

Incidence of cervical and lumbar spine injuries in Brazilian air force helicopter pilots

Abstract

This paper is a brief analysis of the incidence of pain and discomfort caused by flying rotary-wing aircraft. This is due to the excessive vibration exerted by the rotors on the pilot's seat, which is absorbed by the pilot's spine, and the posture adopted by the pilot during the flight due to the layout of the controls. Air forces from various countries such as Israel, Sweden, England, among others, have considered low back pain to be a primary health problem in airmen and admit that this type of problem is detrimental to flight safety, given that the pain acts throughout the flight and can appear at a level that distracts the pilot. The aim of this study was to clarify the incidence of pain and discomfort among rotary-wing pilots in the Brazilian Air Force. To help carry out the study, an online questionnaire with multiple-choice, scale and full answer questions was used, answered by 124 aviation officers belonging to the Brazilian Air Force. Corroborating previous research in this area, we identified that the main discomforts are related to the position of piloting the aircraft, mainly located in the region of the spine. Most of this discomfort lasts from a few minutes to a few hours. The main preventative methods used by helicopter pilots are related to strength training. Thus, we can infer the awareness of pilots and authorities of the importance of physical exercise, thus inferring an important preventative measure.

Keywords: spine, pain, pilots, rotating wings

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Introduction

The incidence of pain and discomfort in people can be a risk to their health and to their professional activities. According to a study by Wosiack,¹ around 80% of the world's population suffers from spinal pain. In addition to the elderly, research also reports an increase in complaints among active workers.²

According to Strauss, maintaining a good state of health for pilots is related to physical conditioning compatible with the demands of their activity, duration and quality of flight, contributing to favorable conditions for increasing resistance to flight fatigue. Figure 1 shows some of the most frequent disorders related to military pilots.

Gz force

The effects of acceleration forces on the body are caused by rapid changes in speed and direction of movement in airplanes and often affect the body during flight. Each time the plane makes a turn, the centrifugal force is determined by the following relationship: $F = \frac{mv^2}{r}$

Where F is the centrifugal acceleration force, m is the mass of the object, v is the speed of travel and r is the radius of curvature. The force is inversely proportional to the closure of the curve; the smaller the radius, the greater the centrifugal force. Figure 2 shows the Gz force vectors that can enter the pilot's body during a military flight.

Spinal injuries in helicopter pilots

Flying helicopters, according to Thuresson, Ang and Ringdal,⁵ provides favorable conditions for spinal pain due to the posture adopted by the pilot throughout the flight, the strong vertical vibration and the layout of the controls of this type of aircraft.

According to research by Bridger et al.,⁶ and Sharma and Agarwal,⁷ low back pain comes first, followed by neck pain as the most frequent problems of spinal pain. Low back pain (pain in the lower back) is one of the most common back problems in Western society, affecting approximately 80 to 85% of the population.⁸ Many countries, such as the United States, Norway and Israel, have invested in research into the occurrence of low back pain in their airmen and have come to

consider it a primary health problem, which has a major influence on flight safety and the operability of the Air Forces.⁹⁻¹³ In the Norwegian Air Force, low back pain is considered to be a primary health problem among rotary-wing pilots and somewhat less serious among other crew members, with the most important etiological factor being the asymmetrical posture adopted by this class of pilots.¹³

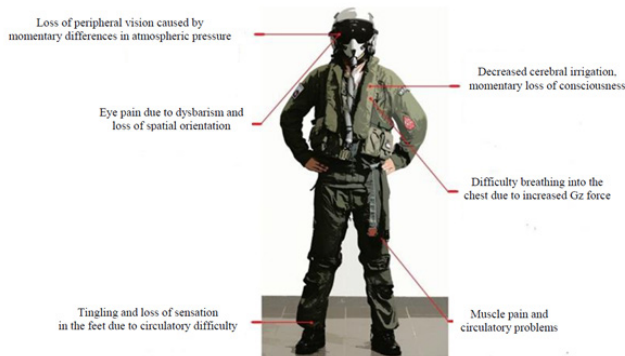


Figure 1 Frequent disorder in military pilots.

Source: Bezerra.³

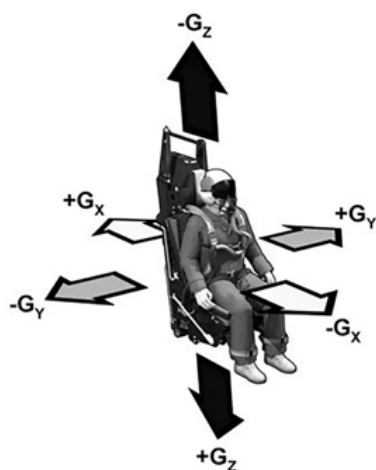


Figure 2 Gz force vectors.

Source: Bezerra.⁴

This asymmetrical posture refers to the one that helicopter pilots are forced to adopt during flight (trunk tilted forward and rotated to the left) due to the arrangement of the flight controls (cyclic and collective). Cervicalgia is a type of musculoskeletal problem which, according to Fejer, Kyvik and Hartvigsen,¹⁴ affects around 50% of the world's population. It is well known how common cervicalgia is in fighter pilots. However, cervicalgia also affects helicopter pilots (HP) on a large scale, as evidenced by a study carried out in the Swedish Air Force by Ang and Harms-Rindahl.¹⁵ Bongers et al.,¹⁶ carried out a study with 100 PHs and 297 officers from the Dutch Air Force who worked in office services (comparison group-GC). The prevalence of back pain recorded by age group was 80% for PH against 12% of CG, for ages under 25; 57% (PH) and 19% (CG), for ages 26 to 35; 80% (PH) and 23% (CG), for ages 36 to 45; 48% (PH) and 25% (CG) for ages 46 to 55.

Lately, neck pain in helicopter pilots has been recognized as a significant medical problem in modern air forces, with an estimated prevalence of around 50% over a 3-12 month period.^{6,15} Experimental results and subjective evaluations show that head and torso postures

in the cockpit are significant for neck muscle load⁵ and back pain.⁶ Normally, the helicopter pilot sits leaning forward with the torso and shoulder turned slightly to the left, in order to control the cyclic control of the flight with the right arm. The left torso and shoulder are lowered slightly to grasp collective control, while the feet continuously control the rudder pedals. Maneuvering the helicopter thus requires precision work from all four extremities in bad postures during all phases of flight. In addition, helicopter pilots increasingly use helmet-mounted vision enhancement technology during night missions, increasing the workload on the neck⁵ and contributing to neck pain.¹⁵

Although pilots on flying duty represent a relatively homogeneous group, with similar selection and training procedures and, to a large extent, the same work-related exposure, an important question is why some pilots have recurrent episodes of neck pain and others do not. The Brazilian Air Force has a wide variety of rotary-wing aircraft (helicopters): H-50, H-1H, H-60, H-34, VH-35, MI-35 M, VH-36, Sikorsky S-70 HM-2 Black Hawk (Figure 3).

Figure 4 shows the most common areas of spinal injury in helicopter pilots.



Figure 3 Sikorsky S-70 HM-2 Black Hawk.

Source: armasnacionais.com/2021/12/s-70a-black-hawk-no-exercito-brasileiro.html

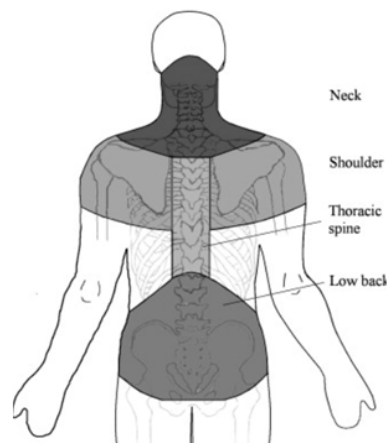


Figure 4 Most common regions of spinal injuries in Helicopter Pilots.

Source: Bjorn.

This work is justified by the importance that several countries have given to the study and research of this type of dysfunction, given that these problems can affect operability and also generate costs in terms of medical treatment. In addition, the high rate of absences and injuries can generate costs related to the replacement of personnel, and in the case of injuries, it can even have a very negative influence on flight safety, due to the detour of attention caused by the pain that the pilot feels during the operation. The aim of this study is to demonstrate the importance of injury prevention in PH. This information can be useful in minimizing the rate of absences, thus contributing to society, which includes the Brazilian Air Force. The aim of this study was therefore

to analyze the incidence of pain and discomfort related to helicopter flying in pilots of the Brazilian Air Force.

Methodological procedures

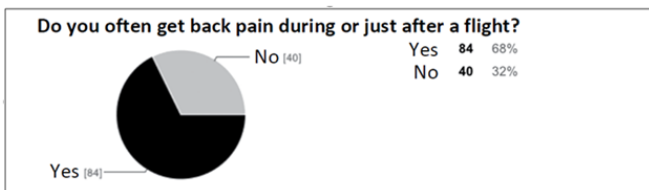
This descriptive study was carried out using a quantitative approach and qualitative data to support the discussions. The data collection instrument used was a questionnaire applied to 124 officers of both sexes belonging to the Brazilian Air Force in 2023.

This questionnaire was made up of closed and open questions covering - the duration of pain after a helicopter flight. With regard to the questionnaire, the first question asked whether pilots experience back pain after flying. The second question asked about the duration of the pain after the flight. The third question asked about the intensity of the pain. The fourth question concerned location (body region affected after flight). The fifth question asked about the use of night vision goggles (NVG). The NVG is a piece of equipment widely used in aviation, which allows pilots to see better in the absence of light, and it was asked whether the use of this equipment can generate neck pain in pilots.

The questionnaires were administered using the “Google Docs” application with multiple choice answers, a scale of zero to ten (zero = no pain, ten = very intense pain) and an image to associate with the location of the pain. As a prerequisite to guarantee the study’s purposes, only Helicopter Pilots (HP) with a minimum of six months in this specialty answered the questionnaire. The research was carried out in accordance with the criteria of Resolution 196/96 of the National Health Council/MS, of 10/10/1996.

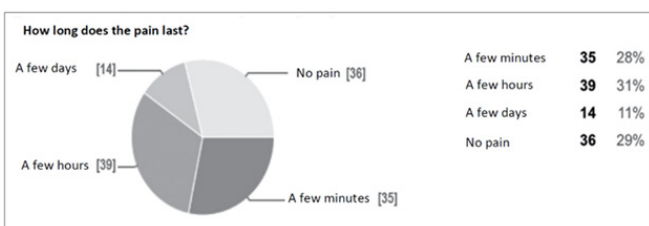
Results

The first question asked whether pilots felt back pain after flying. Graph 1 shows that 84 pilots (68%) experience back pain after flying, confirming our first hypothesis. The second question concerned how long the pain lasted. The subjects had four options: a few minutes, a few hours, a few days and no pain.



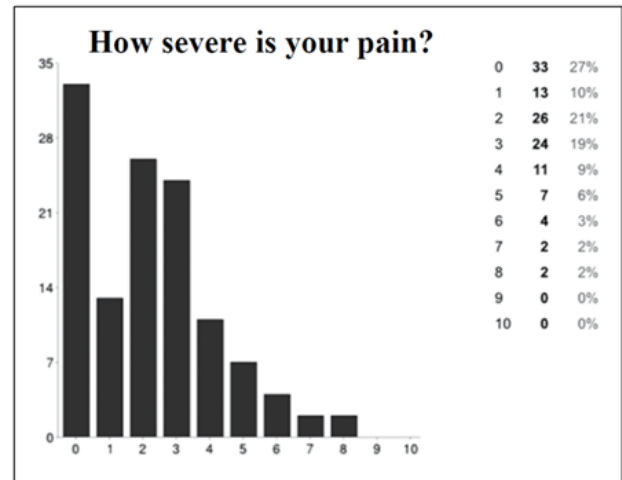
Graph 1 Existence of pain.

In Graph 2 we can see that 36 PHs marked the option “I don’t feel pain”, while the answer “a few days” was selected by 14 PHs, 39 PHs marked “a few hours” and 35 pilots chose the option “a few minutes”. The third question was designed to investigate the intensity of the pain. The answer was based on a scale of zero to ten, where zero meant that the pilot felt no pain and ten meant that the pain was extremely intense.



Graph 2 Duration of pain.

According to Graph 3, we can see that the intensity of the pain was diagnosed in a large proportion up to grade 3 (77%) on a scale of 0-10. We can therefore infer that these discomforts may, despite being minimal, pose significant risks to helicopter piloting. The survey also provided the opportunity to check the location of the pain.



Graph 3 Intensity of the pain.

An image of the human body divided into various numbered regions (Figure 5) was used as an aid to answering. Of all the subjects analyzed, 28 pilots didn’t answer the question and another six said they didn’t feel pain. It is worth noting that some pilots reported feeling pain in more than one region (Graph 4).

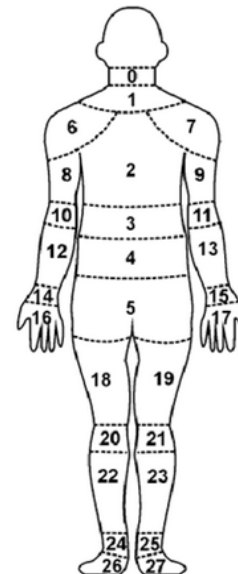
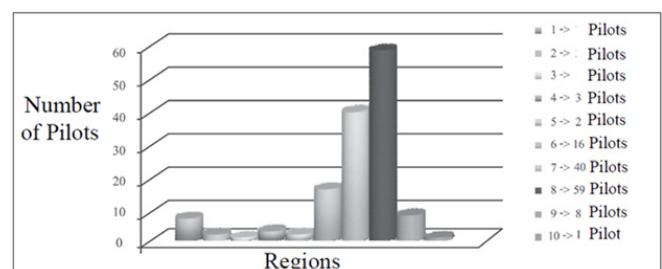


Figure 5 Pain regions.



Graph 4 Regions with the highest incidence of pain.

In which of these areas do you feel pain?

The fifth question asked about the use of night vision goggles (NVG). The NVG is a piece of equipment widely used in aviation which allows pilots to see better in the absence of light. It amplifies brightness by up to 50,000 times and, together with the light emitted by the moon and stars, enables night flying, which is poor in visual references.

Night vision is a precision electronic instrument used to observe the target at night and twilight. In order to find yourself in a very low light intensity, night vision with infrared irradiation light source, turn on the power switch, you can adjust its brightness by switching. NVG10 is a night vision comes with infrared laser irradiated light source. Under bright and dim light shows color and images while the black and white image in the dark with green display option. The prolonged use of this equipment by pilots can cause discomfort due to its weight (approximately 5 kg - the model used by the Brazilian Air Force). Therefore, the question in this regard is to find out a little more about what the pilot says about its use.

Of the 124 PHs in this survey, two did not answer this question. We saw that 53 pilots (43%) have used this equipment frequently, while 69 pilots (56%) do not use it frequently. Of the pilots who have used this equipment, 21 subjects said they felt pain in the cervical region after flying.

Question six aimed to analyze whether the pilots resorted to some kind of treatment to ease the pain caused by flying and which treatments were most commonly used. From the results, we can see that most pilots do not use any treatment for pain ($n=79$). Among the treatments that are carried out, the most popular is physiotherapy ($n=18$) followed by pilates ($n=10$), weight training ($n=7$), stretching ($n=6$) and swimming ($n=4$). There were also answers with "other alternatives" made up of the following: massage therapy ($n=1$), osteopathy ($n=1$), chiropractic ($n=3$), medication (1 pilot), various physical activities ($n=3$), yoga ($n=1$). Eight subjects did not answer this question. It's important to note that some subjects said they underwent more than one type of treatment.

Question seven was formulated with the intention of identifying the treatment for back pain with the help of weight training in the prevention of pain and discomfort and its effectiveness. The result was that 67 of the pilots questioned do not use weight training as an alternative for prevention, while 46 do. Of these 46, only one reported not having noticed any improvement with the treatment. We also noted that eleven subjects did not answer this question.

Discussion

It is extremely important to raise awareness of the degree of occurrence of spinal injuries, at different levels of severity, due to various aspects of helicopter flight, such as the posture adopted by the pilot throughout the flight and the vibration that the pilot's spine absorbs, so that the authorities can invest in studies and preventive methods. This study addresses this problem. The first diagnosis confirms the initial hypothesis of the study, that flying aboard rotary-wing aircraft causes pain in pilots. The hypothesis was confirmed when 68% of the survey respondents said they felt pain after flying. As mentioned earlier, according to Thuresson, Ang and Ringdal,¹⁵ this pain is due to the slightly tilted position to the left that the pilot adopts throughout the flight, due to the position of the controls and the vibration of the rotor, which is largely absorbed by the pilot's spine. The duration of this pain varies greatly. In most cases, it lasts from minutes to hours. Its intensity can be said to be low in the vast majority

of cases. When analyzing the regions with the highest incidence of pain, it can be seen that the most affected regions are the thoracic and lumbar spine.

Several studies show a higher prevalence of low back pain in pilots when compared to the general population.^{10,17} The Air Forces of several countries, such as England, the United States, Japan, Canada, Iraq, Spain, Israel, India, Norway, Sweden, among others, have considered low back pain in pilots to be a primary health problem, given its great influence on the operational capacity of the Force. In addition, this pain has been considered a factor in reducing flight safety, since it can distract the pilot and cause an aeronautical incident or accident.⁹⁻¹³ Low back pain can alter the economic, administrative and operational aspects of a flight squadron, making it necessary to study this dysfunction in greater depth.

A survey of 131 military helicopter pilots was carried out in Australia, in which 16% reported regular low back pain (LBP) associated with flying, 28% complained of back discomfort and 39% reported that they experienced LBP occasionally. Of these, 85% mentioned that they felt pain during or after the flight and stated that the cause of the LBP was related to the flight.¹¹

In a survey of 174 general aviation pilots (flight instruction, freight operations, air cab, small cargo transport operations, private and sports flights) from 45 airfields in the UK and Ireland, 53% reported feeling pain or discomfort in some area of the spine.¹⁸ According to Bongers et al.,¹⁶ this position requires a great deal of effort from the paravertebral muscles. It is worth noting that several authors state that approximately 80% of LBP cases are related to weakened paravertebral muscles. These same authors agree that only specific exercises can strengthen these muscles and prevent and treat this disorder.^{9,19-23}

This consensus is corroborated by Da Silva²⁴ when he verified that the fact that his sample was physically active did not influence the prevalence of LBP and, in another study, Da Silva²⁵ compared two groups of FAB PH ($n=77$) for a period of 12 weeks, where the experimental group (EG) carried out a specific program to reduce LBP ($n=38$) and the comparison group (CG - $n=39$) carried out generalized exercises (physical education classes), and found a 36% reduction in the pain levels of those who carried out the specific exercise program when compared to the group that did not.

In a study carried out in the Aeromobile Forces of the Spanish Army, around 78% of the PHs said they felt back pain or vertebral algia (VA) while performing aerial activities, 60% of whom mentioned that the pain occurred in the lumbar region.¹²

Froom et al.,¹⁰ in a study of 373 fighter pilots (PC), 264 helicopter pilots (PH) and 165 transport pilots (PT), all from the Israeli Air Force, observed that the PH had a prevalence of chronic LBP (constant pain, requiring long periods of rest and radiating to the legs), similar to the transport pilots and that the PC had about twice the prevalence of chronic LBP when compared to the transport and helicopter pilots. On the other hand, PHs had a prevalence of 34.5% compared to 12.9% of fighter pilots and 4.8% of transport pilots with regard to LBP perceived during or immediately after the flight (recurrent LBP).

According to Bowden,²⁶ one possible explanation for this result could be the high load that the structures of the spine are subjected to as a result of the high speed and the force of gravity that occurs during maneuvers in a fighter jet and which possibly results in permanent damage to the spine, causing chronic pain.²⁴ However, although helicopter vibration is more persistent, the load is less severe, and the

great strain on the spine is due to posture and vibration, causing pain during or immediately after the exercise of aerial activity and ceasing after a period of between one and two hours of rest (recurrent pain).

As far as treatments are concerned, the most commonly used involve strengthening the muscles in the area, such as physiotherapy, weight training and Pilates. It is worth highlighting the role of weight training as a treatment method for pain, given that of the 46 airmen who used this type of treatment, only 1 pilot reported not having noticed any improvement.²⁷

Conclusion

From the questionnaire, we can draw some conclusions about the effects of rotary-wing aviation on pilots' spines. Finally, it can be concluded that pain in the cervical and lumbar spine has been a constant in the lives of pilots and it is a fact that it can hinder their performance in air missions.

Therefore, it is of great value for the Brazilian Air Force, as well as for all other institutions that have HFs, to offer their airmen adequate conditions for prevention and treatment which, as diagnosed in this study, can be through strength training (weight training). The possibility of having physiotherapists who work with Global Postural Re-education (GPR) in Military Organizations (OM), or a professional trained to teach Pilates classes, or even a physical education professional who draws up a workout and accompanies the aviation officers during weight training activities in a well-structured gym within the Military Organizations, are low-cost and highly effective alternatives, thus making a difference to the pilots' quality of life and operational routine.

Acknowledgments

None.

Conflicts of interest

The author declares that there is no conflict of interest.

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