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RESEARCH ARTICLE

EVALUATION OF SENSORINEURAL DISCOMFORT IN BRAZILIAN AIR FORCE PILOTS CAUSED BY IN-FLIGHT KINETOSIS

Thiago A. Rochetti Bezerra[1,2], Alexandre D. Vivas[2], Júlio E. Calheiros[2], Caroline P. Golin[2], Eliza F. Prezotto[2], Juliana F. B. Paschoal[2], Thalita P. M. Alineri[2], Délio T. M. Malaquias[2], Luiz Rodolfo T. Silva[2], Samantha R.G. Sanches[2], Ana Carolina P. Bergamin[2], Charline C. Casaril[2], Leonardo T. Silva[2], João Paulo P. Santos[2], Talita R.Q. Lopes, Elton L. F. Oliveira[2], Isadora O. Soler[2], Diego P. Mariz[2], Adriana F.V. Delgado, Larissa O. Santos[2], Caio V. Sá Bertozzi[2], Lorenza R. Galvan[2], Liliana M. Occulate[3], Pedro N.S. Costa[4]; Thiago G. Trigueiro[4] and Hiromi M.K. Fujishima[4]

1. Graduated in Physical Education, Federal University of São Carlos, PhD in Medical Sciences, Ribeirão Preto Medical School, Ribeirão Preto, São Paulo, Brazil, 1º Lieutenant of the Brazilian Air Force Academy.
2. Medical Student. University of Ribeirão Preto. Guarujá, São Paulo, Brazil.
3. Medical Student. Universidad Central del Paraguay, Paraguay.
4. Medical Student. Potiguar University. Natal. Rio Grande do Norte, Brazil.

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Abstract

In-flight kinetosis (aerokinetosis) is a normal physiological response to the perception of unusual movement, occurring frequently in airmen. The aim of this study was to investigate the prevalence of aerokinetosis among cadet aviators in the Brazilian Air Force, their search for medical treatment and the influence of symptoms on their performance. To this end, a cross-sectional prevalence study was carried out, based on a questionnaire created by the researchers. The airmen (cadets) answered objective questions individually. The number of cadets assessed was 186. The average age was (22.5±1.8) years, with the majority being male n=174. The small number of women does not allow us to infer a comparison between the sexes. The number of cadets diagnosed with aerokinetosis was 112 (60.2%), while in international studies it ranges from 10% to 39%. The maneuvering and acrobatics phase had the highest incidence of aerokinetosis, cited by 75 of the 186 cadets. Of the 112 cadets diagnosed with aerokinetosis, 37 reported that their performance was affected on a mission, and of the cadets who showed symptoms, 91% sought medical assistance after the crisis. Among those who had already undergone some form of treatment (n=102), 98 cadets used medication, 58 reported using trampoline exercises prescribed by their doctor and 2 were treated with acupuncture. Only 35 cadets reported improvement after some kind of intervention. Most of them did not undergo specialized treatment, even though their performance was impaired during their flight routine.

Corresponding Author:- Thiago A. Rochetti Bezerra
Address:- Graduated in Physical Education, Federal University of São Carlos, PhD in Medical Sciences, Ribeirão Preto Medical School, Ribeirão Preto, São Paulo, Brazil, 1º Lieutenant of the Brazilian Air Force Academy.

Introduction:-

Kinetosis: the movement syndrome

The pathogenesis of kinetosis is not fully understood, but the most widely accepted explanation today is the sensory conflict theory (SHUPAK; GORDON, 2006; SCHMÄL, 2013).

Nerve impulses pass from the inner ear to the center of the bulb, causing nausea and vomiting (TORTORA, 2000).

Tortora (2000) states that kinetosis is a functional disorder generated by excessive movements and sudden accelerations, such as exposure to gravitational load (G) or the imposition of high speeds, excessively stimulating the vestibular apparatus.

Salmito (2018) explains that motion sickness is the result of incompatible perception of movements between the eyes and the labyrinth, one of the parts of the ear that detects body movements. This mismatched information is described when the labyrinth perceives movement, but the eyes indicate that the body is stationary.

Aerokinetosis

Basically, aerokinetosis is a variation of kinetosis that occurs in aircraft (TEMPORAL, 1995).

Schmäl (2013) explains that it is a physiological reaction that occurs universally due to the perception of unusual movement, bringing strangeness to the organism, and can occur as a response to exposure to aerial activity.

Temporal (1995) explains that aerokinetosis is often referred to as altitude sickness and agrees that, in a general sense, this relationship exists because the absence of firm ground increases the range of possible movements. It is also mentioned that in the past, when aerospace medicine was not so developed, the term "air sickness" was identified as a type of vertigo and used as a diagnosis for most of the symptoms that pilots were not used to feeling.

Vestibular system

Tavares, Santos and Knobel (2008) state that the vestibular system (VS) is responsible for the onset of kinetosis symptoms, due to the sensory conflict between it and vision, the parts of the body responsible for balance and orientation.

It is characterized by informing the sense of angular accelerations on the body, and all the information it absorbs is sent to the Central Nervous System, where it is analyzed and processed (TAVARES; SANTOS; KONOBEL, 2008).

The VS is basically made up of the semicircular canals, saccule and utricle (FIGURE 1). The utricle is arranged horizontally, while the saccule is vertically, both having a sensory region called the macula, a place covered in cilia where otoliths (calcium carbonate crystals) are attached. The action of this region is based on the inclination of the thousands of cilia that occurs when there is the action of gravitational force or any other acceleration to which the body is subjected. For example, when someone starts to move forward, the cilia are displaced backwards, due to the inertia of the otocytes, causing a kind of controlled imbalance in this direction, causing the person to move forward. In this way, it is possible to determine the position of the head in relation to the forces acting linearly on it (JANUÁRIO; AMARAL, 2010).

The semicircular canals are ducts through which the fluid called endolymph moves, which is responsible for moving the cilia. They are arranged in three different orientations (anterior, posterior and lateral) which are vertical to each other. They act by forming three basic patterns of impulses that are sent to the brain, based on the movement of the cilia in the ampullae of the canals: when the head is moved to the right, the cilia move to the left; when the head is moved to the left, the cilia move to the right; when the head remains still, the pattern informs stagnation (JANUÁRIO; AMARAL, 2010).

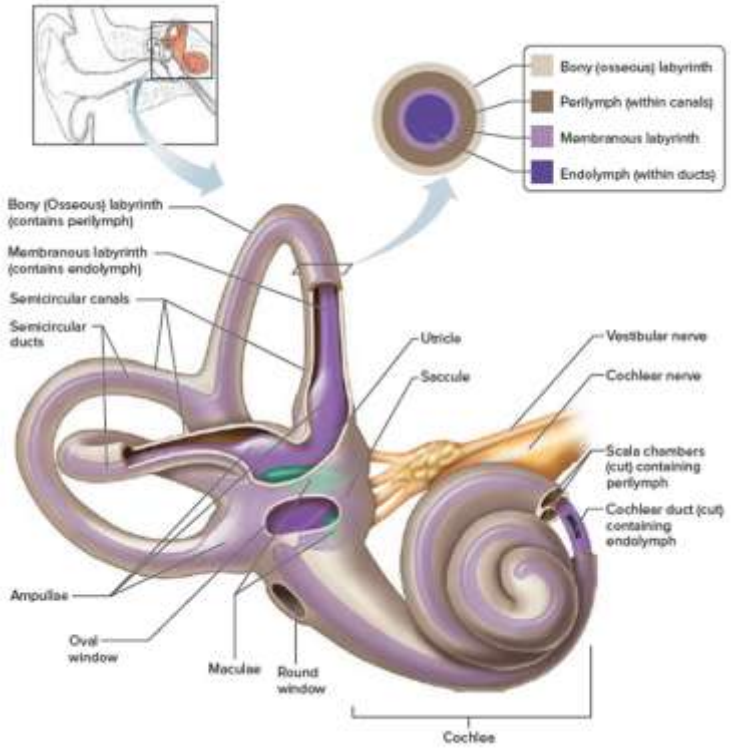

Figure 1:- Structures linked to the Vestibular System
Source:healthjade.net/vestibular-system.

The vestibulo-ocular reflex. A rotation of the head is detected, which triggers an inhibitory signal to the extraocular muscles on one side and an excitatory signal to the muscles on the other side. The result is a compensatory movement of the eyes (FIGURE 2) (TORTORA, 2000).

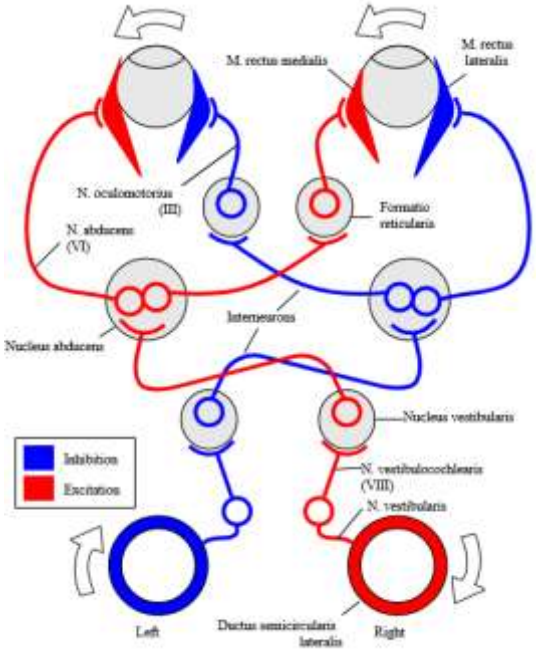

Figure 2:- The vestibulo-ocular reflex.
Source: healthjade.net/vestibular-system/

Aerokinetosis symptoms

The symptoms of aerokinetosis are quite varied and are divided into two types: subjective and objective. Subjective symptoms are those that indicate that the passenger may be experiencing bad feelings due to the movement and that involve emotional aspects, such as anxiety and nervousness. In this type, the first sign to appear is gastrointestinal dysfunction, since this system of the body is one of the most primitive and is usually one of the first to react to emotional disturbances. This dysfunction leads to nausea, which often makes the skin feel clammy and often progresses to vomiting, which brings relief for a short time. As this situation progresses, there may be signs of increased emotional and muscular tension, the latter being mainly responsible for the great prostration that takes over the body when tensions are replaced by a feeling of greater relaxation. All these factors together lead to an unpleasant, generalized somatic state. In terms of objective symptoms, the preceding signs are pallor and cold sweats, mainly on the face. When these characteristics are present, there will probably be a progression to vomiting and muscle weakness. In addition, there is a predominance of an appearance of illness, an increase in blood pressure and heart rate, signs that return to normal some time after the crisis (TEMPORAL, 1995).

Aviator cadets who are in the second year of the Brazilian Air Force's Aviator Officer Training Course (CFOav), take a basic military piloting course in the Second Air Instruction Squadron (2º EIA) with the T-25 UNIVERSAL (FIGURE 3) aircraft. In this phase of flight training, the cadets develop the individual qualities of military pilots. The phases of flight training are; maneuvers and acrobatics (MAC), graduation flights and navigations. During flights, some cadets face a problem related to the fact that they experience symptoms caused by the movement of the aircraft, which affects the systems responsible for maintaining the balance of the human body (vestibular system, vision and proprioceptive system). In some cases, these symptoms affect air instruction (BEZERRA et.al, 2014).

Figure 3:- Airplane T-25 Universal.
Source: AFA

Effects of Aerokinetosis on the training of the Cadet Aviator

During the second year of the course (CFOav), once the cadet has learned about the structure of the aircraft, the procedures to be carried out during flight and how to deal with crashes during military flight missions, he begins to come into contact with practical aviation learning.

The cadet suffering from aerokinesis, in addition to worrying about the intrinsic (aircraft handling) and extrinsic (environmental conditions) factors that are present in the flight, must remain focused so that the symptoms do not affect his performance on the mission, making his flight deficient.

Objectives:-

- ✓ To identify the prevalence of Aerokinetosis symptoms among cadets undergoing aviation training in the Brazilian Air Force.
- ✓ To verify the incidence of cadets affected by aerokinetosis.
- ✓ To verify the symptoms that have an impact on flight learning.

Methodology:-

Ethics committee

Ethical considerations were based on scientific purposes, with the cadets' identities being respected, free from coercion or conflict of interest on the part of the institution or individuals involved in the project. Collections complied with technical safety protocols. The volunteers were informed in advance of their express consent on a specific form (Informed Consent Form - ICF), in accordance with CEP resolution 196/96. Report Number: 1.015.756 Date of Report: 14/04/2023, CAAE: 40667114.7.0000.5504.

Location
The work was carried out at the Brazilian Air Force Academy in Pirassununga, state of São Paulo, Brazil, with due authorization from the Commandant of the Academy.

Of the 140 cadets, 46 male aviator cadets from the 2nd year of training in 2023 with symptoms of aerokinetosis were selected and randomly assigned by lot.

The experimental group for this study was cadet aviators from the Brazilian Air Force (FAB). It was characterized by an epidemiological investigation of a quantitative and exploratory nature, verifying the prevalence of aerokinetosis in FAB aviator cadets.

A questionnaire was applied with questions about the incidence of the effect of aerokinetosis in flight on the health of cadets, related to the objective of the study.

Questionnaire
Objective questions were asked to investigate the existence of symptoms characteristic of kinetosis and factors associated with possible episodes, such as interference with performance during flight and whether or not treatment had been carried out. The questions were as follows: During your flights at the 2nd EIA, did you suffer from any effects of aerokinetosis?; What symptoms of aerokinetosis did you experience during your flights?; At what stage of the flight did the symptoms of aerokinetosis start?; Did you have your instruction impaired after suffering from aerokinetosis?; Did you have your flight aborted because you were unable to continue with the mission? When you discovered that you were suffering from aerokinetosis, did you go to the squadron doctor for treatment? What did you try to do to alleviate the effects of aerokinetosis? Did the measures adopted to alleviate the effects of aerokinetosis contribute to any improvement?

Results:-

Profile of the study population
186 cadets answered the questionnaire, 12 of whom were female and the rest male. The average age was (22.5±1.8) years. The average amount of instruction in practical flying lessons was 86.15 hours.

Prevalence and symptoms of Aerokinetosis in the study population
Of the 186 individuals, 112 were diagnosed with aerokinetosis (60.2% of all interviewees). Among the cadets diagnosed with aerokinetosis, 21 (18.7%) presented excessive sweating, 3 (2.6%) yawning, 5 (4.4%) excessive salivation, 82 (73.2%) nausea, 95 (84.8%) vomiting, and 5 (4.4%) other symptoms.

Aerokinetosis interferes with aeronautical performance
Of the cadets who presented aerokinetosis (n=112), 56 (50%) presented the symptoms in the ground and pre-ground phase, 11 (10.1%) in the graduation phase, 75 (66.9%) in the Maneuvers and Acrobatics (MAC) phase, and only 2 cadets (1.7%) in the navigation phase. Of these, 68 (60.7%) cadets reported that their instruction had been hampered by aerokinetosis, and 37 (33%) aborted their mission due to the symptoms.

Regarding knowledge of Aerokinetosis, 91% of the cadets said they were aware of it and 9% said they were unaware of the symptoms.

When complementing the previous question by asking how many flights the symptoms occur on, 28% showed some kind of symptom during a flight instruction, followed by 26% who showed symptoms on 3 flights, 22% showed symptoms on 2 flights, 13% always showed symptoms and 11% showed symptoms on 4 flights.

When asked which maneuver caused the most symptoms of aerokinesis, it can be seen that the phase of flight with the highest incidence of symptoms was the screw maneuver, with 33%, followed by the curve and others with 29%, and level flight with 9%.

According to question five, which asks whether in some of the flights, the symptoms could hinder the pilot's performance, 61% answered that the symptoms of kinetosis hindered their performance, and 39% said that they were not hindered by the symptoms.

Of the 39% of respondents who said their performance had been impaired by the symptoms of aerokinetosis, all reported symptoms on 2 flights, 28% on 1 flight, and 11% said they had been impaired on 3 flights, 4 flights or more and always.

When asked if any flights were aborted because they were unable to continue with the mission, even though the results show that the symptoms of aerokinetosis hinder pilots, only 4% had their flight aborted because they were unable to continue with the mission, while 96% continued with the mission.

Regarding seeking medical assistance after a kinetosis attack, even though it is a worrying syndrome for flight safety, of the 46 cadets selected, only 63% sought medical assistance after an aerokinetosis attack, while 37% chose not to seek medical assistance or preferred to undergo treatment on their own.

When asked about the treatment of kinetosis symptoms, 35% said they were undergoing some kind of treatment, and 65% said they were not undergoing any kind of treatment.

When seeking treatment to understand and alleviate the symptoms of aerokinetosis, only 35% sought medical help, while 65% of the participants said they had not sought specialized help

For the eleventh question, some options were presented for measures used to alleviate symptoms during the flight. Of the participants, 76% reported having done exercises prescribed by their doctor, 21% reported having sought other forms of treatment, 3% sought help through acupuncture and there was no search for physiotherapy or psychotherapy.

Aerokinetosis and the search for treatment

Of the cadets who reported aerokinetosis, 91% sought medical assistance after the crisis. Among those who had already undergone some kind of treatment, 98 cadets had used medication, 58 reported using trampoline exercises prescribed by the doctor and 2 had used other types of treatment through acupuncture. Only 35 cadets reported improvement after some kind of intervention.

Discussion:-

The study population showed a prevalence of 60.2% of aerokinetosis among the 186 aviator cadets at the Brazilian Air Force Academy in Pirassununga, São Paulo state, a percentage slightly higher than that found in international literature, which ranges from 10% to 39% among military aviation students (Lucertini et al., 2008; Giles; Lochridge, 1985; Benson; Tott; 2006; Rashedin et al., 2009).

However, according to data from the National Aeronautics and Space Administration (NASA), aerokinetosis affects approximately 50% of military aviators at some point in their career (Acromite, 2011).

There were very few female cadets (only 12 out of 186 interviewees). This may be due to the recent entry of women into the ranks of the airmen, which has taken place since 2003. The number was not sufficient to establish a relationship between the sexes.

In a study carried out at the Indian Air Force Academy, 57% of military students with symptoms of aerokinetosis developed it during the MAC phase, a lower rate than the 66.9% at the Brazilian Air Force Academy (Rashedin et al., 2009).

In addition to this negative impact on aerial activities, aerokinetosis can lead to premature termination of the flight, negatively affect the pilot's motivation and generate a great deal of anxiety.

In this study, adherence to medical treatment was remarkable: 91% of the individuals affected by aerokinetosis underwent treatment. The high level of adherence can be partly explained by the fact that, in the military environment, this factor can be preponderant in the success and continuity of studies at the AFA.

However, due to the intense routine at the AFA, many cadets opt for medication and don't seek out more time-consuming treatments, such as trampolining and acupuncture.

Aerospace medicine could be used as an educational measure in the first year of the aviation officer course at the Air Force Academy. This could be followed by screening and preventative treatment, before beginning airborne activities.

This could minimize - or even eliminate - the symptoms and increase the cadet's motivation, favoring greater development of their potential. It is therefore highly recommended that a thorough search be carried out for cadets with symptoms of aerokinetosis, preferably before they begin their aerial activities, in order to offer them early clarification and treatment of this important condition.

The incidence of aerokinetosis varies greatly and is influenced by various factors. Temporal (1995) cites an 11% rate of occurrences in basic aviation courses, i.e. courses taken by civilian pilots, characterized by more stable flights that don't involve exacerbated movements and great exposure to G-load acceleration, factors that determine why there are fewer cases. In military aviation, on the other hand, the rates are much higher

In view of all these analyses, it is clear that, in addition to the aspects naturally involved in the Flying Officer Training Course, such as the rigorous assessment and high level of demand, some cadets have to deal with the extra difficulty of symptoms that impair flight management.

Each year, airmen are taught about aerospace medicine, flight safety and other subjects of this kind, which provide good opportunities for instructors to focus more on aspects of aerokinesis. However, these classes generally deal with the subject in a more superficial way, just for general knowledge purposes. As such, it would be commendable if, even before beginning their first year of aviation activity in the Air Officer Training Course (CFOAV), all aviation cadets received instruction on movement syndrome and the other aspects involved.

In this way, more useful time is also given to students on the course who already want to start practicing methods such as the Cawthorne and Cooksey Protocol exercises, in order to allow for greater desensitization of the body systems involved in the process that leads the pilot to consent to the evil of aerial movement. Therefore, as far as the aeromedical section is concerned, it would be interesting to take a broader approach in terms of the amount of information made available and a more specific approach in terms of targeting it. This could be done by imparting knowledge about the different bodily processes involved, from the reactions of the human body's balance systems to the functioning of the digestive system and its possible influences on the onset of kinetosis symptoms.

In conjunction with the aeromedical section, it is of the utmost importance to involve physical education professionals and nutritionists, as this is one of the most important areas linked to aerokinetosis.

In this way, information can be correlated, such as explanations and examples of preventive exercises and foods that should be avoided on days of aerial activity because they negatively influence digestion and other processes, such as the excessive production of intestinal gases. As a result, many cadets would start the 2nd EIA course with a greater awareness of the basic exercises that help prevent and treat aerokinetosis and specific foodstuffs that can be harmful to their well-being, their relationship with metabolism and reactions in the body itself. As a way of complementing this, the psychology section also plays an important role, as factors such as anxiety can also be aggravating factors in cases of aerokinetosis (BRASIL, 2012).

During the second year of the CFOAV, once knowledge of the aircraft's structure, procedures to be carried out during flight and how to deal with crashes during military flight missions has been established, the cadet begins to come into contact with practical aviation learning. The cadet who suffers from aerokinesis, in addition to worrying about the intrinsic (aircraft handling) and extrinsic (environmental conditions) factors that are present in the flight, must remain focused so that the symptoms do not affect his performance in the mission, making his flight deficient.

The incidence of symptomatic possibilities can be decisive in the failure of a mission carried out by cadets. Included in the evaluation form is the item Adaptation to air activity, related to the general aspects that define good physiological conditions for flight performance. If the symptoms constitute a factor that makes it impossible for the cadet to continue the mission, the instructor can assign a poor grade for the flight in question.

One factor that carries a lot of weight in the 2nd EIA is that the flight schedule - a list of the instructor on the mission and the time - is made in such a way that periods close to the main meal, lunch, are also used, in order to maximize the number of aircraft departures for instruction on the day.

It is therefore essential that cadets know how to balance their meals based on these possible situations. If it is not possible to have lunch before take-off, the foods mentioned above should be avoided and priority should be given to a snack made up of options with a volume/calorie content that is not too high and a small amount of liquids. Now, if it is possible to have lunch as normal, the meal should be balanced, without excesses. Again, the menu should preferably be free of aggravating options and the essential amount should be consumed, especially if there is a short period between consumption and take-off. It is also important to maintain a regular diet, so that there is no change in the body's routine that could be harmful (BRASIL, 2012).

In addition, a meal based on excess, for example, needs to recruit a greater amount of energy for digestion, bringing the well-known feeling of drowsiness to the pilot, which, combined with the lethargy and prostration resulting from aerokinetosis, can be a determining factor for inattention and slow reactions inside the aircraft cabin.

With regard to all these alternatives, it is important to emphasize that the pilot should not perform any type of stimulus or exercise that could generate symptoms of aerokinetosis before take-off on mission days. After the flight, if symptoms occur, it is recommended to wait six hours before practicing again (TEMPORAL, 2000).

According to data from the National Aeronautics and Space Administration (NASA), kinetosis affects around 50% of military aviators at some point in their career (ACROMITE, 2011).

Airsickness is a significant obstacle in the training of some pilots. When conventional therapy fails, desensitization therapy may be indicated. Using the experience gained by the RAF and USAF, the Canadian Forces (CF) started this program in 1981. After identifying the patient, treatment consists of three phases: biofeedback relaxation therapy, ground desensitization training and in-flight desensitization therapy with a pilot surgeon. Employing a definition of healing used by the RAF, success was compared with that of the RAF and USAF programs. A total of 22 pilots underwent rehabilitation, 17 of whom were successfully treated for a success rate of 77%.

This is comparable to the success rates of other programs. It is reaffirmed that desensitization is a valid clinical tool in the treatment of airsickness (BANKS; SALISBURY; CERESIA, 1992).

Airsickness remains a significant obstacle for aircrew both in the flight environment (feeling airsick) and for aircrew at sea (seasickness). Even though some motion sickness medications provide reasonable valence, adverse neurocognitive effects demarcate their use in military personnel engaged in safety-sensitive operational functions such as flying. The aim of this study was to investigate the impact of promethazine, meclizine and dimenhydrinate on psychomotor performance and to analyze whether the addition of pseudoephedrine or damphetamine to promethazine would improve its adverse effects. In this study 21 subjects (11 men, 10 women), aged between 22 and 59 years, were assessed for psychomotor performance in 4 tasks, as well as with sleepiness and drug side effect questionnaires.

Another article presented the physiological data of two male pilots who completed a 6-hour training program for the control of motion sickness at the US Aeronautics and Space Administration's Ames Research Center. The program consisted of an Autogenic Feedback Training Exercise in which research participants learn through operant conditioning techniques to regulate various physiological responses to suppress their symptoms. The progress of the training was evaluated during tests of motion sickness in a rotating chair. Motion sickness tolerance was assessed by calculating the number of cumulative rotations the research participants were able to achieve in the rotating chair before reaching their primary motion sickness goal. Motion sickness symptoms were assessed using a standard diagnostic scale. No physiological data was obtained from a pilot during a training flight in an F-18 aircraft after the end of his training. The results showed a significant increase in tolerance to laboratory-induced encephalopathy tests and a reduction in autonomic nervous system response levels after training. During subsequent flight qualification tests in F-18 and T-38 aircraft, both pilots were successful in controlling their patience and returned to active flight status (COWINGS et al., 2005).

Vomiting is one of the most detrimental factors in aerial activity, as the cadet must use a motion sickness bag to do so, and may suspend the progress of some exercise and, depending on the intensity, abort the mission due to their physical

state, probably obtaining a poor grade. This may be due to exaggerated movements and sudden accelerations, such as exposure to G-loads or the imposition of high speeds, excessively stimulating the vestibular apparatus (TORTORA, 2000).

This corroborates what França (2015) mentions, when he states that kinetosis can become a risk, since even mild symptoms can impair the person when carrying out multitasking.

Based on the results of the first question, it is clear that a large part of the class has, at least once, experienced some symptoms of aerokinetosis. It's worth noting that these symptoms don't just include vomiting itself, but also nausea, weakness, headaches, among others. Based on the responses, the statement that motion sickness affects the body of a considerable number of cadets in the primary stage of the T-25 at the AFA is corroborated, an aspect that is also mirrored in other groups in society, where none of them chose vestibular rehabilitation, which is shown to be the most appropriate behavior for adapting individuals to environments that evoke the symptoms pointed out (MANTELLO, 2013; LUCERTINI; LUGLI, 2004 apud VOLTOLONI, 2013).

Final considerations

The aim of this study was to investigate how aerokinetosis affects the performance of aviation cadets during instructional flights. The data obtained in the research indicates that the symptoms of aerokinetosis affect cadets quite frequently, as well as having a negative impact on their performance during flight instruction. The most common symptoms reported were nausea and vomiting. The phase in which there was the highest incidence of aerokinetosis was Maneuvers and Acrobatics.

It was found that aerokinetosis wastes time and money, since many flights had to be interrupted and redone because of their reactions. Flight safety is also jeopardized, since the cadet is flying solo.

It is therefore necessary to try to identify and treat cadets who are more susceptible to aerokinetosis in the air environment before they begin their aerial instruction. Such a measure would help to reduce the adverse effects that lead to underperformance by trainee military aviators.

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