precise. Despite this, and sometimes precisely because of this, military medical commissions deciding on the suitability of candidates for service on high-maneuverability airplanes may have doubts – do they consider certain clinically asymptomatic changes in spinal MRI tests to be disqualifying/potentially endangering the safety of pilots and flights or just a variant of the acceptable standard, despite the potential risk of their progression due to extreme flight

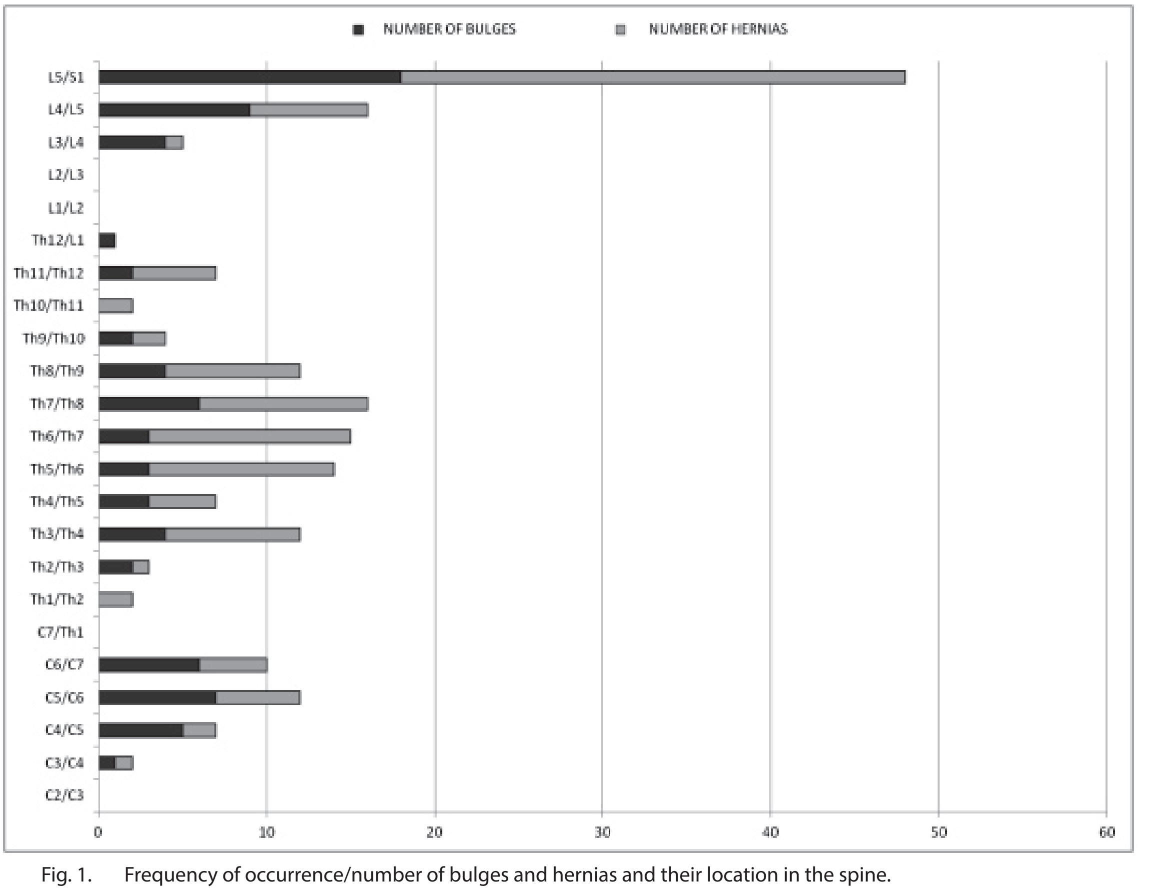

Fig. 1. Frequency of occurrence/number of bulges and hernias and their location in the spine.

factors? Therefore, ethical considerations are also taken into account when making medical opinion flight decisions.

In literature, changes in neuroimaging tests of the spine in patients without clinical signs are described relatively often [2,8,23]. However, computed tomography may be a more sensitive test for detecting bone lesions or fractures, while magnetic resonance (MRI) is better for nervous structures imaging [22]. The high resolution of MRI allows for revealing early degenerative changes of the spine, often completely unexpected, which are not accompanied by any pain [22]. This was also the case in the group of young people examined by us.

The first tests of the spinal column using MRI were published in the 1990s with the aim of estimating the frequency of abnormalities in asymptomatic subjects [2,8,23]. However, they were conducted on small groups, of 60 to 100 individuals and the subjects were aged 20 to 80. A few years ago the results of 554 MRI tests were published, from subjects aged 20 to 23, of which only 167 (30%) had no clinical symptoms [21].

In our studies, the percentage of asymptomatic patients aged 19 to 20, with changes in MRI, was significantly higher (42.8%) and comparable to other publications, in which it was 43% to 67% [8,20,23]. The percentage of bulges and hernias in Jensen's and Weishaupt's studies was higher, but also the average age of the subjects was higher than in our study. The frequency of abnormalities in the spinal column imaging is increased with the age of patients [2,8], which is quite understandable. In our study, we recorded a total of 80 bulges and 115 hernias. As in the case of other researchers, the most frequent occurrence of bulges in the lumbar segment was observed at L5/S1 and L4/L5 [2,9,20]. It should be noted that the aforementioned studies [2,20,23] concerned only MRI tests of the Lumbar spine segment, and that single bulges were found much less frequently than multiple ones, both in women and men [20]. Our study results concern the entire spine and the population of very young people. Single hernias were found to be nearly 2x more frequent than multiple hernias, while the numbers of single and multiple bulges were comparable. As in Jensen's study, SNs were the most common abnormality [8]. This is the prominence of the nucleus pulposus of the intervertebral disc through the endplate. They are visible in both sectional and imaging tests. The incidence of SN in autopsy studies ranges from 38% to 79% [12,15,18]. Although they are visible in routine X-ray images, they are three times less frequently reported compared to MRI [11,19]. The controversies related to SNs refer to their clinical significance. They may be present both in persons without ailment and with pain in the lumbar spine. In our material, SNs were found in 57.5% of the subjects, i.e. much more often than in a comparable age group in a Finnish study (10%) [20]. This percentage was also higher than in studies conducted in older age groups (30-40 to 60-70 years old) in which SNs were found in 19-38% of the subjects [19,24]. Such a high percentage of SNs in our material is probably due to the fact that the study covered the entire spine, not only the lumbar segment. In our material, the majority (about 60%) of SNs were located in the thoracic part of the spine. Others specified a similar location [24]. Some pointed to the higher incidence of SNs in patients with clinical symptoms [11,20,24]. Although the majority of our subjects (90.6%) had multiple SNs, they did not have any symptoms. Maybe this was influenced by their very young age.

In 2015, a systematic review of 33 reports was published, which analyzed the frequency of changes in neuroimaging tests in a total of 3110 asymptomatic subjects [4]. The percentage of tests revealing degenerative changes in intervertebral discs differed depending on the age group and increased from 37% in 20-year-olds to 96% in 80-year-olds [7]. Due to the above, it was suggested that they are a consequence of aging rather than disease changes requiring intervention. Others observed a correlation between pain in patients with hernia observed in spinal MRI tests [1,17].

Nevertheless, prognostic values of deviation from the norm in spinal column MRI in asymptomatic patients have not been shown as yet [3,5,14]. More importantly, there is no correlation between the result of surgical procedures and the deviations found [10]. Due to the above, it is recommended to interpret changes in MRI of the spine only with reference to subjective and physical examination [6,22]. According to the recommendations elaborated by the American College of Physicians and the American Academy of Family Physicians, neuroimaging tests should not be performed in patients with spine pain lasting for less than 6 weeks if no red flags, i.e. symptoms indicating a serious cause of the patient's pain, have been found [6]. These recommendations are based on studies that do not show significant differences in prognosis in patients for whom tests have been performed at an early stage of illness.

However, the above recommendations cannot apply to spinal imaging diagnostics in candidates for flight training, especially in airplanes with high acceleration. Aviation training applicants must have a routine spinal column MRI, because:

1. The possible "pathological" changes within the intervertebral discs may be asymptomatic, and slight spinal excretions may be considered by the candidate to be insignificant, thus omitted in medical history.
2. The pilot of military supersonic airplanes is expected to meet health requirements and safely fly until the end of the planned service.
3. During training and service on high-maneuverability airplanes, the pilot is exposed to physical work factors: high overloads (as a result of accelerations), mainly in the head-to-legs axis (+6 to +9Gz) and vibrations, which may influence the progression of degenerative changes of the spine.

Acceleration forces that act on a pilot in the +Gz axis (head to foot) cause displacement of soft tissues, organs and body fluids toward the lower part of the body. Blood redistribution and reduced venous return to the right heart lead to hemodynamic disturbances [26]. They increase with the value of G-force in play, decrease in the capacity of physiological compensatory mechanisms and reduction in the effectiveness of anti-G straining maneuvers (AGSM). Such maneuvers involve contracting skeletal and abdominal muscles with simultaneous attempted exhalation against partially (M-1 maneuver) or completely (L-1 maneuver) closed glottis. The stronger the contraction, the greater the pressure exerted on peripheral vessels. Therefore, ASGM has a muscular and a respiratory component [25].

Due to the above mentioned facts, great amount of attention is paid to pilots' physical training. The exercise training structure of pilots and pilot candidates is very specific. It is characterized by the frequent use of high-intensity resistance exercise movements. It is also worth noting that anti-G respiratory maneuvers are much more exhausting if performed while the G acceleration is in play. This means that muscles participating in the inspiratory phase are then working against the G-force vector, which requires greater effort in stretching the chest and that the axial or external compressive load can be greater than the applied horizontal force, which must be taken into account.

It is also worth noting that in the case of gravity induced loss of consciousness (G-LOC) due to accelerating effects, the pilot does not maintain the proper position of the body in the armchair (head lowered inertly and torso supported by belts), which increases the negative effect of spinal overload. An additional adverse factor may be clonic-tonic seizures of varying severity and duration, which also predispose to injuries of the spine, especially in its neck segment. Strong muscles and healthy spinal structures can have a significant impact on the spine, especially when catapulting. The structure of the body has its own independent, significant influence on the degree of the effect of accelerations +/- Gz on the spine and spinal structures.

The criteria for disqualification of candidates for training in high-maneuvering airplanes adopted by our military aviation-medical committee are, maybe, too restrictive / protective, but were supported by substantive, ethical and medical reasons. Because of the latter, there is also a need to establish criteria for admissible standards for changes in spinal MRI among candidates for pilots of this type of airplanes. We believe that they should take into account not only the type of abnormalities found, but also the degree of their severity. However, this requires further prospective MRI tests in groups of disqualified individuals. They will allow for tracing the natural history of the changes described earlier. At the same time, clinical studies of high-maneuverability airplane pilots may provide information on the influence of flight factors on the progression and clinical symptoms of these changes.

AUTHORS' DECLARATION:

Study Design: Ewelina Zawadzka-Bartczak, Lech Kopka, Marcin Kopka; **Data Collection:** Ewelina Zawadzka-Bartczak, Lech Kopka, Marcin Kopka; **Manuscript Preparation:** Ewelina Zawadzka-Bartczak, Lech Kopka, Marcin Kopka; The Authors declare that there is no conflict of interest.

REFERENCES

1. Beattie PF, Meyers SP, Stratford P, Millard RW, Hollenberg GM. Associations between patient report of symptoms and anatomic impairment visible on lumbar magnetic resonance imaging. Spine. 2000; 25(7):819-828.
2. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. J Bone Joint Surg Am. 1990; 72(3):403-408.

3. Borenstein DG, O'Mara JW, Boden SD, et al. The value of magnetic resonance imaging of the lumbar spine to predict low--back pain in asymptomatic subjects : a seven-year follow-up study. J Bone Joint Surg Am. 2001; 83-A(9):1306-1311.

4. Brinjikji W, Luetmer PH, Comstock B, et al. Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. AJNR Am J Neuroradiol. 2015; 36(4):811-816.

5. Chou R, Fu R, Carrino JA, Deyo RA. Imaging strategies for low-back pain: systematic review and meta-analysis. Lancet. 2009; 373(9662):463-472.

6. Chou R, Qaseem A, Owens DK, Shekelle P, Clinical Guidelines Committee of the American College of Physicians. Diagnostic imaging for low back pain: advice for high-value health care from the American College of Physicians. Ann Intern Med. 2011; 154(3):181-189.

7. Hamanishi C, Kawabata T, Yosii T, Tanaka S. Schmorl's nodes on magnetic resonance imaging. Their incidence and clinical relevance. Spine. 1994; 19(4):450-453.

8. Hilton RC, Ball J, Benn RT. Vertebral end-plate lesions (Schmorl's nodes) in the dorsolumbar spine. Ann Rheum Dis. 1976; 35(2):127-132.

9. Jarvik JJ, Hollingworth W, Heagerty P, Haynor DR, Deyo RA. The Longitudinal Assessment of Imaging and Disability of the Back (LAIDBack) Study: baseline data. Spine. 2001; 26(10):1158-1166.

10. Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. Magnetic resonance imaging of the lumbar spine in people without back pain. N Engl J Med. 1994;331(2):69-73.

11. Junghanns H, Schmorl G. The Human Spine in Health and Disease. Grune & Stratton. 1971.

12. Kanayama M, Togawa D, Takahashi C, Terai T, Hashimoto T. Cross-sectional magnetic resonance imaging study of lumbar disc degeneration in 200 healthy individuals. J Neurosurg Spine. 2009; 11(4):501-507.

13. Lurie JD, Moses RA, Tosteson ANA, et al. Magnetic resonance imaging predictors of surgical outcome in patients with lumbar intervertebral disc herniation. Spine. 2013; 38(14):1216-1225.

14. Modic MT, Masaryk T, Boumphrey F, Goormastic M, Bell G. Lumbar herniated disk disease and canal stenosis: prospective evaluation by surface coil MRI, CT, and myelography. AJR Am J Roentgenol. 1986; 147(4):757-765.

15. Modic MT, Obuchowski NA, Ross JS, et al. Acute low back pain and radiculopathy: MRI imaging findings and their prognostic role and effect on outcome. Radiology. 2005; 237(2):597-604.

16. Pfirrmann CW, Resnick D. Schmorl nodes of the thoracic and lumbar spine: radiographic-pathologic study of prevalence, characterization, and correlation with degenerative changes of 1,650 spinal levels in 100 cadavers. Radiology. 2001; 219(2):368-374.

17. Robertson JT. The rape of the spine. Surg Neurol. 1993; 39(1):5-12.

18. Siddiqui AH, Rafique MZ, Ahmad MN, Usman MU. Role of magnetic resonance imaging in lumbar spondylosis. J Coll Physicians Surg Pak. 2005; 15(7):396-399.

19. Stäbler A, Bellan M, Weiss M, Gärtner C, Brossmann J, Reiser MF. MRI imaging of enhancing intraosseous disk herniation (Schmorl's nodes). AJR Am J Roentgenol. 1997; 168(4):933-938.

20. Takatalo J, Karppinen J, Niinimäki J, et al. Association of modic changes, Schmorl's nodes, spondylolytic defects, high-intensity zone lesions, disc herniations, and radial tears with low back symptom severity among young Finnish adults. Spine. 2012; 37(14):1231-1239.

21. Takatalo J, Karppinen J, Niinimäki J, et al. Prevalence of degenerative imaging findings in lumbar magnetic resonance imaging among young adults. Spine. 2009; 34(16):1716-1721.

22. Tavee JO, Levin KH. Low Back Pain. Continuum (Minneap Minn). 2017; 23(2, Selected Topics in Outpatient Neurology):467-486.

23. Weishaupt D, Zanetti M, Hodler J, Boos N. MRI imaging of the lumbar spine: prevalence of intervertebral disk extrusion and sequestration, nerve root compression, end plate abnormalities, and osteoarthritis of the facet joints in asymptomatic volunteers. Radiology. 1998; 209(3):661-666.

24. Williams FMK, Manek NJ, Sambrook PN, Spector TD, Macgregor AJ. Schmorl's nodes: common, highly heritable, and related to lumbar disc disease. Arthritis Rheum. 2007; 57(5):855-860.

25. Wood EH, Hallenbeck GA. Voluntary (self-protective) maneuvers which can be used to increase man's tolerance to positive acceleration. Fed Proc. 1946; 5:115.

26. Zawadzka-Bartczak EK, Kopka LH. Cardiac arrhythmias during aerobatic flight and its simulation on a centrifuge. Aviat Space Environ Med. 2011; 82(6):599-603.

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DOI: 10.13174/pjambp.30.10.2019.02

REVIEW ARTICLE

ANALYSIS OF THE HUMAN FACTOR IN AIR ACCIDENTS IN POLISH CIVIL AVIATION IN THE YEARS 2010-2015

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Abstract: Air accidents are inherent to aviation, regardless of the level of advancement of aviation technology. Both at the stage of aircraft construction and production, as well as during their operation, there are both failures of technological solutions and their handling by ground services or crews during air missions. At each of these stages, different tasks and activities are carried out by a person who may contribute in the short or long term to the inefficient operation of the system: crew – aircraft – environment (C-Ac-E) [17] that resulted in a catastrophe or air accident. The analysis of accidents often focuses on the impact of the so-called human factor on the causes that led to the accident or catastrophe.

The aim of the paper was to analyze the most frequent causes of accidents as a result of the human factor. In order to achieve this objective, the available documentation of 210 civil air accidents that occurred in the Polish airspace was analyzed. Among the examined accident records for the years 2010-2015 , the cause of the majority of accidents was the so-called human factor, which accounted for 80% of all unfortunate events.

Keywords: aviation, human factor, stress, accidents and catastrophes

Figures: 4 • **Tables** 4 • **References:** 19 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2018 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

INTRODUCTION

People have always dreamed of going up in the air, mainly because of the correlation between flying and the sense of freedom and the range of possibilities that could be opened up to them. The first descriptions of attempts to rise above the ground can be found in the ancient legend about Daedalus and Icarus. From this legend we learn that the human factor, in this case disobedience or excessive fantasy, was the cause of the catastrophe. However, such a message did not stop mankind from further attempts to rise above the clouds. Kites that could carry people, first prototypes of helicopters made of bamboo, hot air balloons and even prototypes of parachutes have been built across the ages.

Already in the fifteenth century, after many years of observing birds flying, Leonardo da Vinci designed and described in detail the first flying machines, such as: ornithopters (fig. 1), gliders, aerial screws or parachutes [8].

In 1783 the first demonstration of Montgolfier brothers' hot-air balloon took place (fig. 2), and gliders have been in use since 1883.

However, the actual beginning of aviation is assumed to be the first flight of an airplane with an engine, which was carried out by the Wright brothers (fig. 3). It took place on December 17, 1903 and allowed to traverse the distance of 36 meters and lasted only 12 seconds [8]. To sum up, it can be said that each of the methods of flight is more than 100 years old.

In the 20th century, people's requirements for the execution of flights rose sharply. People wanted to spend more and more time in the air, move long distances and afterwards land safely. It was then that the boom in the development of aviation began. And so, in 1969, man managed to land on the moon. This success was made up of many elements, such as the incredible technological development before and during the Second World War. Already then, attention began to be paid to the abilities (psychophysical capabilities) of the human body associated with the effective performance of tasks in the air. After the end of the Second World War and during the Cold War, the military began to examine the ability of the human body to cope with high-G, to receive information and to control the level of spatial and geographical orientation. It turned out that the technological development of aircraft construction and their operational capabilities were ahead of the pilot's capabilities of effective operation. At the beginning of the 20th century, for every 2 catastrophes caused by human error there were 8 catastrophes caused by technical problems. In the 1970s, this ratio was practically reversed [2,4,8,10].

It was the military aviation during the Second World War that began to pay attention to the ergonomics of aircraft, as well as the appropriate procedures for training pilots. At present, both military and civil aviation have a wide database of aviation events (incidents, accidents and catastro-

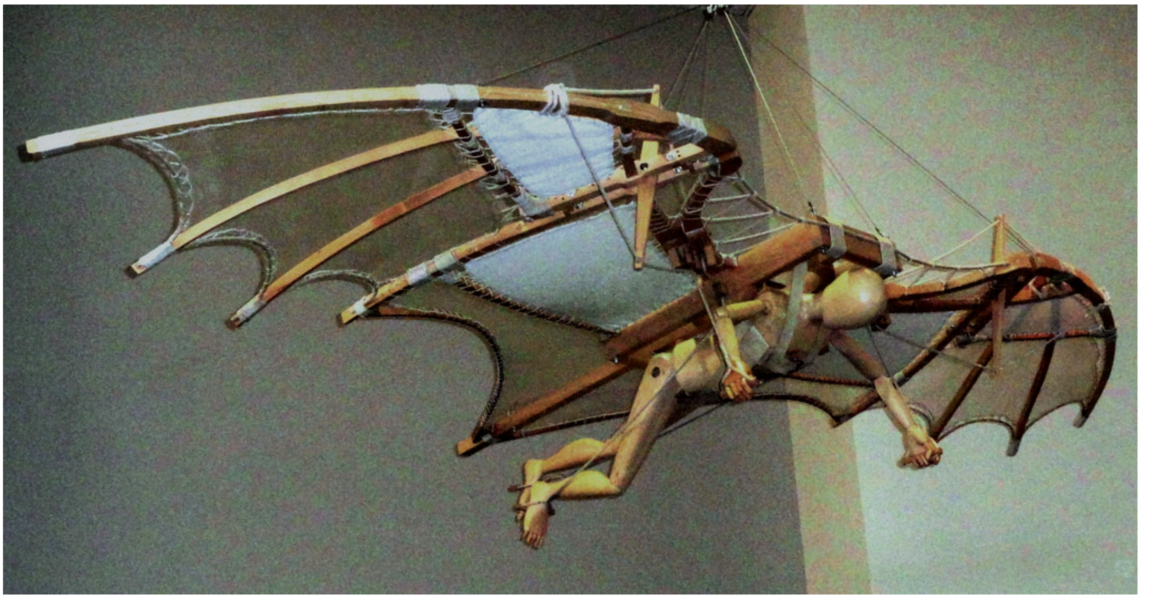

Fig. 1. Model of Leonardo Da Vinci's ornithopter (Source: http://www.katalogmonet.pl/Katalog/Pieni%C4%85dz-zast%C4%99pczy/III-RP-%C5%BBetony/%C5%BBetony-pami%C4%85tkowe/19873-20-ornitopter%C3%B3w-Leonardo-da-Vinci-WZORZEC-PRODUKCYJNY-DLA-MONETY-PR%C3%93BA-mied%C5%BA-patynowana-dp2).

Fig. 2. The Montgolfier brothers' balloon
(Source: https://www.google.com/search?client=firefoxd&channel=trow&tbm=isch&sa=1&ei=TY5nXeqvGeWkrgT_2JHIBg&q=balonu+na+gor%C4%85ce+powietrze+braci+Montgolfier&oq=balonu+na+gor%C4%85ce+powietrze+braci+Montgolfier&gs_l=img.3...459966.459966..471199...0.0..0.55.55.1......0....2j1..gws-wiz-img.M71kr1PKAGY&ved=0ahUKEwiqivOY1qfkAhVlkosKHX9sBGkQ4dUDCAY&uact=5#imgrc=gleLw6zgxx9jaM:).

phes), the analysis of which may enable preventive actions to be taken and thus prevent the occurrence of further accidents [2].

In Poland, in the years 2010-2015, there were on average 33 accidents per year, while in the United States there were about 1000 accidents, whereas the percentage share of accidents in the number of air operations is very similar and is still decreasing. In addition, it is worth mentioning that there are far more accidents in private air traffic than in commercial air transport, where pilots are much better trained and airlines make every ef-

Fig. 3. The Wright Brothers' machine
(Source:https://www.google.com/search?q=si%C4%99+pierwszy+lot+samolotu+z+silnikiem,+kt%C3%B3ry+zrealizowali++braci+Wright&client=firefoxd&channel=trow&source=lnms&tbm=isch&sa=X&ved=0ahUKEwig2e2a3afkAhVq-yoKHUneDpwQ_AUIESgB&biw=1680&bih=936#imgrc=rQjo46tHpqdJCM:).

fort to ensure the safety of the services provided [5,7,11,12,15].

The causes of these accidents or catastrophes are usually numerous, but most frequently they are caused by people who constructed the flying apparatuses, operated it, or are flight organizers or crew members. Each of the above causes results to some extent from the so-called human factor and usually indicates the unreliability of the activities or tasks performed by man, at different stages of the functioning of the functional system, i.e. crew – aircraft – environment (C-Ac-E). Thus, we can speak of the following risk areas depending on the above factors:

– human (unreliable operation determined by physical condition, mental fitness, current psychophysical well-being),
– technical (design errors, defective materials, failure to observe production regimes, inspections, maintenance, operation, etc.),
– legal and organizational (non-observance of rules for the use of aircraft equipment and flight organization),
– social environment (family, task force atmosphere, crew line-up in a given flight mission, organizational climate),
– random activities independent of those mentioned above.

Therefore, in the context of aviation, we can speak of the following types of errors resulting from unreliable human activity, which may lead to unreliable flight crew activity. These are the following types of errors: cognitive, ergonomic, design, aerodynamic, psychosocial, organizational, health errors.

These errors have different characteristics and origins, and have a negative impact on aviation incidents. They have specific effects that can be eliminated or preventive action can be taken.

In addition, it should be stressed that aviation events tend to have a high media impact and attract public interest. Therefore, the causes of accidents in the public perception are first sought in the area of the human factor, i.e. the errors made by the aircraft crew. These errors may or may not be attributable to the crew and may be due to: the specific nature of the task, the operability of the equipment, the meteorological conditions, the training conditions or the organization and coordination of a specific task by ground-based flight control and safety services (Air Traffic Service, Flight Information Service).

The most common cause of air accidents is, however, the errors that accumulate at a certain point in time and place. Then, there occurs the so-called domino effect (a metaphor used to describe a situation in which one small event triggers a series of consecutive events that cannot be stopped because they result from one of the other events), which was proposed by the leader in safety research, pilot and psychologist James T. Reason (fig. 4). This researcher was a psychologist at the Royal Air Force (RAF) from 1962 to 1964, conducting research at the Institute of Aviation Medicine in Farnborough and then at the US Naval Aerospace Medical Institute in Pensacola, Florida. Then, from 1964 to 1976, he was an assistant lecturer, lecturer and researcher at the Psychology Department of the University of Leicester [14].

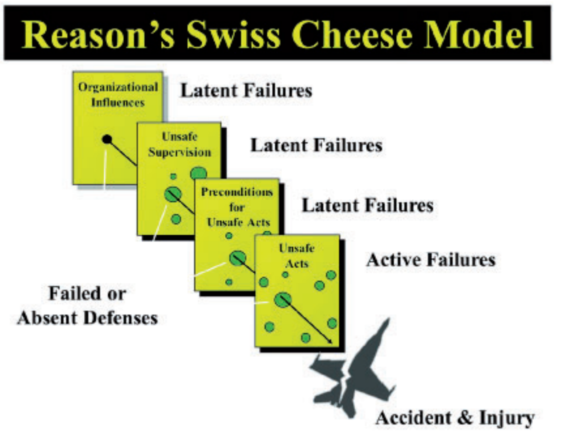

Fig. 4. James Reason's model of the occurrence of an aviation accident (Source: https://www.researchgate.net/figure/Reasons-Swiss-Cheese-Model_fig4_303364455).

This author claims that there is always a root cause that triggers a series of adverse events and, as a result, usually leads to an accident. According to Reason, this root cause is the predisposition of man, preferring to take dangerous actions. However, it seems that the assumption that risky behavior is an immanent feature of a person is a rather simplified explanation of the causes of accidents. On the other hand, literal application of the above model in preventive actions would mean the creation of a series of prohibitions and bureaucratic barriers that would allow the tasks to be carried out only in very idealized conditions, and even sometimes would make it impossible to carry them out effectively.

However, it should be borne in mind that aviation, especially military aviation, sports aviation and sometimes even civil aviation, operates very often in extreme situations.

Therefore, the occurrence of accidents in aviation should be looked at holistically, taking into account many negative factors which have a synergistic effect on the course of flights and, in the end, may contribute to an accident or catastrophe. Therefore, such an analysis should also take into account the previous: accident premises (situations that occur frequently and create an accident hazard, or may sometimes lead to an accident), accident incidents (events that caused a strong, subjective sense of safety risk, or serious incidents (situations that could have led to an accident or disaster, but thanks to a happy coincidence of different circumstances it was possible to avoid an extreme event).

It seems that only such a broad approach to the investigation of accidents and catastrophes in aviation gives the commission an opportunity to investigate such events and to explain them reliably, pointing out the comprehensive reasons for the impact of:

- the human factor at the stage of manufacture, overhaul and preparation of the aircraft for the mission,
- pre-flight assessment of aircraft and efficiency of operation of individual aggregates, pilot-navigation devices during flight,
- mission planning,
- the meteorological conditions,
- the control and coordination of the flight,
- the efficiency of the crew,
- the psycho-physical condition of the crew before and during the execution of the flight,
- other factors that could not have been foreseen.

A similar opinion is shared by David Beaty, a psychologist who is also a pilot and a writer, author of the cult book "Naked Pilot: The Human Factor in Aircraft Accidents" [2]. Based on his experience as a pilot, he makes a psychological analysis of the mistakes made by the aircrew. He also points to the fact that human errors are most often due to individual characteristics of a given person, but are also conditioned by many other elements, often independent of the flight crew.

Moreover, the development of information sciences and mathematical modeling, especially artificial neural networks, provides an opportunity to approximate and explain accidents or air disasters in the aforementioned holistic approach.

Among the generally understood formulation of the human factor, we can also distinguish the following conditions that may lead to aviation disasters, i.e.: fatigue, distraction, poor assessment of the situation, stress, age, illness, medication, current bad psychophysical condition of the body, family and professional problems, etc. In addition, bad nutrition or malnutrition as well as incomplete sleep or sleep deprivation may also have a negative impact on the psychophysical performance of the pilot in flight.

In order to assess which factors had an impact on air accidents during this time period, the following analysis was made. The aim was to identify the most frequent causes of human factor-induced air accidents in civil aviation.

METHOD OF ANALYSIS

As regards the analysis of air accidents, reference should be made to the basic concepts adopted in this area. Thus, in accordance with Annex 13 of the Convention on International Civil Aviation, signed in Chicago on 7 December 1944. - Chicago Convention [18], an air accident is an occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, occurs between the time any person boards the aircraft with the intent to fly and the time that the person disembarks. In the case of an unmanned aerial vehicle, however, such an occurrence is assessed from the moment the aircraft is ready to move in order to perform a flight until it comes to a halt at the end of the flight and the moment the propulsion system is switched off, where:

a) a person on board an aircraft is fatally or seriously injured as a result of:
   - being on board an aircraft, or
   - direct contact with any part of the aircraft, including parts that have been detached from the aircraft, or
   - a direct blast of an aircraft engine, except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when a person is injured hiding outside the areas normally accessible to passengers or crew members, or
b) the aircraft sustains damage or structural failure that endangers its structural durability, performance or control characteristics and would normally require major repair or replacement of the damaged component, except for engine failure or damage, where the failure is limited to the engine itself (including its covers or accessories), propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear flaps, wiper blades, aircraft covering (such as small dents or holes) or minor damage to the main rotor blades, tail rotor blades, landing gear, and those caused by hail or bird strike (including holes in the radio locator antenna casing), or
c) the aircraft is missing or completely inaccessible.

Note 1. Only in the interests of uniformity of statistics, an injury causing death within 30 days of the occurrence of an accident shall be classified by ICAO as a fatal injury.
Note 2. An aircraft is considered missing if the wreck is not located and the official search is closed.

Classification of causes of accidents

Only the main cause of the accident was taken into account in the statistical analysis. Where the State Commission on Aircraft Accidents Investigation (SCAAI) gave, for example, two main reasons, the more significant one was used for the analysis. Initially, accidents were classified by the general cause into four categories: those caused by human factors, technical problems, bad weather or other causes. In the next part of the paper, attention was paid to subcategories of the human factor, distinguishing nine areas concerning both the pilots themselves and the control or maintenance staff, such as: poor assessment of the situation, distraction, excessive self-confidence, communication problems, the psychophysical condition, non-compliance with procedures and competition. Despite the fact that according to the "Swiss Cheese Model" created by James Reason (fig. 4) the occurrence of an aviation accident requires a combination of different factors at different levels of management and operation, on the basis of the reports examined, one factor seems to dominate over the others in terms of responsibility for the accident [7,13]. The State Commission on Aircraft Accidents Investigation (SCAAI) conducts investigations and records of all events, incidents and air accidents that occurred in the territory of the Republic of Poland or abroad, but due to the Polish national affiliation of the aircraft were reported for investigation at the SCAAI. In this paper, the analysis of SCAAI reports on accidents that occurred in the period from 1 January 2010 to 31 December 2015 was performed.

The analysis included 210 civil air accidents that occurred in the Polish airspace and which were investigated by the State Commission on Aviation Accidents Investigation. The causes of these accidents have been classified into the following categories: the so-called human factor, technical cause, meteorological cause and others.

Analyzing the role of the human factor in the literature [1,2,4,5,6,8,13,14,17,19], the most frequently pointed to errors related to: poor assessment of the situation, lack of knowledge, non-compliance with aviation standards and procedures, excessive self-confidence, problems with the transfer of information between crew members or ground control and flight organization services, and factors related to the desire to compete, occurring during air shows and competitions.

RESULTS

Out of all 210 analyzed reports published by the State Commission on Aviation Accidents Investigation, the largest number of them concerned aircraft (57), then gliders (49) and parachutes (42) (tab. 1). Such a distribution is obvious and very similar throughout the world, mainly due to the popularity of the form of air transport in question. On the other hand, on motor gliders and para gliders, the accidents of which constitute only 1% of all air accidents, constitute the lowest number of air operations taking place in Poland [5].

There is no information available on the detailed characterization of the psychological characteristics and the individual suitability to fly on different aircraft. For this reason, advanced sta-

Tab. 1. Aviation accidents investigated by the State Commission on Aircraft Accidents Investigation (SCAAI) in Poland, 2010-2015 [9].

Aircraft type	2010	2011	2012	2013	2014	2015	2010-2015	Percentage
AIRPLANE	9	13	6	4	12	13	57	28%
GLIDER	7	5	3	4	14	16	49	24%
PARACHUTE	3	3	10	4	22	1	43	21%
PARAGLIDER	5	3	4	4	2	0	18	9%
MOTOR GLIDER	3	2	2	2	4	2	15	7%
HELICOPTER	3	0	0	3	1	0	7	3%
GYROCOPTER	1	0	0	0	0	4	5	2%
BALLOON	0	0	1	2	1	0	4	2%
MOTOR PARAGLIDER	0	1	1	0	1	0	3	1%
Total	**31**	**27**	**27**	**23**	**57**	**36**	**201**	**100%**

tistical analyses cannot be carried out, nor can detailed assessments of the impact of individual predispositions on critical events resulting in accidents or air accidents be made.

Table 2 presents an initial breakdown of the causes of air accidents in Poland between 2010 and 2015 into four basic categories: human factor, technical defects, bad weather conditions and others. The human factor ranks first with 80% of all accidents. Unfortunately, the published SCAAI reports, probably due to the provisions of the act on personal data protection, do not provide detailed information allowing to precisely describe the personal characteristics of the persons who contributed to the unreliable operation, and which in consequence led to a situation extremely dangerous for the aviation mission.

Tab. 2. The main causes of the aviation accidents investigated by the State Commission on Aircraft Accidents Investigation (SCAAI) in Poland, 2010-2015 [9].

Cause of the air accident	Number of accidents	Percentage
HUMAN FACTOR	160	80%
TECHNICAL FAILURES	32	16%
BAD WEATHER CONDITIONS	7	3%
OTHER	2	1%
Total	**201**	**100%**

In turn, table 3 shows the percentage of human factor in all causes of accidents on a given type of aircraft. It is clear that for more advanced vehicles, such as gliders and airplanes, the human factor is the vast majority of the causes of accidents. Balloons or old types of helicopters had to deal with great technical problems. In addition, the balloon as a means of transport is highly weather dependent, so the main cause of accidents involving this type of aircraft in more than half of the cases was other than human negligence.

Tab. 3. Percentage of the human factor as the cause of air accidents on a given type of aircraft in Poland, 2010-2015 [9].

Aircraft type	Percentage
GYROCOPTER	100%
GLIDER	88%
PARAGLIDER	88%
PARACHUTE	87%
AIRPLANE	77%
MOTOR GLIDER	73%
MOTOR PARAGLIDER	67%
HELICOPTER	43%
BALLOON	25%

Table 4 presents the results of the analysis of reports in which the human being was the basis of the accident and the division of these causes into subcategories. It was possible to clearly distinguish 7 areas in which the human factor was revealed. These were: poor assessment of the situation, distraction, overconfidence, poor psychophysical condition, non-compliance with procedures or a tendency to compete, ineffective communication between crew members and with the organization and flight control services [5].

Tab. 4. Percentage of the human factor in the aviation accidents investigated by the State Commission on Aircraft Accidents Investigation (SCAAI) in Poland, 2010-2015 [9].

Human factor	Number of accidents	Percentage
POOR ASSESSMENT OF THE SITUATION	62	39%
DISTRACTION	19	12%
OVERCONFIDENCE	30	19%
COMMUNICATION PROBLEMS	4	3%
BAD PSYCHOPHYSICAL CONDITION	24	15%
NON-COMPLIANCE WITH PROCEDURES	16	10%
TENDENCY TO COMPETE	5	3%
Total	**160**	**100%**

Analysis of the causes of air accidents

Among the accidents analyzed for the period 2010-2015, most of them were caused by the human factor, which accounted for 80% of all accidents. Another important factor was technical reasons (16%) and atmospheric conditions (2%). Among the human factors, 39% accounted for the inability of the pilot to assess the situation or the lack of appropriate skills, which in 21 out of 62 cases was related to very little experience of the pilot or pilot-student, and in 5 cases to fatigue. The main causes of air accidents among the human factor are: excessive self-confidence of the pilot (19%), bad psychophysical condition - 15% (15 out of 24 cases 15 are stress-related), distraction (12%), non-compliance with procedures (10%), and the competition factor (3%) and communication problems (3%).

The results show very clearly that the average percentage of the human factor in the causes of air accidents in Poland in the six-year period between January 1, 2010 and December 31, 2015 was at 80%, which does not differ from world standards. The number of accidents per number of air operations on a given type of aircraft is also standard compared to global data. In the analyzed reports, the most common cause of air accidents in the human factor group was poor assessment of the situation (39%), excessive self-confidence

(19%) and poor psychophysical condition (15%) [4,5,8,19].

A poor assessment of the situation is a cause closely related to little experience. In 28 out of 62 cases, the operator had less than 150 hours of experience with a given type of aircraft or no authorization at all. In the next 5 out of 62 cases, the poor assessment of the situation was caused by fatigue, which is also associated with improper psychophysical condition of the operator. The solution to the problem of insufficient experience is primarily the individual extension of the training period with an instructor [18].

Another risk factor was excessive self-confidence, which led to the omission of checklists in 9 out of 30 cases and bravado in 7 cases. Such behavior was most common in pilots with relatively little experience (150 to 500 flight hours) or in very experienced pilots (more than 5000 flight hours). In the first group, this is due to a particularly young age and relatively fast progress in training, in the initial phase, which can give a false sense of self-confidence. In the case of experienced pilots, excessive self-confidence is the result of routine and hitherto mostly accident-free aviation activity.

In both groups, it is important to make operators aware of the possible misconceptions associated with different hazards, both in flight and on the ground, and to check their knowledge of procedures and working in accordance with them [2,4,6].

In the third most common subcategory, stress came first, contributing to 67% of all accidents categorized as being caused by poor physical and mental health. Delayed reaction, often associated with fatigue, ranked second, and about 10% of these accidents were caused by the operator's medication or illness. Stress is a well-known factor these days. There are many ways to deal with stress, and even training in stress management techniques, which allow for quick coping, is being introduced.

In the case of recreational aviation, an operator who is not in good psychological and physical condition can easily opt out of planned activities in the air. On the other hand, government or commercial aviation employees often conceal the inadequate condition of their bodies and expose themselves and others to danger. In this case, employers play an important role, as they should have safety friendly policies and, in cases of chronic stress of their employees or other problems in their private lives, provide them with appropriate leave or dismissal. This category also includes alcohol, under the influence of which the operators performed flight operations. It is obvious that every narcotic drug impairs the nervous system of the human body, affecting the speed of reaction and the ability to perceive the situation. In such a situation, for legal reasons, the State Commission on Aircraft Accidents Investigation has the right not to investigate an accident of an aircraft whose operator was under the influence of narcotic drugs, which may also distort the analysis statistics [3,4,8,19].

Other dangerous factors taken into account in this paper were: distraction (caused 12% of accidents in the human factor category) and insubordination to regulations (10%). Visual distraction was often associated with poor psychophysical condition, but was distinguished as a separate factor due to the fact that it was even more associated with the operator's experience. The frequency of distraction among operators is similar to the distribution of complacency. Pilots with little experience often misjudge the situation or make other mistakes, but remain fully focused. Pilots with extensive experience and those with 150-500 flight hours can be exposed to distraction. Such a division also occurs in the case of insubordination to regulations. The rarest problems were communication problems and willingness to compete (each factor with a share of 3%). This distribution is extremely simple to explain. Air transport has been unified by standard phraseology, which allows for a clear exchange of information even in case of problems with the radio, and competitiveness occurs basically only during air competitions, which constitute a very small percentage of all air operations conducted in the Republic of Poland [2,3,6,8,19].

DISCUSSION

The main objective of the above paper was to analyze the sources of air accidents that occurred in Polish civil aviation in the years 2010-2015, with particular emphasis on human participation in the causes of accidents. In the paper, a new method of division of human factor causes was applied, which in the future may facilitate the orientation of aviation training or qualification verification in relation to groups of operators threatened by a given factor. The above analysis is also a source of knowledge for the operators themselves, explaining what they should pay special attention to.

As regards helicopter accidents, in 2016, statistics were published that highlighted the problem of a greater number of helicopter accidents caused by technical issues than accidents involving airplanes. Moreover, research conducted since the 1970s and published at the first International Symposium on Helicopter Safety shows that the number of helicopter accidents was 43 times higher than the number of airplane accidents [16].

However, trends in the causes of air accidents have changed enormously over the years. Thus, the Billings and Reynard paper [4] on the human factor in aviation incidents from October 1985 states that more than half of all events were caused by the human factor [8]. Moreover, the most frequent factors connected with unreliable functioning of a human being were: incorrect decision-making processes, incorrect management of cockpit resources, boredom, excessive self-confidence and tiredness. Therefore, these problems were of interest to psychologists and flight training organizers. CRM (Crew Resource Management) training programmes have been developed, teaching pilots how to cooperate in a team. At present, extensive procedures and lists adapted even to emergency situations are used to evaluate decision-making processes in commercial aviation.

However, the most difficult to assess is the influence of factors related to personality traits and current psychophysical status on unreliable action in extreme situations [8]. This is due to the fact that for over a dozen years now, in the periodic examination of aviation personnel, no assessment of the personality and current operator skills (perception, motor, psychophysical) of airline pilots, flight attendants or flight security personnel has been carried out. Until the end of the 1990s, however, during periodic examinations, psychological examination, in addition to medical examination, was a sine qua non for decision-making by an aviation and medical commission and the issuing of a certificate on the current state of health, which determined the continuation of work in aviation professions. At that time, periodic medical examinations for airline pilots were conducted every six months, while other crew members were subject to mandatory examinations by the aviation and medical commission every three years. The current legal regulations are very liberal as regards the assessment of individual predispositions to perform aviation professions and boil down to medical examinations conducted by authorized medical practitioners within the framework of individual medical practice. However, only 1st class pilots are examined by aviation and medical commissions and subjected to the certification procedure in the Aeronautical Medicine Centers authorized by the Chief Medical Officer of the Civil Aviation Authority.

Moreover, it should be stressed that in the near future the human factor can be largely eliminated or minimized by replacing many of the activities currently performed by the pilot by systems controlled by artificial intelligence, which will effectively support human decision making during the control of aircraft.

CONCLUSIONS

In the Polish airspace, as in the entire world, the percentage of human factor in aviation disasters was reduced to 80%. Among the causes related to the human factor, the following are still dominating"

- the lack of ability to correctly assess the situation due to lack of professional experience,
- the bravado of pilots and their poor psychophysical condition.

In addition, the psychophysical condition and current fitness of flight crews should be monitored more precisely by means of organizational and legislative measures including:

- introduction of psychological assessment during periodical examinations carried out at Aeronautical Medicine Centers,
- introduction of psychological assessment during periodical examinations performed by authorized medical practitioners within the framework of individual medical practice.

The substantive problem of the above mentioned organizational activities is also the qualifications of psychologists performing the tasks of certification of aviation personnel. At present, there are no legal regulations or specialist centers providing training in this field. There is a lack of psychologists with knowledge and experience in the field of procedures and rules for investigating incidents and accidents and air disasters.

There are no such specialists in civil aviation, and there are only two people left in the structures subordinate to the Ministry of National Defense who could undertake such tasks in order to transfer knowledge in this area and provide substantive preparation for such tasks.

AUTHORS' DECLARATION:

Study Design: Justyna Skrzyńska, Zdzisław Kobos, Zbigniew Wochyński; **Data Collection:** Justyna Skrzyńska, Zdzisław Kobos, Zbigniew Wochyński; **Manuscript Preparation:** Justyna Skrzyńska, Zdzisław Kobos, Zbigniew Wochyński; **Funds Collection:** Justyna Skrzyńska, Zdzisław Kobos, Zbigniew Wochyński. The Authors declare that there is no conflict of interest.

REFERENCES

1. Badania Thomasa G. C. Griffina, https://www.researchgate.net/scientific-contributions/16401142_TGC_Griffin.
2. Beaty D. Pilot. Naga prawda. Czynnik ludzki w katastrofach lotniczych. Wydawnictwo W.A.B., Warszawa 2013.
3. Billings CE, Demosthenes T, White TR, O'Hara DB. Effects of alcohol on pilot performance in simulated flight. Aviation Space Environment Med. 1991; 62(3):233-235.
4. Billings CE, Reynard WD. Human factors in aircraft incidents: results of a 7-year study. Aviation Space Environment Med. 1984; 55(10):960-965.
5. Dąbrowska J. Czynnik ludzki w lotnictwie. Prace Instytutu Lotnictwa. Warszawa 2011; 12(221):66–70.
6. Gore BF. Minimizing Human Risk: Human Performance Models in the Space Human Factors and Habitability and Behavioral Health and Performance Elements, In the 7th International Conference on Applied Human Factors and Ergonomics (AHFE). Orlando, FL, United States, 27-31 Jul. 2016.
7. Griffin TGC, Young MS, Stanton NA. Human factors models for aviation accident analysis and prevention. Ashgate Publishing Company, Burlington, USA, 2015.
8. Kałużna E, Fellner A. Metody uwzględniania czynnika ludzkiego w zarządzaniu bezpieczeństwem systemu transportu lotniczego. Oficyna Wydawnicza Politechniki Warszawskiej. 2014; 103:99-111.
9. Komunikaty Państwowej Komisji Badania Wypadków Lotniczych, https://www.gov.pl/web/infrastruktura/szukaj?query=komunikaty&page=1.
10. Krause SS. Aircraft Safety. Accident Investigations, Analyses & Applications, McGraw-Hill Education (2nd Ed.), New York 2003.
11. Program zapobiegania wypadkom. Wprowadzenie do wyroku pilotażowego, http://www.sjflight.com/images/pilot_judgment.pdf.
12. Raporty z badań wypadków lotniczych publikowane na stronie Państwowej Komisji Badania Wypadków Lotniczych, https://www.gov.pl/web/infrastruktura/panstwowa-komisja-badania-wypadkow-lotniczych.
13. Reason J. Human error. Cambridge University Press, 1990.
14. Reason J. Managing the Risks of Organisational Accidents (1997), http://www.safetyleaders.org/superpanel/superpanel_james_reason.html.
15. Shappell SA, Wiegmann DA. The Human Factors Analysis and Classification System–HFACS, U.S. Department of Transportation, Federal Aviation Administration. Final Report. DOT/FAA/AM-00/7. Washington 2000.
16. Statystyki bezpieczeństwa lotniczego w UE. Eurostat. Statistics Explained, http://ec.europa.eu/eurostat/statistics-explained/index.php/Air_safety_statistics_in_the_EU.
17. Terelak JF. Człowiek w sytuacji pracy w okresie ponowoczesności, Wydawnictwo UKSW, Warszawa 2012.
18. Urząd Lotnictwa Cywilnego. Załącznik nr 13 do Konwencji o Międzynarodowym Lotnictwie Cywilnym (Konwencja Chicagowska) z dnia 7 grudnia 1944 roku, http://www.ulc.gov.pl/pl/prawo/prawo-międzynarodowe/206-konwencje.
19. Wiener EL, Nagel DC. Human Factors in Aviation - Cognition and Perception, Academic Pres, San Diego 1988.

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SHORT COMMUNICATION

APPLICATION OF HUMAN CENTRIFUGE TO SIMULATE PARABOLIC FLIGHT: EARLY EXPERIENCE

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Introduction: We have used our human centrifuge to simulate the parabolic flight environment. Tests were carried out on four candidates taking part in a parabolic flight program. The main idea behind the project was to test the possibility of simulation of a near zero Gz environment with the centrifuge as a cheaper and simpler alternative to parabolic flight. An additional goal was to try to identify crew members who would present excessive symptoms of motion sickness.

Methods: The flight profile was adjusted to replicate the characteristic conditions and specificity of a parabolic flight. The study was performed as a practical test in a variable acceleration environment similar to a real parabolic flight (with G-limits: max. +2 Gz, min.0 Gz, and up to 13 repetitions of a cycle). Evaluation of eye-hand coordination, orientation and Romberg tests were performed. Each candidate was monitored (HR, ECG, SaO2, earpulse). The exposure was performed twice on two consecutive days.

Results: All participants completed the expositions with positive outcomes. They reported that they had the illusion of microgravity. They exhibited similar hand-eye coordination issues as in microgravity. Last but not least, with repeated exposures, the average heart rates were decreasing, pointing to adaptation to the procedure. Trained behaviors and organism reactions have been successfully used and verified afterwards during the real parabolic flight organized by the ESA.

Figures: 7 • **References:** 4 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2018 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

Conclusions: Despite the preliminary nature of the study, promising results were obtained, which may be further developed and ultimately used to improve the quality and effectiveness, especially the cost effectiveness, of ground preparation of astronauts for microgravity. Furthermore, the profile might be adjusted to evaluate experiments involving the use of neuroimaging techniques in space.

Keywords: human centrifuge, parabolic flight, micro-gravity, simulation, adaptation

INTRODUCTION

The parabolic flight (PF) is considered to be an analog of microgravity (μ-g) that is widely used in mimicking some of the features of spaceflight in a more-controlled and less-expensive manner. In PF, an aircraft flies in sequences of parabolic trajectories that provide short-duration periods of free fall (μ-g for at least 20 to 23 sec, see fig. 1). Before and after the μ-g phase the aircraft has a mild high positive G-force (posGz) pull-up and pull-out (1.5 to 1.8 g, 20 sec). Between each parabola, there has been a "recovery phase" (30 to 40 sec). The parabolic flight is unique in allowing for real μ-g in a ground-based facility [4]. However, parabolic flight campaigns (PFC) are still pretty expensive and can only simulate a short time μ-g.

In the long-arm human centrifuge (HTC) at the Military Institute of Aviation Medicine [1,2,3] an active gondola can be rotated in different axes during centrifugation. This allows for acceleration with positive Gz-forces (posGz) used in military high-posGz training. But it can also generate negative Gz-forces (negGz - by rotating the gondola in the other direction) analog to μ-g due to the fluid shift component in μ-g. The idea behind this project was to demonstrate problems with precise hand movements in microgravity to the future crew of European Space Agency´s (ESA) eDeorbit mission involving μ-g. It was designed to capture and deorbit large items of space debris as part of the Agency's Clean Space initiative.

Certainly, an HTC is not the same as a PFCs because in one direction gravitation is still 1 and μ-g is only the result of gyration in axes. Therefore, the spin and its source of symptoms result in a state similar to motion sickness. The project aimed to select crewmembers for space missions by identifying individuals who would develop excessive symptoms of motion sickness. An additional goal of the training was to assess the eye-hand coordination of the participants, as well as examining how they deal with various psychophysiological factors (such as disorientation, reaction to stimuli,

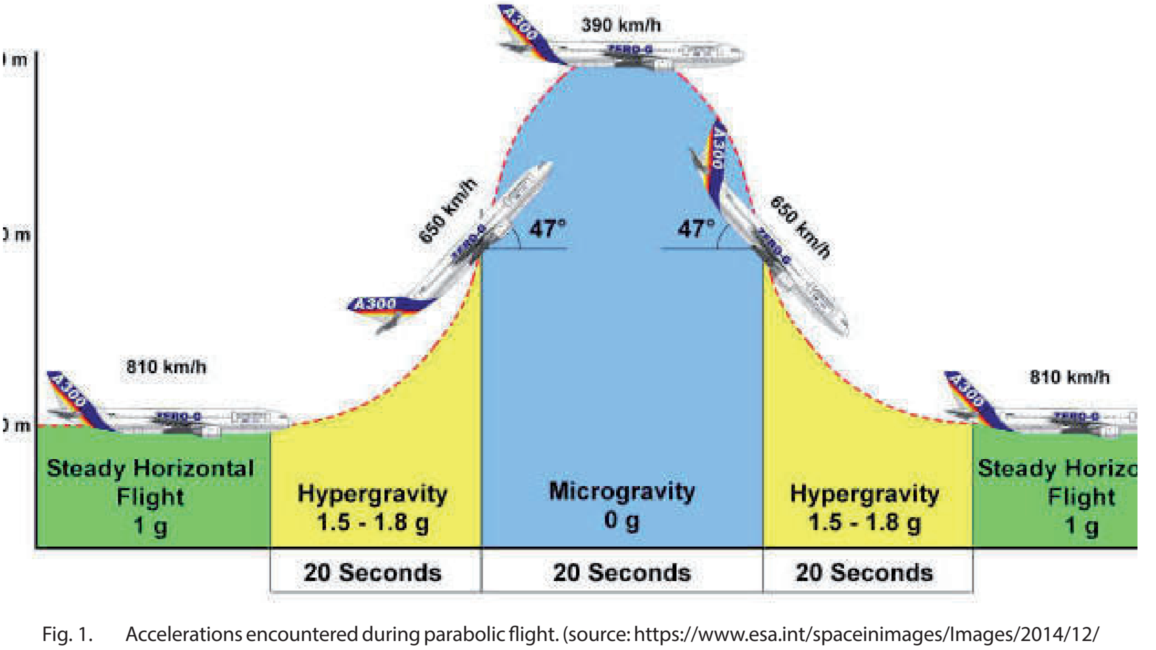

Fig. 1. Accelerations encountered during parabolic flight. (source: https://www.esa.int/spaceinimages/Images/2014/12/Prabolic_flight_manouvres). At MIAM, only the part shaded in blue was simulated.

cyclically variable accelerations) that may impact the human body during such exposure. Looking into the future, we expect that this approach could be used as an essential part of the selection, and furthermore — for training before human space flight.

METHODS

Four representatives of ESA preparing for the unique experience of weightlessness on a PFC participated in the centrifuge training developed by the Aeromedical Training Department of MIAM. Before the HTC training, the participants underwent extensive ENT examinations to eliminate any labyrinth disorders. The substantive scope of the HTC training was focused on maximizing the experience of acceleration and gravitational conditions prevailing during PF.

The acceleration profile was adjusted to replicate similar conditions and PF specificity. The study was performed as a practical test in a variable acceleration environment similar to real PF (with G-limits: max. 2 posGz, min. μ-Gz, see fig. 2). The acceleration profile was designed to reflect the z-acceleration profiles and their durations during the parabolic flight. On day one, there were up to seven repetitions of the cycle (acceleration profile), each of which simulated one parabolic flight. After each repetition of the profile, the participants were asked if they wish to continue. If they declined, the exposition was terminated. On the second day, the participants were exposed to up to 13 cycles. The numbers of repetitions were shortened at the pilot's request due to symptoms of motion sickness.

Evaluation of eye-hand coordination, orientation, and Romberg tests were performed. Each candidate was monitored (HR, ECG, SaO2, earpulse). The exposure took place twice on two consecutive days. The mean HRs were calculated over the 20 second-long periods with Gz=2.0 (preceding microgravity) Gz=0 (microgravity), and Gz=2.0 (after microgravity).

The study protocol was approved in advance by the Bioethical Committee of the Military Institute of Aviation Medicine in Warsaw. Each subject provided written informed consent before participation and they were compensated for taking part in the experiment.

RESULTS

All participants completed the expositions with positive outcomes. The first participant completed 13 cycles on the first day and seven on the second day (fig 4). The other pilots respectively completed 12 and 6 cycles (fig. 5), 13 and 3 cycles (fig 6), and 13 and 5 cycles (fig 7).

They reported that they had the illusion of microgravity. They exhibited similar hand-eye coordination issues as in microgravity (fig. 3).

The transitions between the different phases of the profiles, in particular the switch from μ-g to 2G, were reported to be the most difficult for the participants. It was when the boogie of the centrifuge flipped upside down while the centrifuge was still rotating, leading to significant symptoms of motion sickness. Another such event was during the centrifuge was braked to stop. For the rest of the time, no problems were reported, unless the participant moved their head.

Another finding was improvement with Romberg tests. Initially the participants had problems with touching their noses with their index fingers (usually they ended up somewhere in the skull

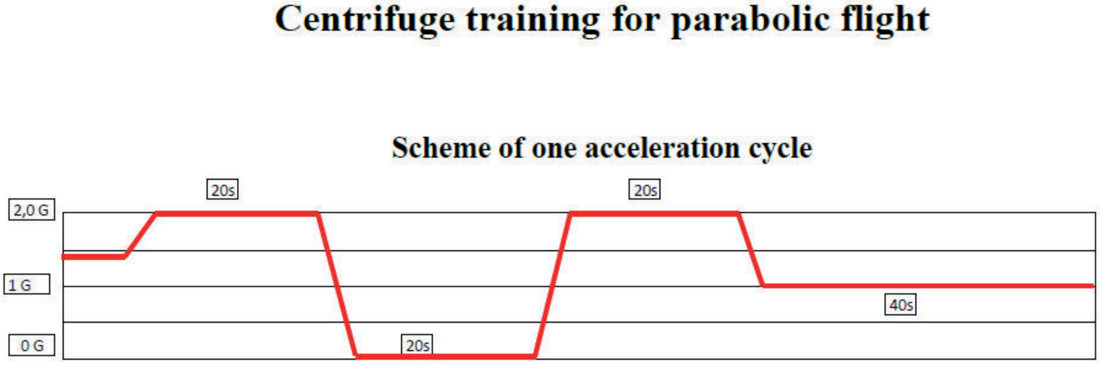

Fig. 2. The timing of z-accelerations during one cycle (single parabolic flight). This cycle (single parabolic flight) was repeated up to 13 times on the first day and up to seven times on the second day of training.

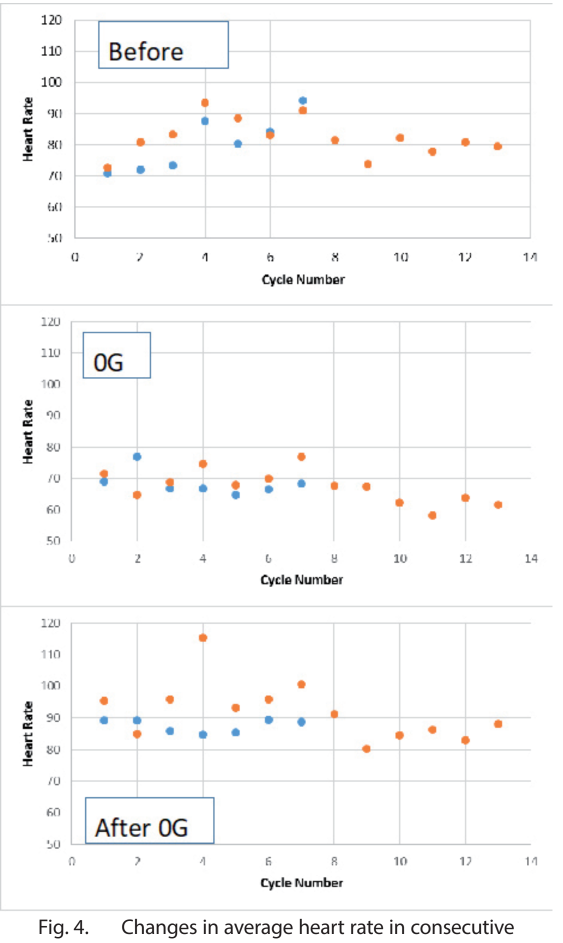

Fig. 4. Changes in average heart rate in consecutive cycles preceding simulated zero gravity, during simulated zero gravity, and afterwards (participant #1). Blue dots = 1st day; red dots = 2nd day. "Cycle number" refers to the successive number of the flight profile depicted in fig. 2.

frontal area). After couple of repetitions this function went back to normal after a short time.

Last but not least, with repeated exposures, the average heart rates decreased, indicating adaptation to the procedure (fig. 4, 5, 6, 7).

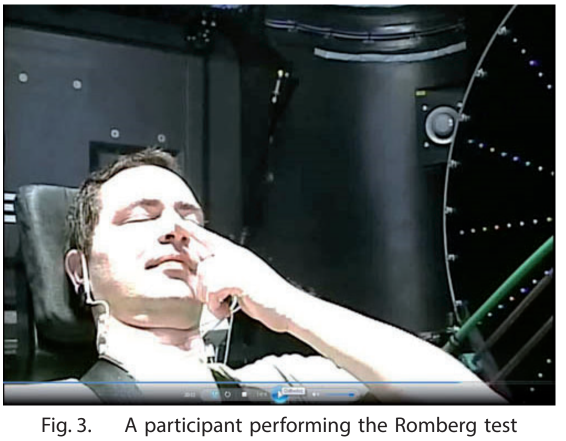

Fig. 3. A participant performing the Romberg test during simulated microgravity.

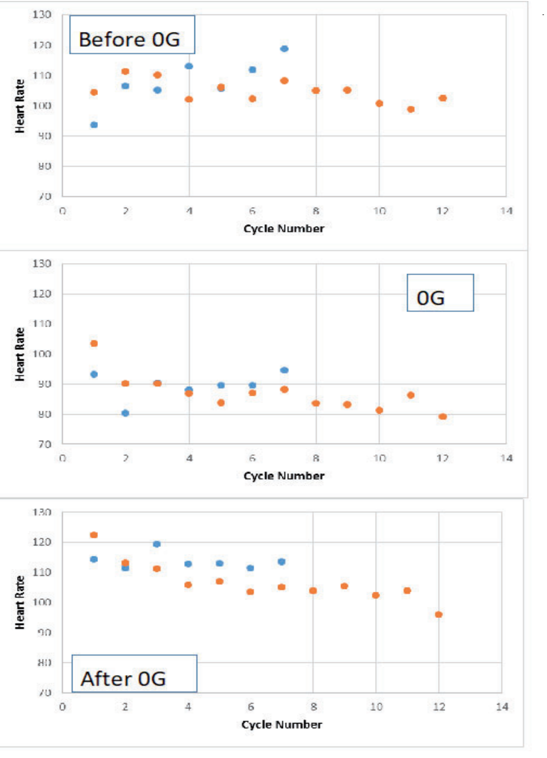

Fig. 5. Changes in average heart rate in consecutive cycles preceding simulated zero gravity, during simulated zero gravity, and afterwards (participant #2). Blue dots = 1st day; red dots = 2nd day. "Cycle number" refers to the successive number of the flight profile depicted in fig. 2.

DISCUSSION

Trained behaviors and organism reactions have afterwards been successfully used and verified during the real parabolic flight organized by the ESA. Despite the preliminary nature of the study, promising results were obtained, which may be further developed and ultimately used for improving the quality and effectiveness, especially the cost-effectiveness, of ground preparation of astronauts for microgravity.

ACKNOWLEDGMENTS

This study was shortly described at http://www.esa.int/spaceinimages/Images/2015/02/Polish_human_centrifuge and at http://www.wiml.waw.pl/?q=en/node/478.

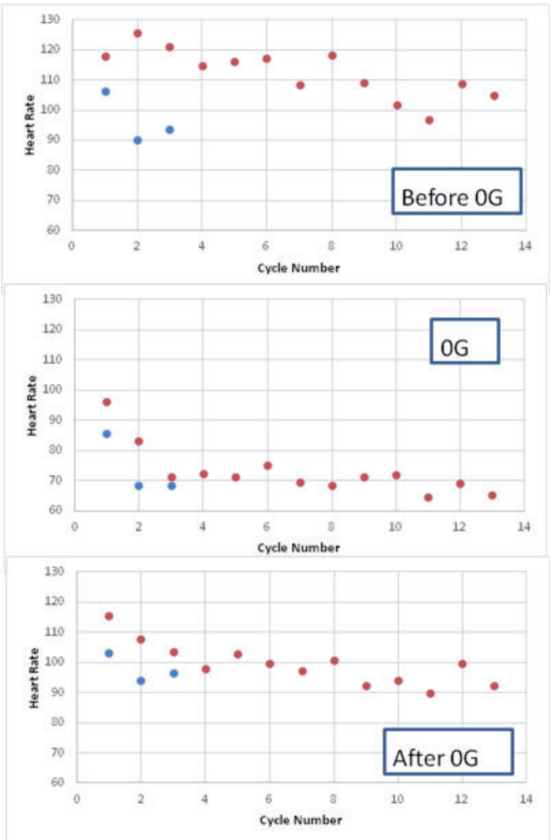

Fig. 6. Changes in average heart rate in consecutive cycles preceding simulated zero gravity, during simulated zero gravity, and afterwards (participant #3). Blue dots = 1st day; red dots = 2nd day. "Cycle number" refers to the successive number of the flight profile depicted in fig. 2.

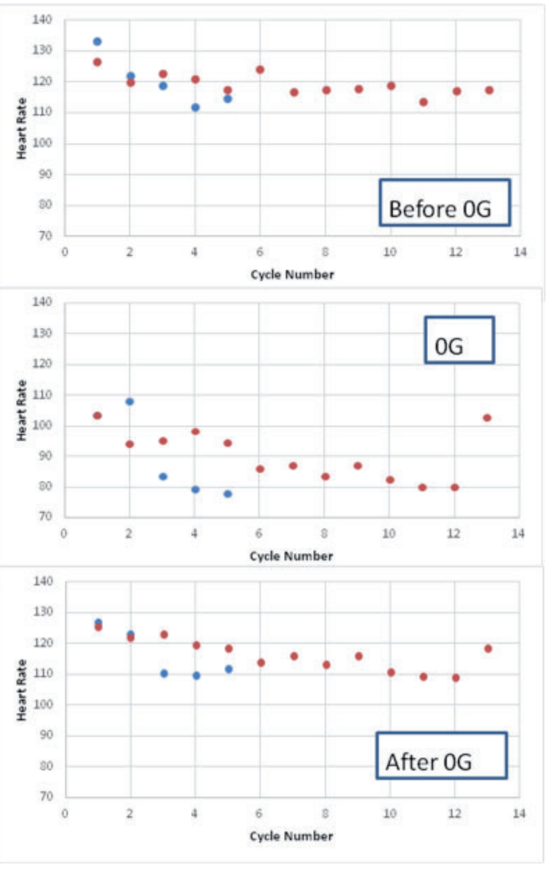

Fig. 7. Changes in average heart rate in consecutive cycles preceding simulated zero gravity, during simulated zero gravity, and afterwards (participant #4). Blue dots = 1st day; red dots = 2nd day. "Cycle number" refers to the successive number of the flight profile depicted in fig. 2.

AUTHORS' DECLARATION:

Study Design: Krzysztof Kowalczuk, Kjetil Wormnes, Mariusz Walas, Marcin Strojek, Tadeusz Grzeszuk. **Data Collection:** Michał Janewicz, Mariusz Walas, Marcin Strojek, Tadeusz Grzeszuk. **Manuscript preparation:** Krzysztof Kowalczuk, Stefan Gazdzinski, Andreas Werner. **Funds Collection:** Kjetil Wormnes. The Authors declare that there is no conflict of interest.

REFERENCES

1. Biernacki MP, Tarnowski A, Lengsfeld K, Lewkowicz R, Kowalczuk K, Deren M. +G(z) Load and Executive Functions. Aviation Space and Environmental Medicine. 2013; 84(5):511-5.
2. http://www.wiml.waw.pl/?q=en/Dynamic_Flight_Simulator
3. Kowalczuk K, Puchalska L, Sobotnicki A, Czerw M, Janewicz M, Wylezol M, et al. Effects of Gradual Onset +Gz on Hemodynamic Parameters and Brain Oxygenation in Military Pilots: Preliminary Study. The Polish Journal of Aviation Medicine, Bioengineering and Psychology. 2016; 22(3):5-11.
4. Shelhamer M. Parabolic flight as a spaceflight analog. Journal of Applied Physiology. 2016; 120(12):1442-8.

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SHORT COMMUNICATION

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DOI: 10.13174/pjambp.30.10.2019.04

MASS CASUALTIES TRIAGE ALGORITHM WITH THE USE OF StO_2 LEVELS, HR AND BODY TEMPERATURE MEASUREMENTS

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Objectives: The paper presents the advantages and disadvantages of the current mass events victim care system with use of the START (simple triage and rapid treatment) procedure and the usefulness of the StO_2, HR and body temperature measurements, which are communicated via the newly created communication system to the rescue personnel. The aims of this procedure were:

1. Providing answers to the following:
   - Is there a correlation between StO_2 values and the associated heart rate changes (Δ HR)?
   - Are the values of StO_2 and HR measured at ambient temperatures ranging from -15 to +40 degrees using the pulse oximeter reliable and reproducible?
   - What values of StO_2, HR and body temperature of the victim may be a basis for secondary evacuation (yellow band) of the victim, and at what point immediate evacuation (red band) is required?
2. Development of a medical segregation algorithm for use in mass operations, taking into account the values of StO_2, HR and body temperature of the injured.

Methods: The purpose of the study was to determine the needs for triage, is there a correlation between StO_2 values and associated HR values, determined in hypoxia. All of the subjects were evaluated for HR changes (ΔHR) associated with gradually decreasing StO_2 values, which were determined by near-infrared spectroscopy (NIRS).

Figures: 7 • **Tables** 3 • **References:** 6 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2018 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

Also, if StO_2 levels, HR and body temperature measurements are reliable in temperatures in the range of -15 to +40 degrees. Lastly, a modified medical segregation algorithm for the injured was developed, taking into account the results of the conducted research.

The test material was obtained from 100 pilots during training in the hypobaric chamber, under normobaric hypoxia conditions (when breathing in a low-oxygen gas mixture), and results from the thermal chamber examinations.

Results: The studies have shown that as the StO_2 decreases to about 85%, there is an increase in the heart rate. After that, in most of the subjects, it slows down without a transitional phase of oscillations or plateau rhythm. StO_2 levels ranging from 95% to 85% showed an average, significant relationship with HR -$r = -0.361$; $p < 0.001$. In the StO_2 ranging from 84% to 70%, a significant but weak negative correlation with HR was found - $r = -0.231$; $p < 0.001$.

Conclusions: Based on the results of the research and theoretical considerations, a validated triage algorithm was proposed.

Keywords: vital signals, simple triage, rapid treatment evacuation

INTRODUCTION

Triage is the medical segregation procedure to help the victims of mass accidents, developed to provide order in emergency assistance via codes. Procedure should be continued and validated until the end of the rescue operation. In the current system of segregation and treatment of victims in such events, the 'START' (simple triage and rapid treatment), the following facts/parameters are taken into account:

1. Whether the victim is able to walk.
2. The presence of spontaneous breathing and its frequency – with retained or restored airway patency.
3. The presence of pulse in the radial artery.
4. The capillary blood flow restitution time.
5. Consciousness, allowing reactions to simple commands.

Based on these, the "rescuer" (doctor, medical rescuer, fireman or other suitably trained person) performs medical segregation. Besides the undoubted benefits for the rescue of victims, this system has significant limitations. The most important of these is the fact that after first aid delivery and determining the order of evacuation (giving the appropriate colour of the straps), victims' health is no longer monitored by the rescuer. It should also be noted that measurements of shallow breathing frequency and capillary blood flow restoration time, as recommended for the initial segregation, may not always be possible to make. For example, at night or in inaccessible places, at low ambient temperatures and always in unfavourable circumstances such as stress and rush.

The possibility to determine saturation (StO_2/StO_2), heart rate measurement (HR) and additionally the body temperature altogether provides a better, more accurate diagnose of the current state of affected individuals and gives opportunity to prioritize appropriate medical care. Our armband (EvaCopNet) with built-in sensors, records and measures the value of the abovementioned parameters and sends it via a wireless communication system to the rescue station. Apart from that it allows the rescuer to track the current location of the victim. Using this device has helped to create conditions for monitoring victims' health and whereabouts. Our research created the basis for the verification of the existing rescue algorithm. An answer to the question of whether the values of StO_2 and HR should be used as interrelated or completely independent of one another is needed for verification purposes.

Scope of work

The aims of this procedure were:

1. Providing answers to the following:
   a. Is there a correlation between StO_2 values and the associated heart rate changes (Δ HR)?
   b. Are the values of StO_2 and HR measured at ambient temperatures ranging from -15 to +40 degrees using the pulse oximeter reliable and reproducible?

   c. What values of StO_2, HR and body temperature of the victim may be a basis for secondarily evacuation (yellow band) of the victim, and at what point immediate evacuation (red band) is required?

2. Development of a medical segregation algorithm for use in mass operations, taking into account the values of StO_2, HR and body temperature of the injured.

METHODS

The testing material consisted of:

1. Levels of StO_2, HR and Δ HR obtained from 100 pilots during the assessment of the TUC "time of useful consciousness", while in the hypobaric chamber (KNC), under conditions corresponding to the height of 7,500 meters above the sea level.
2. Levels of StO_2 and HR obtained during the assessment of the TUC in pilots breathing the hypoxic nitrogen-oxygen gas mixture (7.1-7.3% oxygen) - corresponding to the altitude of 7,500 m under normobaric conditions [3].
3. Levels of StO_2 and HR measurements of four subjects in a thermobaric chamber under standard conditions, at temperatures of -15ºC, 0ºC, + 15ºC, + 40ºC.

While marking the TUC - time of useful consciousness (the time measured from the onset of acute hypoxia, to the end of one's consciousness and functional fitness) in the hypobaric chamber, pilots were exposed to acute hypoxia, corresponding to a height of 7,500 m. and reduced barometric pressure, which at this height is about 1/3 of the pressure at sea level. The study was conducted before the noon, subjects were seated and at least 2 hours after the meal. All pilots were equipped with personal high-altitude equipment - a helmet and a mask, connected to breathing regulators set at 100% oxygen in the chamber. The oxygen was inhaled for 45 minutes prior to altitude exposition as a decompression sickness precautionary measure. After this period the pressure in the chamber was lowered to that corresponding with 7500m (around 25 000 feet) and StO_2, HR and ECG were recorded and monitored. Each pilot was exposed to hypoxia by switching his breathing circuit to breathing chamber air. Additionally, as a psychophysiological measure, pilots counted down from 1000 to 0 on a sheet of paper. Indications for termination of the test and re-administration of oxygen were manifestations of hypoxia such as: a substantial decrease in StO_2 (less than 70%), a sudden increase in heart rate by at least 20 per minute or rapid HR decrease, cardiac conduction disturbances and a large number of errors in counting numbers or unreadable hand writing.

A similar methodology was used to determine the TUC with breathing a low-oxygen gas mixture (7.1-7.3% oxygen), using a GSz-6 sealed helmet, under normobaric conditions. Criteria used for exposition termination were the same in both test procedures.

All of the subjects were evaluated for HR changes (ΔHR) associated with gradually decreasing St02 values, which were determined by near-infrared spectroscopy (NIRS). An integrated "Barbakan" monitoring system and a PXM - 200 pulseoximeter (put on the 2nd or 3rd finger of the hand) were used for recording.

The effects of temperature on the StO_2 sensor were measured using a thermobaric chamber at temperatures -15°C; 0°C; 15°C and 40°C, in normobaric conditions. The atmospheric pressure on the day of the test was 769mmHg/1025.25 hPa. StO_2 measurements at -15°C were recorded when the respondents reported feeling cold and chills. The MAX30100 (Pulse Oximeter and Heart-Rate Sensor ICs made by Maxim Integrated) sensor was used (fig. 1). The StO_2 measuring sensor and the skin surface temperature sensor are located on the inner side of the band. During the test, the device was placed on the inner side of the wrist (fig. 2). The test subjects did not wear gloves, the band was exposed directly to ambient temperature.

Fig. 1. The wrist sensor band used in experiments.

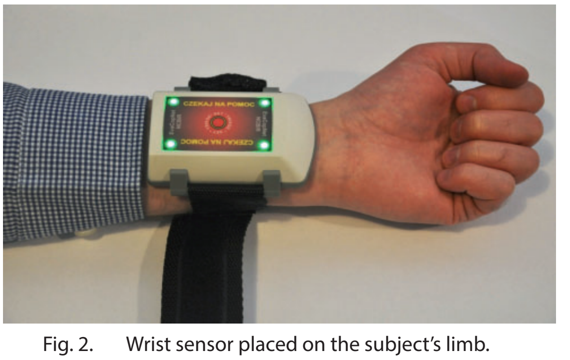

Fig. 2. Wrist sensor placed on the subject's limb.

The results obtained during the TUC measurement (in hypobaric conditions) were subjected to statistical analysis using the R package. For the values of StO_2 and HR obtained for each of the examined and for the whole group, the mean, standard deviation and minimum and maximum values were calculated. The HR values (ΔHR) for the StO_2 range from 95% to 85% were calculated respectively for the heart rate recorded with StO_2 of 95%. For the StO_2 range from 84% to 70% ΔHR was calculated with the HR value recorded at StO_2 of 84%. In order to evaluate the relationship between StO_2 and Δ HR, the Spearman correlation coefficient was determined. The statistical significance level was $p < 0.001$.

RESULTS

The maximum, minimum and average values of StO_2 and HR for the whole group are presented in table 1.

Tab. 1. The maximum, minimum and mean values of StO_2 and HR in the examined group.

N=100	Min	Max	Mean	SD
StO_2(%)	68	92	81,9	4,9
HR/min	72	147	110,7	15,4

HR- heart rate; StO_2 - tissue oxygen saturation

During the measurement, 87 patients had gradually increased HR with progressive decline in StO_2 values, followed by:

1. In 36 patients, there was an oscillation / plateau phase after which the HR dropped – HR response: increase-oscillation-decrease, as shown in figure 3.
2. In 51 subjects, the HR dropped without the transitional phase of oscillation/plateau – HR response: increase-decrease, as shown in figure 4.

In the remaining 13 subjects, the HR changes were not typical of any of the above described change models. The threshold value of StO_2 at which the above HR response types were observed was approximately 85% for most of the respondents.

For the majority of the respondents, the HR drop (regardless of type of response) occurred at StO2 <85% - as shown in figures 5 and 6.

On the common ordinate - HR signal and StO_2signal. Blue line: StO_2 signal in the range of 95-85%, red line - StO_2 signal below 85%. Green line - filtered HR waveform.

Changes in heart rate (ΔHR) in the analyzed ranges of StO_2 values are shown in table 2.

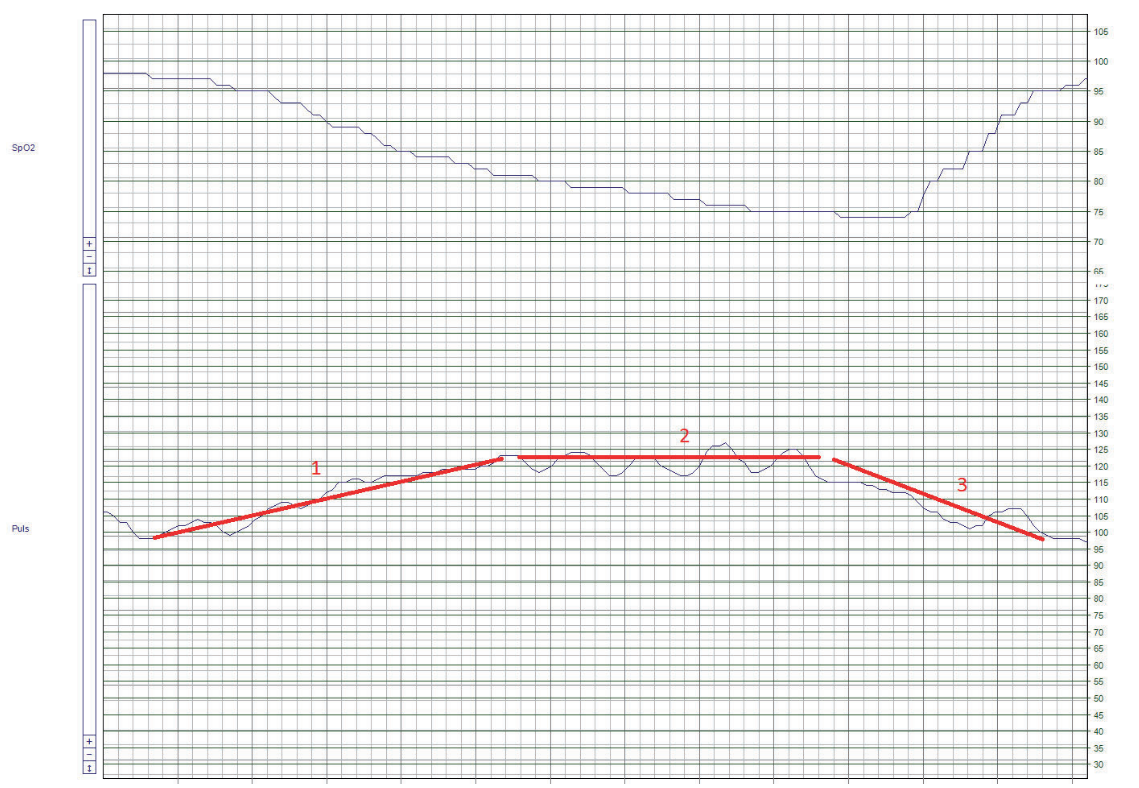

Fig. 3. HR response type: increase - oscillation / plateau – decrease.

Fig. 4. HR response: increase-decrease.

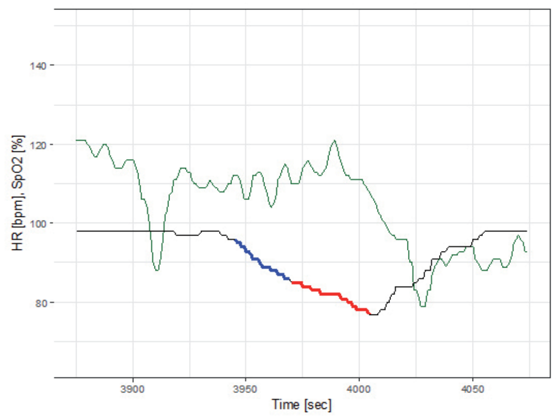

Fig. 5. Rapid HR drop at a StO_2 value of approximately 81%.

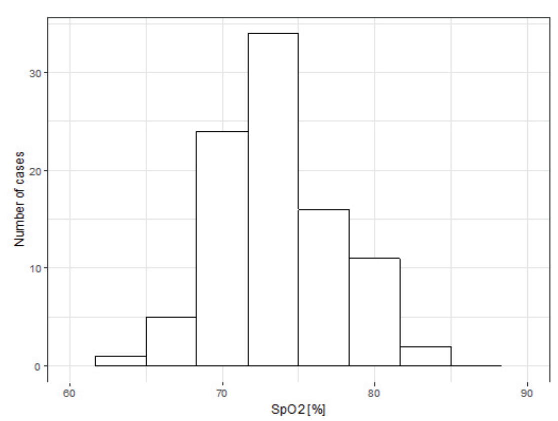

Fig. 6. Histogram of StO_2 values at which rapid HR drop was observed.

	ΔHR (bpm)	
	StO2 95% - 85%	**StO2 84% - 70%**
Min	-27.59	-45.14
Max	32.25	30.22
Mean	2.85	3.19
±SD	6.56	7.84

Tab. 2. Minimum, maximum and mean values of heart rate changes (ΔHR), depending on the StO_2 range.

StO_2 - tissue oxygen saturation; ΔHR – decrese/increase of heart rate

In the StO_2 range of 95%-85% there is a significant, average negative correlation between the HR value and StO_2 - Spearman correlation coefficient r = -0.361; p <0.001. In the StO_2 range of 84%-70% there is a significant, poor, negative correlation between the HR and StO_2 values of the Spearman correlation coefficient r = -0.231; p <0.001.

Similar correlation was observed between $StO_2$and HR values during TUC measurement using a nitrogen-oxygen (7.1-7.3% oxygen) mix under normobaric conditions.

Studies in the thermobaric chamber show that measurements of StO_2 and HR values at temperatures of -15ºC to +40ºC were unaffected/within the range of 95-98%. The discrepancies between the values of consecutive StO_2 determinations at 4-minute intervals (for 16 minutes) ranged between 1 and 2%, occasionally up to 3%, which is consistent with commonly accepted error criteria for this measurement method.

The temperature of 4 patients was measured in the thermobaric chamber. The correlation coefficients between the measured body temperature, measured at room temperature of 22°C, and measured by the sensor (located in the band) at selected ambient temperatures are shown in table 3. The average body temperature of the subjects prior to entry into the chamber was 36.7 ± 0.14 ° C.

	Tambient	Correction factor
1	-15°C	+14.6±0.29°C
2	0°C	+12.6±0.23°C
3	+15°C	+10.6±0.12°C
4	+40°C	+1.6±0.26°C

Tab. 3. Correction factors between the temperature of the body examined before entering the thermal chamber and measured by the sensor in the band at various temperatures inside the chamber.

DISCUSSION

StO_2 determinations are made mainly for clinical purposes, the diagnosis and monitoring of respiratory illness. It should be emphasized that in a healthy individual, the oxygen saturation level should be within the range of 94%-99%. In patients with mild respiratory diseases, StO_2 is 90% or above. Usually, oxygen therapy is administered if the StO_2 value is less than 90%. Numerous studies have been conducted on tissue saturation in the affected population.

Saturation was measured during hospital admission, as a predictor for hospitalization [2], the severity of shock and prognosis of healing [1,6]. It can help predict the need for blood transfusions during the next 24 hours in patients with a high shock risk [5]. So far, data on the study of the usefulness of StO_2, HR and body temperature measurements for medical segregation in mass accidents is nonexistent. The authors underline that the lower the value of StO_2, the worse the prognosis is [1], which - although obvious - at the same time does little to contribute to the rescue algorithm in mass events. Some studies show that the possibility of hospitalization was higher in patients with a StO_2 value below 75-76% [2]. But it is surprising that their general condition was not correlated with the outcome of StO_2 measurement. Some patients with 67% StO_2 values were not eligible for hospital treatment. It is proposed that for the needs of triage, the statistical cut-off value of StO_2 should be 76-78%. In addition, there is no information on the further fate of patients not qualified for hospital treatment despite such low saturation values, and equally important for the START algorithm is how long they had a reduced StO_2 value before they reached the hospital emergency department. And how did it affect the prognosis?

The system (during the EvaCopNet project) of monitoring and transmitting the current values of these parameters to the rescuers has created a basis for verifying the current algorithm of the START system. In our own studies, an insufficiently big negative correlation was found between StO_2 and HR values to allow for the use of such interrelation (in a significantly related way) for triage. However, it was found that in most pilots the heart rate increased with the drop of StO_2 up to the value of 85% and then gradually decreased.

But it should be emphasized that:

- the study involved clinically healthy pilots,
- StO_2 and HR markers were performed in persons at rest and relaxed, under specific oxygen deficiency conditions. Therefore, the results may, for the purposes of triage, only be useful for examining the correlation between StO2 and HR values,
- hypoxia is individually varied and even unequal in the same pilots during subsequent periodic examinations,
- lesser tolerance to hypoxia is observed in: older people, less fit (with lower VO2max), physically overworked or sleep deprived. Subjects with increased metabolism (e.g. with elevated body temperature, hyperthyroidism, hyperactivity), anaemia, vascular-motor dysfunction (e.g. under the influence of alcohol) cope even worse.

It is also worth noting that:

- factors other than saturation may influence the HR level of victims: pain, anxiety, stress, environmental or weather conditions and most importantly, the health condition before the event,
- injured persons with a decreased haemoglobin level can have normal haemoglobin saturation and at the same time be in severe hypoxia,
- StO_2 measurement has some limitations - the causes of incorrect measurement may be: movements, muscular tremor, lack of adequate pulse wave amplitude (e.g. hypothermia, reduced peripheral perfusion due to hypotension, tachycardia or significant bradycardia – resulting in prolonged response time of the pulse oximeter), lowered Hb value - by 7-6 g% , administration of pressure amines, car-

bon monoxide poisoning (in such event SpO_2 values oscillate within 100%),

– smoking can result in the overestimation of the SpO_2 score, and nail polish (green, blue, black) may lead to underestimation (depending on the light absorption).

For above-mentioned reasons, regardless of the results of the studies, the relationship between StO_2 and HR values cannot be used in a coherent manner. For triage, it is important to establish the StO_2, HR and body temperature values for victims at which a patient still has a chance of survival, including the potential for oxygen therapy and the time needed for hospital transport or specialist medical attention.

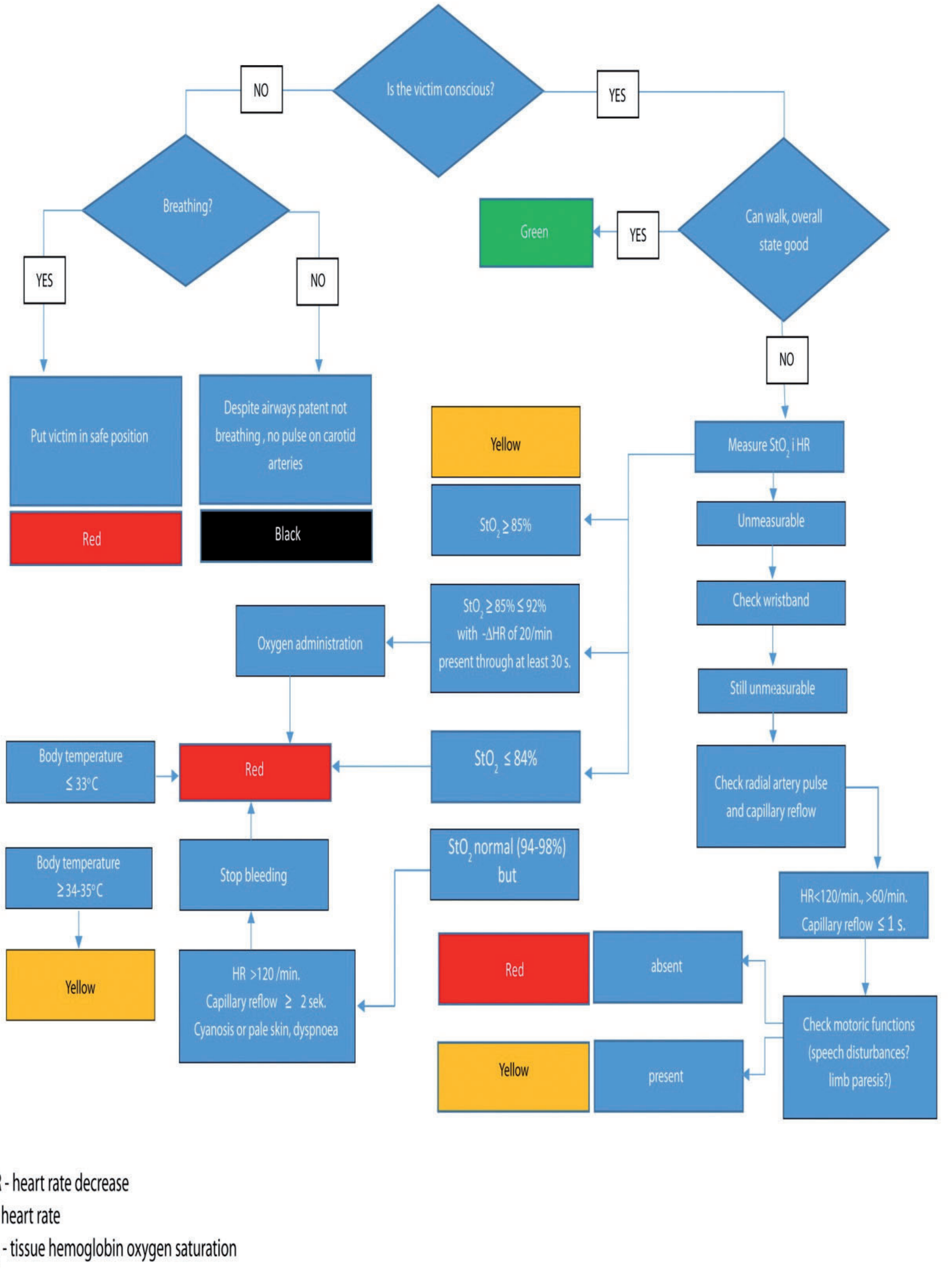

Fig. 7. Verified algorithm for dealing with victims.

In this study it was shown that in most pilots the heart rate increased with the drop of StO_2, up to its value of 85%, and then gradually decreased, which was in line with the beginning of the hypoxia decomposition. The results of the study were included in the developed algorithm as well as the values of StO_2, Δ HR and body temperature. It is worth noting that for the needs of the START system, the very fact of the presence of a measurable heart rate, which allows for the measurement of StO_2 level, is valuable.

The time of useful consciousness for pilots breathing with a low oxygen gas mixture (7.1-7.3% oxygen) - under normobaric conditions, is about 2 minutes longer than that measured in low pressure chamber at a simulated altitude of 7,500 m above sea level (under hypobaric conditions) and is within the range from 4 min 40 s to over 10 min 30 s (average 7 min 20 s to 8 min 10 s). It shows that even in such extremely unfavourable conditions of oxygen shortage, the rescuer providing medical care at the scene of the event would have enough time to administer the necessary oxygen therapy. These facts are included in the proposed triage algorithm.

Studies conducted in a thermal chamber show that the temperature in the range of -15 to +40 degrees Celsius, does not affect the functionality or reliability of the sensors used to determine SpO_2 levels as the subjects were kept at -15°C until the first sensations of cold or light chills (about 16 min), our results could not be used to assess temperature effect on the SpO_2 value of the human body. With longer-lasting cooling of the body, it would be expected that circulatory/congestive hypertension would lead to an additional decrease in SpO_2. Hypothermia is a condition in which the body temperature drops below 36.6 degrees Celsius. Its value below 29 degrees Celsius is life-threatening. For triage purposes, it is worth noting that during therapeutic hypothermia (for the purpose of protecting the CNS), the controlled cooling of the body is kept to a temp of between 32 and 33 degrees for 12 to 36 hours. Taking into account all of the above, it seems that, for the purposes of the START algorithm, if the victim's body temperature is less than or equal to 33 degrees Celsius, he/she requires immediate first aid (covering with a thick blanket, warm jacket, warm tea, etc.) and the band turns red. If the victims' temperature is 34-35 degrees, the band turns yellow. The wristband used in the project has the option to change colour automatically.

In conclusion, further validation of the algorithm, which would allow even more accurate use of the StO_2 and HR values for the triage, would require testing with enforced (breathing a low-oxygen gas mixture) and reduced levels of StO_2 values. The question of how long can an injured person with certain StO_2 values safely wait to receive specialist medical help should be answered. Based on the results of the research and theoretical considerations, we propose a verified algorithm for dealing with victims in mass events, presented in figure 7.

AUTHORS' DECLARATION:

Study Design: Lech Kopka, Ewelina Zawadzka-Bartczak, Krzysztof Kowalczuk, Marcin Piotrowski, Mariusz Krej; **Data Collection:** Lech Kopka, Ewelina Zawadzka-Bartczak, Krzysztof Kowalczuk, Marcin Piotrowski, Mariusz Krej; **Manuscript Preparation:** Lech Kopka, Ewelina Zawadzka-Bartczak, Krzysztof Kowalczuk, Marcin Piotrowski, Mariusz Krej; The Authors declare that there is no conflict of interest.

REFERENCES

1. Cohn SM, Nathens AB, Moore FA, Rhee P, Puyana JC, Moore EE, Beilman GJ. Tissue oxygen saturation predicts the development of organ dysfunction during traumatic shock resuscitation. Journal of Trauma-Injury Infection & Critical Care. 2007; 62(1):44-54.

2. Davis WT, Lospinso J, Barnwell RM, Hughes J, Schauer SG, Smith TB, April MD. Soft tissue oxygen saturation to predict admission from the emergency department: a prospective observational study. American Journal of Emergency Medicine. 2017; 35(8):1111-1117.

3. Golec L. Niedotlenienie wysokościowe. WIML, PTMS, Warszawa 1998:59-61.

4. Leone M. Blidi S, Antonini F, Meyssignac B, Bordon S, Garcin F, Charvet A, Blasco V, Albanèse J, Martin C. Oxygen tissue saturation is lower in nonsurvivors than insSurvivors after early resuscitation of septic shock. Anesthesiology. 2009; 111(2):366-371.

5. Lyon RM, Thompson J, Lockey DJ. Tissue oxygen saturation measurement in prehospital trauma patients: a pilot, feasibility study. Journal of Emergency Medicine. 2013; 30(6):506-508.

6. Smith J, Bricker S, Putnam B. Tissue oxygen saturation predicts the need for early blood transfusion in trauma patients. The American Surgeon. 2008; 74(10):1006-1011.

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SHORT COMMUNICATION

THE INFLUENCE OF RELAXATION TRAINING TECHNIQUES ON PILOTS' LEVELS OF TOLERANCE TO MOTION SICKNESS SYMPTOMS DURING SIMULATED FLIGHT – PRELIMINARY RESULTS

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Introduction: We wanted to assess whether or not relaxation techniques may be useful tools to help pilots with habituation and desensitization, and if they could be used to prevent the symptoms of motion sickness?

Methods: We have decided to use The Motion Sickness Assessment Questionnaire (MSAQ). A MiG – 29 aircraft simulator was used during the testing procedure. The Schultz Autogenic Training procedure was used for relaxation training.

Results: Results: Statistically significant differences were found in the overall score (0,0054 p<0,05) as in some of the factors: Central (0,015 p<0,05) and Sopite-related (0,035 p<0,05). Both the remaining factors exhibited a statistical trend. All the raw scores: overall and factoral ones were lower in the second testing in comparison with the first one.

Discussion: The results show us that a simple, low time-consuming and inexpensive method can possibly be used along other training options to further expand pilots' skills.

Keywords: pilots, relaxation training, motion sickness, simulated flight, air force, military

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NTRODUCTION

We wanted to assess whether or not relaxation techniques may be useful tools to help pilots with habituation and desensitization, and if they could be used to prevent the symptoms of motion sickness [2,3]? Autogenic training gives its user the possibility of achieving autonomic self-regulation. It serves its purpose by removing environmental distractions using a set of easy to learn, accessible exercises. Also, it may be used over a long period of time if needed. The Schultz Autogenic Training is a guided meditation technique in which a narrator's voice guides the user though the process. Autogenic training is based around a few main domains: muscle tension reduction, mental repetition of a verbal formula and passive concentration (the user is instructed to concentrate on inner sensations rather than environmental stimuli) all of which are set to relax both the psychological and the physiological domain [5].

The Schultz Autogenic Training that we utilized is usually performed while sitting or lying down in a comfortable, relaxed position. The technique consists of a few standard exercises:

1. Muscular relaxation: the user repeats a formula (either out loud or in one's thoughts) emphasizing heaviness. Usually something like: "My left hand is heavy" then "my left lower arm is heavy" and so on.
2. Passive concentration on feeling warmth: typically initiated by the instruction "My right/left arm is warm" or "I feel warmth in my arm" and continued all over the body.
3. Initiation of cardiac activity: typically using the "My heartbeat is calm and regular" formula [5].

Motion sickness should be understood as a group of individual symptoms. It starts when a person (a pilot in this case) is exposed to motion stimuli that they are not familiar with. Motion sickness has five main types depending on the type of vehicle it is associated with: sea sickness, car sickness, air sickness, simulator sickness and space sickness. The human centrifuge is a simulator that gives its operators the opportunity to fly with real G-loads, however just like any other simulator, it is not perfect, and sometimes causes motion sickness. Most of the symptoms of all of the above-mentioned motion sickness types are similar and are caused by the same mechanism. The names, motion sickness and i.e. air sickness can be used interchangeably. When there is any inconsistency in the information gathered from the visual and the vestibular system, symptoms may develop. If the information about the pilot's position gathered from the visual and the vestibular system is homogeneous, the symptoms of motion sickness will not occur. The severity of motion sickness may vary among people, individual susceptibility is the most important element in regard of the risk of developing sickness but it is also dependent on the type, strength and duration of the stimulus. The symptoms of motion sickness sum up to a substantially long list of problems which may occur: the main symptom of motion sickness is nausea, a sickness in the stomach, especially when accompanied by sitophobia and an involuntary impulse to vomit. The signs of nausea are: discomfort in the stomach, sweating, pallor, salivation and these all build up to vomiting. Usually, the earliest symptom is discomfort in the stomach. If the situation of uneasiness continues, pallor usually occurs and cold sweating begins. If the stimuli is not eliminated, the patient may experience increased salivation, bodily warmth and lightheadedness. At that point vomiting becomes a possibility [1].

METHODS

Firstly, we assessed which motion sickness questionnaire to use; which one of the possible choices is the most reliable, well established method to use in the specific setting of the human centrifuge. Then came the idea of introducing other types of training, such as relaxation techniques, to the pool of methods to help pilots with their tasks. The questionnaire is the most reliable, well established and easy to use method. We wanted to use the best questionnaire available for our needs. After a careful analysis and assessment of the available questionnaires, we have decided to use The Motion Sickness Assessment Questionnaire (MSAQ) [4]. Because of various levels of English proficiency in our test pilots, we have decided to use the translated version of MSAQ. We planned to test as many jet pilots as possible. During the given time, we tested 8. All the pilots agreed to participate. The test subjects were experienced in flight, all male, between 26-46 years old, active jet fighter pilots. They all had to hold a current, valid permission to fly. The Military Institute of Aviation Medicine ethics committee granted permission for the tests carried out in our unit. The procedure is:

1. First MSAQ testing right after the first test flight.
2. At least 3 weeks of at least 4 relaxation sessions per week before the next phase.
3. Second MSAQ testing right after the second test flight.

A MiG- 29 aircraft simulator was used during the testing procedure. The BFM (Basic Fighter Maneuvers: tactical movements performed by a fighter aircraft during air combat maneuvering) model consisted of:

1. Offensive maneuvers with limited parameters: 6 Gz max, IAS (Indicated Air Speed) up to 400 knots or 740km/h, same altitude flight. The maneuvers performed were: BREAK LEFT, BREAK RIGHT. The aircraft turns left / right, the maneuver consists of turning sharply across the attacker's flight path, to increase the AOT (angle off tail).
2. In the second part of the BFM: max Gz 9, IAS 400-500 Knots at the altitude of 5000-12000 feet. The maneuvers were: HARD BREAK LEFT, HARD BREAK RIGHT. The aircraft turns left / right with maximal flight parameters (speed, Gz, bank angle) with single circle fight, high aspect "butterfly" (the offensive aircraft makes a turn towards the opponent and defensive aircraft to the opposite side with max Gz and bank angle, air combat maneuvering with head on position. After the pass, both fighters may turn to engage) and Yo-yo (variable altitude). Yo-Yo is one of the most useful maneuvers, which sacrifices altitude for an instantaneous increase in speed.

The MSAQ test is shown in its entirety above - we have used the Polish version as previously mentioned.

As for the Schultz Autogenic Training, the entirety of its instruction is in the audio file, together with the procedure. Because of the various English knowledge levels of our test pilots, we have decided to use the Polish version of the recording.

RESULTS

We assessed the results of the group that finished the trial (tested with the MSAQ twice). We used the T-test to see if there are any statistically significant differences in the results before and after the training on the relaxation technique. We tested both the overall scores and the four factors that the test has: Gastrointestinal, Central, Sopite-related and Peripheral. Statistically significant differences in the overall score were found (0,0054 $p<0,05$) as in some of the factors: Central (0,015 $p<0,05$) and Sopite-related (0,035 $p<0,05$). Both the remaining factors exhibited a statistical trend. All the raw scores: overall and factoral ones were lower in the second testing in comparison with the first one.

CONCLUSION

The results show that there is a statistically significant difference between some of the factors measuring the severity of motion sickness after training with the relaxation technique. What it shows us is that a simple, low time-consuming and inexpensive method may be used along other training options to further expand pilots' skills. The results shown were gathered from a small group of subjects that definitely should be broadened. However, the promising results should encourage to continue testing such methods on bigger groups of pilots in the near future as we already intend to do.

AUTHORS' DECLARATION:

Study Design: Michał Janewicz, Krzysztof Kowalczuk; **Data Collection and Analysis:** Krzysztof Kowalczuk, Michał Janewicz, Zofia Przymus, Tadeusz Grzeszuk, Robert Kilian, Stefan P. Gaździński; **Manuscript Preparation:** Krzysztof Kowalczuk, Michał Janewicz, Zofia Przymus, Stefan P. Gaździński; **Funds Collection:** Krzysztof Kowalczuk. The Authors declare that there is no conflict of interest.

REFERENCES

1. Ernsting J, Nicholson AN, Rainford DJ. Aviation Medicine. CRC Press 1999.
2. Golding JF. Motion sickness susceptibility. Autonomic Neuroscience. 2006; 129(1-2):67-76.
3. Kennedy RS, Fowlkes JE, Berbaum KS, Lilenthal MG. Use of a motion sickness history questionnaire for prediction of simulator sickness. Aviation, Space, and Environmental Medicine. 1992; 63(7):588-593.
4. Kennedy RS, Lane NE. Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. The International Journal of Aviation Psychology. 1993; 3(3):203-220.
5. Linden W. Autogenic Training: A narrative and quantitative review of clinical outcome. Applied Psychophysiology and Biofeedback. 1994; 19(3):227-264.

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Book, editor(s) as author

Norman IJ, Redfern SJ, eds. Mental health care for elderly people. New York: Churchill Livingstone; 1996.

Book, Organization as author and publisher:

Institute of Medicine (US). Looking at the future of the Medicaid program. Washington: The Institute; 1992.

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