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INFLUENCE OF STRESS ON THE PERFORMANCE OF PILOTS IN TRAINING

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Abstract

This paper deals with the influence of stress that affects pilots in training, how stress affects their daily lives, but especially how it affects their concentration and performance during pilot training. It describes what risks, whether mental or physical, can occur to pilots in training. It also discusses about the factors that affect pilots. One of the factors is the kinetosis, to which more attention is paid and which had also become the subject of the research in this diploma thesis. The aim was to use a questionnaire to find out whether the pilots in the training encountered signs of motion sickness during the training, how it affected their concentration and how they dealt with these situations. In conclusion, based on these responses, we suggested possible preventive solutions for other future novice pilots on how to avoid motion sickness and if it had already occured, how it should be eliminated as much as possible not to affect performance and concentration of pilots.

Keywords

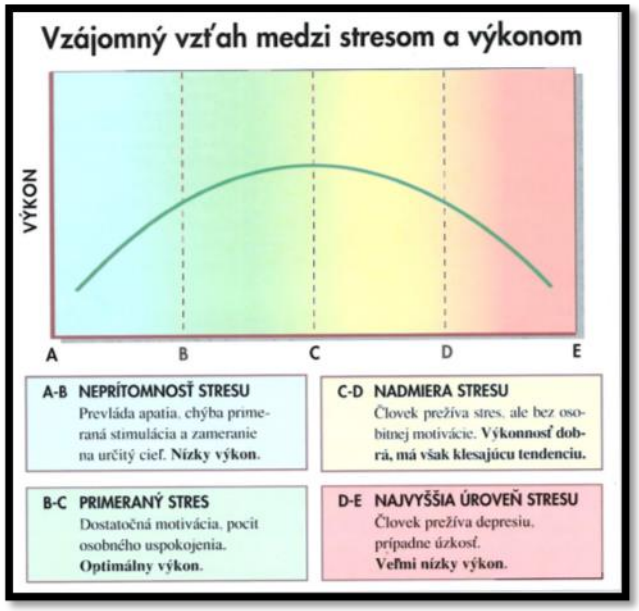
stress, kinetosis, mental stress, physical stress, psychosomatics

1. INTRODUCTION

Pilot work is considered to be one of the most challenging in terms of concentration and stress that pilots experience quite often. High demands are placed on pilots because they are responsible for the aircraft, passengers and all crew members. Pilots in training are inexperienced and, unlike older and more experienced pilots, often do not know how to react correctly to different situations, which can cause stress for them. The research is focused on reducing and eliminating stress and motion sickness, which is one of the stressors with which pilots who start flying can have problems.

2. DEFINITION OF STRESS

When we talk about stress, we are talking about a state in which the level of stress exceeds the tolerable limit in terms of the adaptive capacity of the human body under certain conditions. Stress is associated with situations that are demanding and significantly upset the balance of the body and cause changes and fluctuations in the hormonal and immune system. Stress occurs when the safety of an organism, the so-called integrity, is threatened and the organism must use as many abilities as possible to protect itself. When people were in danger, their bodies mobilized, their muscle tension increased, their breathing quickened, and their adrenaline levels also increased. Their senses sharpened and they watched their surroundings carefully so that they could react as soon as possible. The stress that affects a person can be considered as the body's response to the influences of the environment during his life. The stress that affects a person can be considered as the body's response to the influences of the environment during his life. Stress is divided into eustress, which is positive stress, and distress, which is negative. Although stress is harmful, it can also help a person to some extent. Every person is affected by stressful stimuli, but these stimuli do not have the same effect on every person, because every person is different.



2.1. Eustress

A certain amount of tension is healthy and necessary for the body. Even in dangerous situations, it is important that the body responds quickly to certain situations and that a sufficient amount of adrenaline is secreted into the blood and provides the reactivity that the body needs in these situations. Even in less dangerous situations, it is good to have a little tension and vigilance that people can use, for example, in tests, during important interviews or even in piloting. This type of stress is important when piloting, as the pilot needs to be constantly vigilant, paying attention to the operation and also to unexpected situations that may occur during the flight. This so-called good stress helps to increase performance, improve concentration and sharpen the senses. The impact of stress has also a major impact on learning new things that pilots can better

remember. At low levels of stress, fatigue and boredom can occur, so it can negatively influence pilots´ ability to remember something. That is why there is no need to worry about this type of stress. This type of stress is commonly experienced by people during promotions, weddings or other pleasant situations that they experience throughout their lives.

2.2. Distress

Distress is a negative form of stress that occurs when people find themselves in a situation where they feel uncomfortable, time constrained and do not catch up, or when they find themselves in an embarrassing situation. Just as eustress occurs under certain conditions, distress also occurs under certain conditions, which are uncomfortable in this case, and this occurs, for example, when people have to solve a problem that they do not want to solve. Another unpleasant situation is when the pilots have little control over a certain situation, or they have no control over the situation at all. This can happen, for example, if a pilot gets into an unexpected situation that he is not prepared for or has never encountered. If distress persists, it can turn into chronic stress, which has a negative impact on the immune system.

3. STRESS FACTORS THAT INFLUENCE PILOT

Pilots are affected by many factors, which we call stressors. These factors affect pilots, whether it is training, work or even private life. They cause stress but also affect how long the stress will last for the pilot. These factors can be either different stimuli or situations. What matters is not only how much the stimulus or situation affects the pilot, but also how the pilot can deal with it. Each of us is different and each of us can deal with stress differently. For some, the given stressful situation or stimulus has a great impact and for others only minimal. During the performance of their work, but also in private life, pilots are constantly exposed to burdens (psychological and physiological) or to factors that affect pilots in the form of external influences.

3.1. Determinants of mental stress

One of the determinants that affects pilots but also ordinary people who are not affected by aviation is the psychological burden. In addition to being stressed by the human body as perceived as dangerous or threatening, people create this type of burden in their minds by thinking about stressful situations that have occurred to them in the past. They think about different situations, which may or may not occur, create different scenarios in their heads and sometimes put unnecessary psychological burdens on themselves. This type of load is difficult to defend because it is only in the head. These types of burdens that affect pilots include, for example, family problems, the loss of a loved one, interpersonal relationships between pilots and instructors, between pilots but also in private life, the financial situation that may be related to training, various dependencies that may have a great influence on the psyche and also the medical examinations, which are a condition for the pilot to be able to perform training and later also his work as a pilot. Into this group belong for example loss of a loved ones, interpersonal relationships, financial situation, addictions, medical examinations and many others.

3.2. Determinants of physiological stress

Kinetosis, lack of sleep, unhealthy lifestyle or even hypoglycemia are considered to be determinants of physiological load. These determinants act in such a way that they affect the functions of the human body and also the physical condition, which is important for pilots. However, most of these factors can be influenced by positive lifestyle changes. Into this group belong for example kinetosis, lack of sleep, unhealthy lifestyle and hypoglycaemia.

3.3. Impact of the external environment

The pilot is also stressed by the effects of the external environment, which can be threatening and dangerous for the body. The pilot may not even be aware of this, but his body is under stress. These factors can be, for example, take-offs and landings, meteorological conditions such as wind, turbulence, fog and many others. In this group belong for example take - offs and landings, meteorological conditions, hypoxia, and gravitational overload.

4. MANAGEMENT OF STRESS

The human body works in such a way that when something unusual happens to it, a so-called alarm is triggered, which can sometimes save lives. However, the signals that the body sends must be taken seriously and acted upon. The body triggers defense mechanisms to warn of danger, while activating muscles, organs and glands that are on standby. However, if this so-called alarm system of the body is abused and ignored for a long time, serious disorders of the immune system can occur.

5. THE IMPACT OF STRESS AND THE RISKS OF THE IMPACT OF STRESSORS

In addition to the psychological effects of stress, there can be physical effects that vary from individual to individual. Stress is perceived by the brain as a form of response to danger. As already mentioned, the body prepares for threat and all the senses are activated more intensely. The body is therefore ready to fight or escape, as has happened in the past with our ancestors who fought against their opponents or beasts. Nowadays, however, it is in this situation that it is crucial to calm down and deal with things prudently and with a cool head. When working as pilots, it is important not to panic in a stressful situation, because they are responsible for the lives of passengers, crew and even their own, which must be safely transported to the place. Under the influence of stress, there can be various risks that can endanger the life of the pilot, but also the lives for which the pilots are responsible.

5.1. Psychosomatics

Psychosomatics examines the interaction between a person's body and soul. It deals with the question of how physical illnesses affect the human psyche and also how psychological stimuli affect the body. It has been scientifically confirmed that these interactions between the psyche and the body interact. If a person is exposed to stress that is not addressed in any way, it can affect their health in the form of various diseases. It also works the other way around. If a person develops a more serious illness, such as cancer or other diseases, it can have an impact on mental health. Genetic influences, the job the individual

performs, the environment where he or she lives or works, and social problems also contribute to the human psyche and thus to the development of psychosomatic diseases. In the 80's of the last century, a department called psychoneuroimmunology was created, which deals with the connection between the psyche, the body and also the immune system. The brain has been found to affect the body's defense mechanisms through the secretion of hormones such as cortisol. When stressed or depressed, cortisol can block the immune system. This makes stress-prone people more likely to develop infections. Usually, reducing stress or depression also improves a person's immunity, and conversely, reducing a person's immunity also reduces the level of depression and stress.

5.2. The effect of long-term stress on the individual systems of the human body and on the immune system

The effect of stress on the pilot may not be immediate. They may not even be aware of it, but over time, its effects on the body may manifest themselves. Stress has a negative effect on both the psyche and the body and its systems. It negatively affects individual systems, the digestive system and negatively affects the immune system.

5.3. Hyperventilation

The word hyperventilation consists of the word hyper, which means excess or more than usual, and the word ventilation. The word ventilation in the respiratory system means the exchange of air between the lungs and the outside environment. Hyperventilation changes the state of the respiratory system, which is not natural for the body, as the body does not need as much oxygen as is delivered to the lungs during hyperventilation. For a pilot, this can also manifest as difficulty breathing. In addition to deep breathing, shallow breathing may occur. In an individual, who experiences hyperventilation, breathing from the outside is highly audible. With persistent hyperventilation, there are problems and difficulties associated with the biochemical changes that occur in the blood. Due to the excessive excretion of carbon dioxide from the body and thus from the blood, the arteries narrow. As a result, the oxygenation and blood supply to the whole body and thus to the brain and heart is reduced. There is a higher heart rate in the body and also a higher irritability of the nervous system. The causes of hyperventilation can be various, but it is usually caused by anxiety, nervousness, panic, or stress. In pilots, it can be caused by either increased stress in dangerous or unpredictable situations, or hyperventilation can be accompanied by motion sickness. Hyperventilation can result in disorientation and eventually complete loss of consciousness. In this condition, it is necessary to calm the individual, talk to him and it is also recommended to breathe in a paper bag. Various breathing exercises and relaxation techniques are also recommended to calm the individual.

D. Decreased performance

Everyone who is exposed to stressful situations should control the balance between tension and rest. When one of these things deviates, the individual becomes stressed. In order for the pilot to expect the best possible performance from each other, the tension and rest must be in imaginary balance. When deviating, there is a state of alertness, when the body defends itself, causing muscle tension and nervousness. There is a loss of motivation, a decrease in concentration and fatigue on the body. Performance is declining and the body is not achieving the same results as before. If there are any side effects or health problems associated with this imbalance, there is tremendous pressure on the body. Stress also occurs in monotonous work and in work for which a person is too qualified or bored during this work. This is the other side of the imbalance. With these two aspects of imbalance, an individual experiences frustration or even a loss of appetite. At the same time, one does not want to do anything and his attention fluctuates. These symptoms are manifested mainly in one-sided and repetitive work activities. The most optimal thing for an individual would be a job that would be a challenge for him, but not so demanding as to cause him stress. However, everyone is different and some are adapted to give the best performance under high stress, while others give low or even no performance under high stress.

6. STRESSOR ELIMINATION OPTIONS

The pilot's work is considered prestigious as well as exciting. Young pilots who want to pursue flying throughout their lives and want to build a career see mainly the positives of this job, but are not aware of the psychological problems that this profession entails. Pilots in training are under constant stress, whether due to training in which they experience stressful situations such as weather conditions, kinetosis, instrument flights, night flights, but also interpersonal relationships involving pilots and instructors, but also pilots' relationships in training each other. In addition to training, young pilots can experience stressful situations due to family conflicts, health status, lack of funds and, if the pilot is a student in training, also due to school. Long-term stress has a negative effect on mental as well as physical health and can cause serious problems if it persists. In order to reduce stress for pilots, pilots should either avoid stress and thus prevent stressful situations, or if stress persists, they must learn how to reduce or eliminate stress.

6.1. Stress prevention

One of the ways in which a person can prevent stress is to build and develop psychological resilience to stressful situations. Strengthening resilience can also be seen as increased adaptability, including the use of all resources that have a positive effect. This means limiting or eliminating the impact of risk factors that affect a person. How the body will strengthen against and resist stressful situations can be divided into several points. Preventing the creation of an unreasonable burden, dealing with an already existing burden and choosing the right decisions to deal with it. Strengthening rapid, effective regeneration and recovery. The last point is to look for other solutions to stress relief to some extent. When developing resilience to stress, it is essential to prevent existing potential stressors from becoming real. It is essential that everyone who wants to prevent stress finds out for themselves what causes stress in them. The individual should develop self-knowledge and also how he can use the help of other people and various technologies to manage stress. Another thing to focus on is the evaluation of the stressful situation, how important the situation is, the way in which the situation can be evaluated and whether it is possible for the individual to deal with the situation with their abilities. It is important to reconsider the question of whether it is necessary to be popular, to satisfy everyone at all costs and to solve other people's problems. These things lead to

hasty and distorted conclusions that adversely affect and bother individuals. This can cause frustration and stress. It is necessary to focus on oneself and on things that are solvable, not on things that cannot be influenced. The cognitive aspect of work memory management can be used to build resilience to stressful situations. To prevent stress and strain, a technique can be used to stop negative thoughts by trying to think of positive things that make people happy. If an individual finds out which stimuli have a negative effect on him, he should learn from the situations he has experienced in the past. Another principle that is used to build resistance to stress is called psychological immunization. There are several ways to improve mental immunity. One solution is to avoid the disruptive and dangerous effects that the pilot encounters. However, this is just a theory, which is quite challenging in everyday life, because the pilot is exposed to various situations on a daily basis, which he often cannot even predict or influence. Different forms of training are a better option to adapt the individual to stressful situations. At the beginning, the pilot should be subjected to appropriate loads, but these should increase over time.

6.2. Time management

When working as a pilot, proper time management and preparation are important to prevent stressful situations. Pilots who start training and go to school have a lot of responsibilities and do not always manage to schedule their time. To make the most of your time, you need to clarify your priorities regarding how time is spent. In other words, it is necessary for people to realize what they want to achieve in their lives, set goals and find time in addition to all their responsibilities for things that make them happy. This should serve as a brief guide to how they should organize their time for each activity. Pilots in training should not neglect their training responsibilities so that they can prepare for the flight well in advance and devote sufficient time to pre-flight preparation. When planning time, in addition to training, they should take into account important things such as school, various other responsibilities and the family. People waste a lot of time in their lives especially with searching of various things, such as documents, clothes or other objects that they have founded or lost somewhere. Because of this, it is better to divide individual things into different categories and keep things in order. The advantage of the organization is systematic, better organization and a sense of control over certain things and situations. In practice, it is worthwhile to plan the individual things or tasks that need to be done only for a shorter period of time, for example what needs to be done on a given day, week or month, and also to divide these things according to importance. It is necessary to focus first on tasks that are demanding and that take a lot of time. People tend to put things aside until they end up with a lot of tasks that they can't cope with and thus come under psychological pressure. Then it can help to make a list of things and tasks that need to be done and gradually tick them off after they have been completed.

6.3. Elimination and stress reduction

How pilots cope with stress depends on whether they have ever experienced the situation, their experience of experiencing stress, and the nature of the individuals. However, if they want to deal with stressful situations and manage it, they should first get to know their body and find out how it reacts to individual situations or stressors. People are stressed especially when they place high demands on each other, they try to do their best and not to make any mistakes, they add extra work, they feel responsible for everything, they want everyone to like them and they also ignore all the symptoms that their body warns. It is desirable to eliminate the stress or at least reduce it as much as possible. There are several ways to try this and it might be for example practicing breathing methods, better time management, having good nutrition, having physical activity, taking medication and so on.

7. RESEARCH

In the research, we discuss issues related to stress and its impact on pilots in training, as well as the impact of kinetosis on pilots during flying. We used questionnaire, which was distributed among pilots who are recently in training, but also among those pilots who have already finished training. Data were subsequently collected and evaluated. The research in the next part of the diploma thesis is focused on the evaluation of individual questions. Before the questionnaire for pilots was compiled, a theoretical part had been first created in which the information was obtained by studying various literature and sources related to the issue, such as stress factors that affect pilots, how they are distributed and how stress manifests itself on pilots. The questionnaire consists of 16 questions, which were compiled on the basis of the chosen topic, where the pilots were asked questions about stress and motion sickness. The questionnaire was made in electronic form and was anonymous, which allowed respondents to answer truthfully and share their experiences. Subsequently, this questionnaire was sent to the pilots. During the period when the questionnaire was among the pilots until the time when the data were processed, the questionnaire was filled in by 72 respondents, from which 57 were men and 15 women. One of the respondents did not state his gender, but on the basis of verbal answer in the respondent's questionnaire, it was found that he was a man. At the beginning of the questionnaire, the sex of the respondents was ascertained and also at what age they started the training. These statistics were not included in 16 questions related to kinetosis and stress. They are in the questionnaire only to inform us. The questions in the questionnaire were mostly of the choice type and 2 of the questions were open, where the respondents were given space to give their own verbal answers. The questions were evaluated in the order in which they were included in the questionnaire. The questionnaire was created by Google forms software, which is used to collect and then evaluate data, based on which it creates graphs with individual answers.

7.1. Questionnaire

7.1.1. Stages of training when the kinetosis appeared to pilot

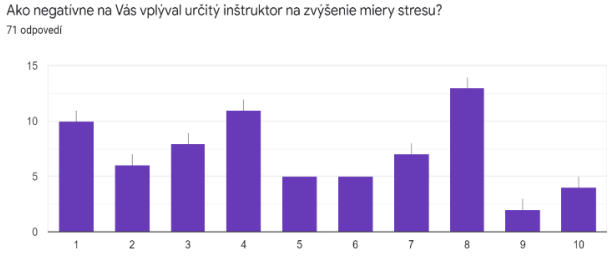
The first question evaluated in the survey was at what stage of training the pilots felt kinetosis. In 21 respondents, kinetosis during the flights did not occur at all, in another 21 it occurred mainly during the training phase of falls, slides and spirals. Other stages in which several pilots experienced kinetosis were picking out unusual positions, flying during strong turbulence that could be caused by thermals or strong winds, reconnaissance flights, but also when practicing emergency procedures such as engine shutdown or engine fire. During the other phases of training, the pilots showed kinetosis only to a lower extent.

7.1.2. *Reduction of kinetosis symptoms*

This question was asked in the questionnaire so that individual respondents could comment on how they tried to reduce or eliminate the symptoms of motion sickness. The question was answered by 55 respondents, 4 of whom said that they did not show kinetosis and therefore did not have to address how to reduce or eliminate the symptoms. According to the answers, the largest number of pilots tried to breathe deeply during the manifestations of kinetosis, to reduce the temperature in the aircraft and to let cold air into the cabin. The other numerous answers given in the questionnaire were of the type of looking out of the plane, either at the horizon or some fixed point, such as a hill or other fixed point that was on the ground and visible from the plane. Some of the respondents said that during the practice of the phases that caused them kinetosis, they took a break for a while, flew in horizontal flight and the symptoms of kinetosis eased after a while. Among the answers there was also mentioned that the manifestations of kinetosis in the respondents stopped after several years. Less common answers were, for example, chewing menthol chewing gum and using ginger.

7.1.3. *Influence of the instructor*

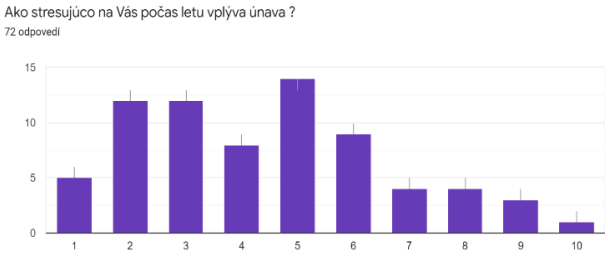
By asking the respondents, we wanted to find out if there is a negative effect that could affect pilots on the plane or on the simulator when there is a certain instructor that the respondents do not have good relationship with. In the questionnaire, respondents had the opportunity to choose a number from 1 to 10 on a scale, where 1 represents the lowest level of stress and 10 the highest. In this question, the largest number of respondents chose the number 8 on the scale, which represents a high level of stress. The second most numerous answer on the scale was number 4 and then number 1. The results of this question shows that the most numerous main groups of respondents were influenced by a certain instructor either to a high degree or to a low degree. The other answers in between were of about the same value.



The graph shows that the influence of the instructor on the increase of the pilot's stress in the training is not negligible, therefore the instructors should pay close attention to the pilot and create a friendly environment during the flight in the aircraft. They should communicate with each other and, if the pilot fails, find a solution to the problem. How the instructor treats the pilot greatly affects the pilot's level of stress, which can be reflected in the pilot's concentration, self-confidence, but also his performance.

7.1.4. *Effect of fatigue*

The answers of individual respondents to the question of the extent to, whether fatigue has a stressful effect on pilots, show that fatigue affects respondents in a medium degree of stress, which is shown in the graph, where most respondents voted on a scale from 1 to 10, where 1 represents the lowest stress level and 10 the highest, number 5. The second and the third most chosen option, which represents about 33%, were low to almost no fatigue stress. For less than 20% of the total number of respondents, the fatigue factor represents a high level of stress.



Based on the results, the number of respondents with fatigue which represents high level of stress is not entirely negligible. In order for these respondents to perform well during the flight, it is important that they take a break and gain strength before the flight. If the pilot is tired and unable to concentrate properly, it is at his discretion whether to fly or prefer to postpone the flight. Inattention while piloting can cause serious complications that can lead to fatal consequences.

7.1.5. *How stressful do the phases and tasks of training work?*

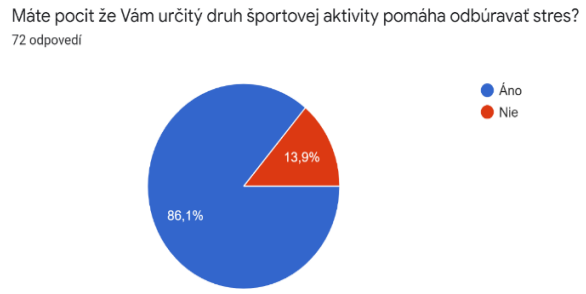
The question included the individual phases and tasks in the training, which were evaluated by the respondents by a number on a scale from 1 to 5, where the number 1 represents the lowest stress level and 5 the highest stress level. The lowest level of stress, according to chart number 13, was mainly affected by line flights, low-altitude circuits, comparative navigation, but also the basics of piloting and piloting techniques. Instrument flights and night flights, in which pilots have to rely mainly on instruments during the flight, affected the pilots' level of stress during training. According to the results shown in the graph, the slightly increased stress load was represented by emergency procedures and the selection of unusual positions. The phase in which the largest number of respondents chose the option of the highest level of stress was the phase in which falls, slips, spirals and high levels of stress were practiced in training.

7.1.6. *Flying frequency and stress*

The question was whether the pilot was affected by the increased frequency of flying to reduce the impact of stress. The question was asked because the increased frequency of flying, with pilots gaining more and more new experience and skills, should have a positive effect on reducing stress, as shown by the answers recorded in the graph. As many as 87.3% of respondents confirmed that the increased frequency of flying has a positive effect on the reduction of the stress rate, and only in 12.7% of the respondents the increased frequency of flying did not affect the stress rate.

7.1.7. *The impact of sports activities*

The graph shows how individual respondents voted on the question of whether a certain type of sports activity has an effect on reducing stress. Most of the respondents, which represents up to 62 of the total number of 72 respondents, confirmed the assumption that any type of sports activity has a beneficial effect on relaxation and reducing stress.



7.2. Research results and solutions

From the results of the questionnaire, we found that pilots who had symptoms of kinetosis during the flight, were caused mainly by more demanding elements, such as falls, slips, spirals, picking unusual positions, fall prevention, performing emergency procedures, flying during severe turbulence, but in some cases, manifestations of kinetosis also occurred during the reconnaissance flight. In the questionnaire, we also analyzed what causes increased stress for pilots. We found that a certain instructor, fatigue, but also the phases and training tasks that caused kinetosis, had also stressful effect on the pilots. On the contrary, the pilots are not affected by stressful factors, which we assumed would represent an increased level of stress, and these are, flights on the new track, hunger and hypoglycemia, noise and radio communication. Instructors should get into situation of young pilots who are starting training and from beginning of the training only take short flights with them, so pilots could used to the new environment which air space is. It is beneficial for novice pilots if there is good communication with the instructor and the right motivation from the instructor. During the manifestations of kinetosis during the demanding elements, the pilots said that it helps to interrupt the demanding flight tasks for a while, to put the plane into horizontal flight and to continue the exercise only when the symptoms subside. We assumed that cold air helped to alleviate the symptoms of kinetosis and that the pilot decreased symptoms by looking out of the plane. Our assumptions were met because several pilots raised these options in an open-ended question. If novice pilots have problems with kinetosis, an individual and patient instructor approach is needed. With the correct procedure of the instructor, the kinetosis will gradually disappear.

8. HEART RATE MEASUREMENT

In addition to the questionnaire, which was sent out to the pilots and which was subsequently evaluated, measurements were also made to verify what was stressful to the pilots during the flight. The purpose of this measurement was to determine which phases and tasks cause the highest level of stress for the novice pilot, and the aim of these measurements is to help pilots as well as instructors to choose the right approach to training tasks so that the stress is as low as possible for the pilot. After discussing with the tuthor, who is also a flight instructor, testing was performed on one of the beginning pilots in the training, who was willing to cooperate.

The increase in stress is measurable in several ways and in several parts of the body. Under the influence of stress on the pilot, many changes take place in the body, which are affected by the secretion of stress hormones. The changes that take place in the body are both physically manifested, which can be observed and measured. These include rapid breathing, decreased body temperature, rapid eye movement, enlarged pupils, increased muscle tension and increased heart rate. From these measurable physiological signals, we chose heart rate measurement

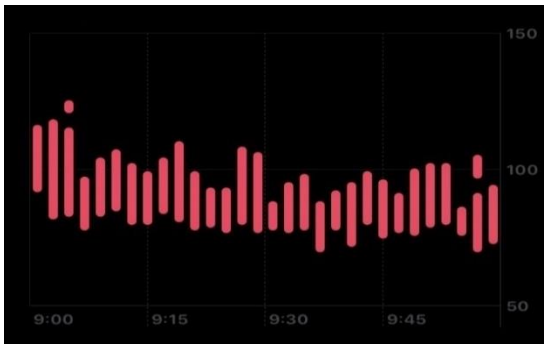
8.1. The course of measurement

The choice of heart rate measurement was chosen based on the easy availability of measuring devices. Heart rate can be measured at multiple parts of the body, such as the wrist or chest. For heart rate measurements, there are simple devices such as a watch or chest strap that send the recorded values to an application installed on the mobile device. With regard to the pilot's comfort, we chose to measure the heart rate on the wrist using an Apple Watch, which, after recording the heart rate, transmits the individual recorded data to the Health application, which was installed in iPhone devices. The pilot on whom the measurements were performed, flew on Zlín 242L aircraft and all these measurements took place at the public international airport Žilina with the designation LZZI, which is located at an altitude of 311 meters above sea level and has a concrete-asphalt runway with a length of 1150 meters. The pilot performed 10 measurements, which started with the circuit phases and ended with solo flight and relaxation in quiet mode.

8.2. Measurement

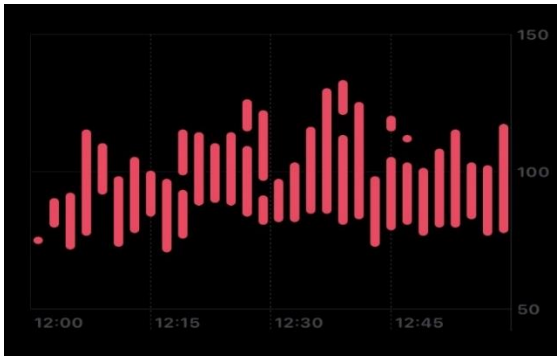
8.2.1. *Measurement n.1*

The first measurement involved 45° turn and practice of preventing a fall from a straight flight, a climb, a descent and a turn. During the measurement, a heart rate in the range of 71 - 124 beats per minute was recorded. The pilot's highest heart rate prevailed at the beginning of the flight and later decreased. The increased heart rate during the flight was measured at times when the pilot and instructor performed the individual elements, which followed in the order in which they were mentioned.



8.2.2. Measurement n.2

Measurements in the phase during which the pilot practiced the avoidance of unusual positions, the avoidance of the spiral showed that these individual tasks seem relatively stressful. The pilot's heart rate ranged from 72 to 132 beats per minute, with an increased heart rate prevailing during the measurement. It can be seen that at the time of 12:37, when the pilot was practicing the prevention of falling from the spiral, his heart rate was the highest and therefore this task caused the greatest degree of stress to the pilot.



8.2.3. Measurement n.3

This measurement was recorded on the day when the pilot completed his first solo flight - circuits. Before that, however, he completed this phase, which was the circuits - the activity of stopping the engine. The flight took place between 10:20 - 11:00 and the pilot's heart rate in training was in the range of 83 - 131 beats per minute. The lowest level of the heart frequency was higher than usual, which could be caused by increased stress because of the solo flight during the day. The graph shows how the heart rate was risen and fallen down during fall prevention during engine shutdown training as well as during landings.

8.2.4. Measurement n.4

This graph shows how the first solo flight affected the pilot's degree of stress, which was reflected in an increased heart rate in the range of 77 - 134 beats per minute. The solo flight took place immediately after the end of the previous measurement, which was the progress test before the first solo flight. At this stage, the pilot recorded the highest heart rate compared to the measurements taken since the beginning of the research. The graph shows that the solo flight had a greater impact on this particular pilot than the other phases and tasks in the training.

8.3. Analysis and results of measurement

The measured values, which resulted from the individual graphs of heart rate measurement, confirmed the expected assumptions, which approached the results from the questionnaire, except for the training phase of engine shutdown. At this stage, the pilot was expected to have a higher degree of stress. This could be due to the fact that the pilot was well prepared for this phase. This phase is first rehearsed on the ground and the pilot must apply the engine shutdown procedures by heart. At the same time, the pilot expected the engine to stop and knew when it would happen. Graph 26 shows the phases of training during which the highest heart rate was measured. The graph shows that the following phases have the highest stress on a pilot during basic training:

- first solo flight - circuits;
- selection of unusual positions of falls, slips, spirals;
- first circuits;
- bends with an inclination of 45 °, fall prevention;
- emergency procedures training;
- engine shutdown.

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