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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 • **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

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

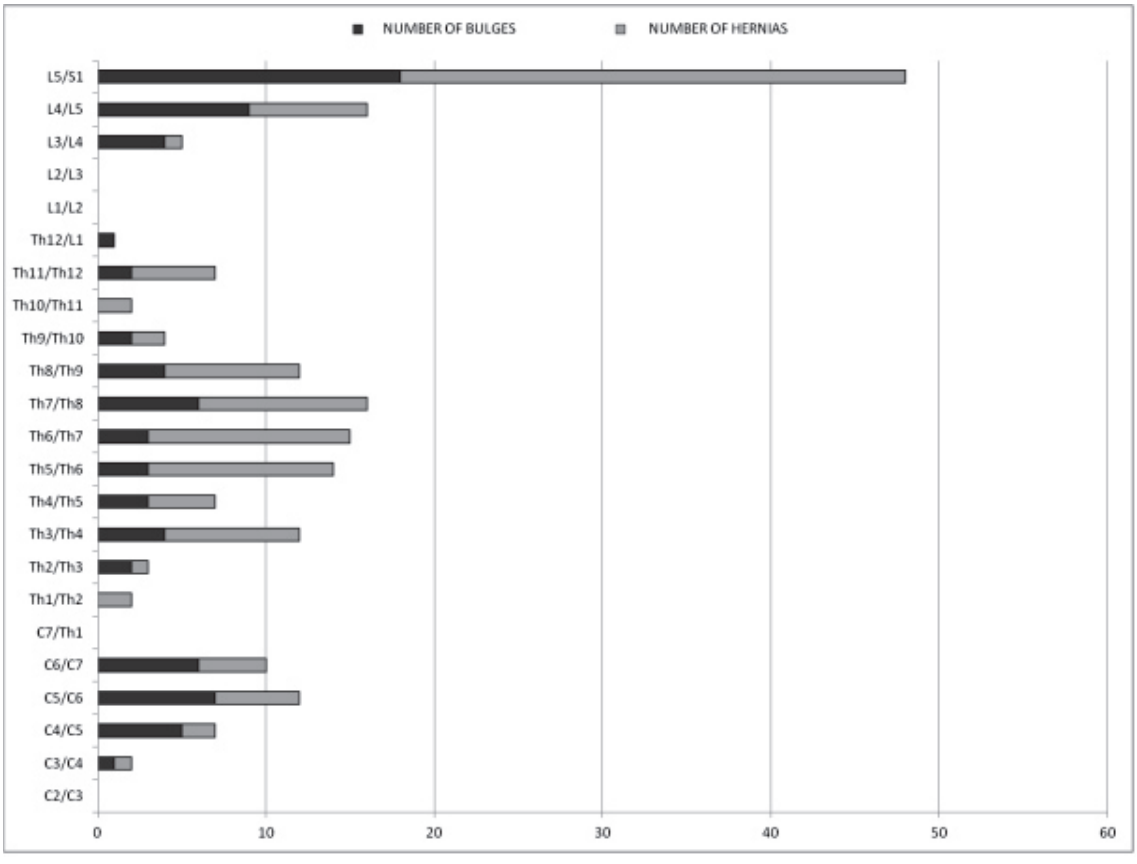

Fig. 1. Frequency of occurrence/number of bulges and hernias and their location in the spine.

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.

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