PHYSICAL AND NEUROPSYCHIATRIC SYMPTOMS APPEAR ON PILOTS DURING HYPOBARIC CHAMBER TRAINING

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Abstract:
It has been known that some neuropsychiatric symptoms also occur on healthy people who are subjected to the low pressure and oxygen level. Especially climbers and pilots experience sometimes severe symptoms. The aim of the research is determine the physical and psychiatric symptoms that the pilots have experienced during hypobaric chamber training and discuss the possible mechanisms related with them. One hundred sixty five pilots from Turkish Air Forces were included in this study. Anonymous questionnaires were used to get information on their physical and mental health history, sensorimotor and cognitive changings and perceptual and affective symptoms they experienced during and shortly after hypobaric chamber trainings. We determined several neurological symptoms, somestetic illusions, derealization symptoms and hallucinations, anxiety and affective symptoms on pilots. Determining the similar symptoms in people who exposure to hypoxia and psyhiatric patients to be considered as a finding to understand the ethiopathogenesis of the disorders.

Key words: Hypoxia, neuropsychiatry, pilots, hypobaric chamber

1. Introduction:

In literature there are several researches about physical and psychiatric symptoms that occurred at low pressure and low oxygen level conditions in healthy people. Pilots, during their flights and trainings, are exposed to diferent conditions that have low pressure and oxygen level. Researches performed on these groups are especially related with gravity changing effects on conscious and cognitive functions (Hanousek et al, 1997; Rickards and Newman 2005). Similarly, motor and sensorial deficits have been determined on pilots but there is no any spesific investigation about hallucinations and illusions.

Altitudes from sea level to 3000 meter height are called 'high altitudes', between 3000-6000 meter is called 'very high altitude' and altitudes above 6000 meter are called extreme altitudes. Different neuropsychological symptoms can occur at every different altitude level related with low oxygen level and low pressure. Hallucinations and white matter changings mostly occur at 6000 meter height or even higher altitudes (Wilson et al, 2009). Studies on climbers show that most of them experience visual, auditory hallucinations and somesthetic illusions. Somesthetic illusions are usually described as feelings that the body's shape is changing, rising from his own body, watching his own body from a higher level or far away and feeling a presence beside or behind him. Otoscopic phenomena is composed of four main symptoms: out of body experience, otoscopic hallucination, heutoscopy and feeling of a presence (Lopez et al, 2008). Déjà vu is something feels like you've experinced that moment before and it is usually described on epileptical patients (Wild, 2005).

Another medical condition named as Acute Mountain Sickness (AMS) was defined on climbers. AMS has been known for long years but its etiopathogenesis has not been clarified completely. The most common symptoms of this sickness are headache, gastrointestinal symptoms (anorexia, nausea and vomitting), insomnia, dizziness and fatigue (Hackett et al, 1998; Roach and Hackett, 2001; Roach et al., 2000). Moderate-advanced AMS causes an increase in intracranial pressure and it's called High Altitude Brain Edema (HABE) (Roach and Hackett, 2001). The studies of magnetic resonance imaging of brain on AMS patients reveal T2 signal intensity on corpus callosum splenium white matter but they do not find any changes on the grey matter. Because of the slow resolution of the edema and the good response to the steroid treatments, edema is considered to be of vasojenic origin (Hackett et al, 1998; Roach and Hackett, 2001).

In this research pilots who have been in hypobaric chamber for several times as a part of their training program were included. Hypobaric chamber simulates low pressure and +G conditions develop during high altitude flights. Even though there are plenty of work on neurological symptoms experienced by pilots we could not find any research especially focused on psychiatric symptomatology. Our aim is determine the neurological, physical and psychiatric symptoms that the pilots have experienced during hypobaric chamber trainings. We will discuss the possible mechanisms underlying these symptoms and the effects of hypobaric hypoxia on brain functions.

2. Methods:

We use anonymous questionnaires to get information about physical and psychiatric symptoms that occur during hypobaric chamber trainings of 165 pilots working for Turkish Air Forces. They were informed about our purposes and informed consents were obtained. Questions were placed about age, gender, education, information about physical and psychiatric disorders which they or their first degree relatives have, surgery history, drug use history, smoking habits, the number and duration of being in

hypobaric chamber, the duration of staying without an oxygen mask in hypobaric chamber and several psychiatric and neurological symptoms they may have experienced during and shortly after these trainings.

Data was analyzed by SPSS 10.00 statistical program for Windows (SPSS Inc., Chicago, IL, USA).

3. Results:

There were 4 women, 161 men and their average age was 32.80±6.17. 95.8% doesn't have any disorders. 30.3% of them have relatives who have at least one systemic disease. 11.5% of them have a surgical history. 33.9% of them are smokers and 3.6% of them use prescribed drugs. The average rate of being in the hypobaric chamber is 2.77±2.49, the average duration is 33.90±19.49 minutes and the average duration of being in the hypobaric chamber without oxygen mask is 5.78±7.53 minutes.

We classified the symptoms as follows; neurological symptoms, hallucinations, somestetic illusions and derealization symptoms, affective symptoms, anxiety and gastrointestinal symptoms. Symptoms and their rates are shown in Table 1, 2, and 3.

4. Discussion:

4.1. Headache and loss of consciousness

The most frequently observed symptoms of AMS were also determined on pilots in this research (dizziness %42,4; somnolence, fatigue %25.5; headache %12.7 and nausea %13.3). AMS is a special kind of headache and International Headache Society describes AMS as a headache that occurs in 24 hours after rising to an altitude higher than 3000 m in a short time (Hornbein, 1999). It is known that brain tissue is not sensitive to pain. Meninges transmit the pain by the trigeminal nerve endings. The signals developed at high altitudes stimulate the trigeminovascular system and brain edema and the increase of the intracranial pressure that results in headache. So it is accepted that the headache occurs because of the activation of the trigeminovascular system through chemical and/or mechanical stimulations (Hornbein, 1999; Marsden and Fowler, 1998). Jaillard et al (1997) intend to determine how the low pressure and oxygen levels trigger headache and investigate the headache complaint among people who live in Peru at 3380 m height above sea level. They found that headache rate is higher than people who live at sea level but the migraine rate does not show any differences.

The loss of consciousness is reported by 21 pilots (12.7%). A study carried out in the Australian Air Forces show that 14% of the pilots have almost a 'loss of consciousness' during flights and 8-18% have G-induced loss of consciousness (Rickards and Newman, 2005). A similar research carried out in the Brazilian Air Forces reports that the rate of the loss of consciousness is 10.3% (Hanousel et al, 1997). These results are similar to our findings. Loss of consciousness is explained by the inability of adaptation of the blood pressure to the rapid changes of air pressure. Due to this inability the amount of oxygen transmitted to brain decreases. A study on predictable features of unconsciousness shows that the more the pilots get +G trainings the less they experience unconsciousness. The authors suggest that repetitive training increases the capacity to adapt to changes in pressure (Sevilla and Gardner, 2005).

4.2. Motor and sensorial deficits

Various acute ischemic episodes with motor and sensorial deficits have also developed at high altitudes (Wohns, 1986). Ninty eight percent of pilots working for Australian Air Forces reported at least one visual changing during high altitude flights and in a study on Brazilian Air Forces, 11.9% of the pilots had peripheral vision loss during flights (Rickards and Newman, 2005; Alvim, 1995). Our study showed that the pilots have experienced a loss of vision (15.2%), double vision (%9.1) and blurred vision (30.3%).

24.8% of the pilots have reported temporary loss of power in their arms and legs. We also found that 32.7% of the pilots have difficulty in pronouncing the words and 38.2% of them reported difficulties in finding the words. The low pressure affects the volume of brain blood and it may cause these deficits. In Dietz and McKiel's research (2000) it is suggested that temporary expressive aphasia developed at high altitudes may stand for the migraine aura. There are also some authors suggest that these acute and temporary neurological disorders occurred at high altitudes develop in a similar way to cortical spreading depression in migraine. Cortical depression can cause blood-brain barrier deterioration (Firth and Bolay, 2004). The other possible mechanism is the deterioration of the endothelial permeability due to hypoxemia (Roach and Hackett, 2001).

4.3. Perceptual disorders

In pilots and in climbers it is known that under certain conditions several perceptual disorders may occur. Especially at altitudes higher than 6000 m the occurrence rate increases. Most of these perceptual disorders have been experienced during the climbs performed alone and because of this it is thought that life-threatening situations may aggravate perceptual changing. The other possible causes are hypoxia, physical fatigue, hypothermia, food scarcity, hypoglycemia, ketosis and dehydration (Brugger et al., 1999). In a study conducted with 33 climbers, it is determined that 6 of them have auditory, 6 of them have somestetic and 4 of them have visual hallucinations at altitudes higher than 6000 m (Brugger et al., 1999). In our study 7 (4.2%) pilots reported that they had seen a different scene which was impossible to appear there. Several brain areas and visual pathways are thought to be responsible for visual hallucinations. Patients whose occipital, temporal and parietal lobes are affected experience visual phenomenon composed of complex visual hallucinations and photopsia. Baier et al (2010) included 23 patients who experienced visual hallucinations after the ischemic infarct developed on their visual pathways and the authors suggested that because of the lesions, some parts of visual cortex and afferent fibers were disinhibited and it results in visual phenomena. The lesions on the visual pathways are thought to be related with visual false perception as well. Although it is difficult to determine the exact etiology and localization, it is usually observed that in patients with visual hallucinations, occipital and occipitotemporal parts near visual pathways are affected (Kölmel, 1993). Acute hypoxia occurred during flights or hypobaric chamber trainings may affect these brain areas and cause temporary functional changings and visual hallucinations.

There are several hypotheses about auditory hallucinations observed in schizophrenic patients. The temporal cortex and superior temporal gyrus were indicated (Ertugrul and Rezaki, 2005). Verbal auditory hallucinations are meant to be explained by the patients inability to follow their internal speech and misinterpretation of their mental images; an inability to suppress the excessive attention to the voices and impairment of executive control functions of frontoparietal areas (Hugdahl, 2009). Musical hallucinations are considered to be different from verbal hallucinations by means of neural compounds (Cope and Baugley, 2009). In our study we found a very low rate of auditory hallucinations: 3 pilots (1.8%) reported hearing a voice of someone who was not really there, 5 pilots (3%) described auditory hallucinations such as hearing music, song or bell ring. 3 pilots had visual and auditory hallucinations together. Musical hallucinations described in climbers are thought to be resulting from some changings in inner ear structures such as a decrease in perilymphatic pressure related with the leakage due to a tear of round and oval windows (Gordon, 1999). This may also explain the auditory hallucinations experienced by the pilots.

Somestetic illusions and otoscopic phenomena are thought to be resulting from the inability to integrate the information related with the body (vestibular, proprioceptive and tactil) (Lopez et al., 2008). Vestibular functions and the integration of sensorial inputs occur in parietal and temporal cortexes and related limbic structures. It is suggested that acute and chronic hypoxia especially have an effect on temporo-parietal junction and prefrontal cortex. Right angular gyrus is a part of parietal cortex and it's

located on the junction of parietal and temporal lobes. The electrical stimulation of right amygdale, inferior parietal cortex or angular gyrus originate reproducible vestibular dysfunctions. These dysfunctions involve imbalance, feeling of a presence, out of body experience, feeling of swimming on the surface of the water and distorted bodily perceptions. The intensity and the duration of the stimulus determine the nature of the symptoms (Firth and Bolay, 2004). In literature it is reported that a feeling of a presence may experienced by the epileptic patients and also by the electrical stimulation of the right amygdale (Ardila and Gomez, 1998; Firth and Bolay, 2004). Nagahama et al (2010) suggested that symptoms like Capgras Syndrome, phantom boarder, reduplication of person and place and misidentification of a person result from the relative lack of blood supply on the left hypocampus, insula, ventral striatum and bilateral inferior frontal gyrus. Another explanation for the otoscopic phenomena is that the stressful life events may induce the release of endorphins that are known to decrease the temporal lobe epilepsy threshold (Arzy et al., 2005). Some authors hypothesized that alterations about body perception occur as a spectrum and the more parts of the brain are affected the wider symptom cluster appears (Lopez et al., 2010). In our study we found that 2.4% of the pilots have the feeling that their extremities are shortened, extended or felt as if they changed their shapes, 4.2% have the perception that the objects are getting bigger or getting smaller, 6.7% have the feeling that the shape of their body is changing, 13.9% have the feeling that the weight of his body is changing, 12.7% have the feeling that they leave their consciousness, 10.9% have the feeling of ascending in the air and 1.8% have the feeling of watching themselves or a part of their bodies in the mirror. In one case, all symptoms described for somestetic hallucinations were determined. Déjà vu has been described by 6.7% of the pilots in our study and although there is an ongoing debate about the origin of this phenomena that amygdale, hippocampus, parahippocampal gyrus and temporal cortex are thought to be responsible for it (Wild, 2005).

The oxygenation of the brain depends on some factors such as arterial oxygenation, the solubility of oxyhemoglobin, the concentration of hemoglobin and cerebral blood flow. Most of these factors are affected by high altitude and physical events such as sleep or exercise. Low atmospheric pressure decreases the oxygenation of the brain, the results of the emotional stress add to this hypoxia and neuropsychological symptoms develop. In our study, one of the pilots describes all somestetic illusions and visual and auditory hallucinations. One of the possible explanations of this result is that pilot may have some kind of psychiatric disorders but none of the participants has any psychiatric history. All these perceptual disorders point out similar brain regions; so another explanation may be that special sensitivity of these regions possibly give rise to some psychiatric symptoms under specific physical conditions. Detailed functional imaging studies focused on these brain areas of schizophrenic patients who experienced hypoxia during prenatal period and labor may provide important findings. It may also be suggested that hypoxic conditions may create sensitivity to the other etiological factors of schizophrenia and affect the symptoms' characteristics.

We have also obtained some affective changing and anxiety symptoms on our study population. Haws et al (2009) suggested that the suicide rate of the particular regions of USA are different from the others and they concluded that they might result from the altitude differences. The low oxygen level at high altitudes is considered to be one of the reasons of the bioenergetical dysfunctions related with the affective disorders. Hypoxia related alteration in favour of the glycolysis on the glycolytic pathway may give rise to depression if it is not treated. Because hypoxic conditions and affective disorders are both related with the switch on glycolytic pathway and mitochondrial dysfunctions, it is especially important to properly treat the metabolic disorders of the patients who have affective disorders and live at high altitudes (Haws et al., 2009). Whether the symptoms such as causeless joy, causeless fear and fear of death which we have determined appear only for a moment, it seems important that a person who does not have not any

psychiatric disorders under normal environmental conditions experience these symptoms through the alterations of these conditions.

The pilots in our study emphasize that the more they get training the less symptoms they experience. The same statement is also described in several researches in literature (Rickards and Newman, 2005; Sevilla and Gardner, 2005). Brugger et al (1999) concluded that the age and the number of climbings have a negative correlation with the hallucinatory experiences. In our study although the difference has no statistical significance, if we look at the symptoms one by one, the pilots who have been in hypobaric chamber 5 or 6 times experience less symptoms then the other pilots who have been in hypobaric chamber for 2 or 3 times. But of course it may also results from the difference among the number of pilots who have been in hypobaric chamber for 5 (5.5%) or 6 (2.4%) times and 2 (25.5%) or 3 (29.7%) times. The experience increases the person's awareness about what they will face and it may decrease the anxiety level and facilitate to adapt to the low pressured and hypoxic state. In a similar way repetitive training may increase the capacity of physiological adaptation to the different environmental conditions. This points out the importance of the cortical and limbic structures over the control of the neuropsychiatric symptoms. Between the doctors and the patients psychiatric symptoms usually become the topic of interviews during the active illness periods. For the diseases that recurrence rate is high such as mood and anxiety disorders, also for schizophrenia, obtaining more information from the patients during remission periods may be beneficial for the control of the symptoms through some neurobiological mechanisms.

There are a number of works on pilots and climbers who stay at high altitude in low pressured and hypoxic conditions. In our study pilots stayed at hypobaric chambers for very limited time periods and it is important to determine that similar symptoms with psychiatric and physical disorders have occurred. In general, low pressured conditions lead to the decrease of the arterial oxygenation and this decrease may affect the brain functions. It is known that the brain areas related with the psychiatric disorders (temporal cortex, temporoparietal junction, hippocampus etc.) are especially sensitive to the hypoxia. In order to evaluate etiological factors and the treatment choices of psychiatric disorders it is important to find that both psychiatric patients and healthy patients who are exposed to hypoxia have similar symptoms.

Acknowledgements: Special thanks to the Turkish Air Forces.

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Table 1. Neurological Symptoms

Symptom	***Rate (%)***
Dizziness	%42.4
Tingling and numbness on the tip of the fingers	%40.0
Difficulties in finding the words	%38.2
Difficulties in pronouncing the words	%32.7
Blurry vision	%30.3
Tinnitus	%30.3
Temporary tingling or loss of sensation in arms or legs	%27.3
Somnolence, fatigue	%25.5
Temporary loss of power in arms or legs	%27.3
Forgetfulness or difficulties in remembering during or after training	%23.6
Difficulties in understanding what was said	%19.4
Vertigo	%18.2
Imbalance	%17.6
Feel swinging like a pendulum	%17.0
Loss of vision	%15.2
Loss of hearing	%13.9
Loss of consciousness	%12.7
Headache	%12.7
Feel like swinging o a swing	%12.7
Feel like sailing	%12.1
Faint	%10.9
Double vision	%9.1
Feel like being pushed	%6.7
Feel as if the ground is sliping under his feet	%6.7
Feel like swimming on the surface of the water	%4.8

Table 2. Hallucinations, Somestetic Illusions and Derealization Symptoms

Symptom	***Rates (%)***
Feeling that the weight of his body is changing	%13.9
Feeling that they were leaving their behind	%12.7
Feeling of ascending the air	%10.9
Feeling that the shape of his body is changing	%6.7
Deja vu	%6.7
Having the perception that the objects are growing or getting smaller	%4.2
Feeling of seeing objects as if they are different things	%3.0
Feeling that their extremities were shortened, extended or feel as if they changed their shapes	%2.4
Feeling of watching himself or a part of his body in the mirror	%1.8
Feeling of a presence	%1.8
Feel like there are two of him	%1.8

Feel as if he is in another place	%4.3
Hearing of music, a song or a bell ring	%3.0
Hearing the voice of a person who wasn't there	%1.8

Table 3. Anxiety and Affective Symptoms

Symptoms	***Rates (%)***
Air hunger and a need to take deep breath	%36.4
Anxiety	%20.0
Causless joy	%17.6
Heart throb and excitement	%11.5
Causless fear	%6.7
Fear of death	%3.0
Feeling of pressure in the stomach and intestines	%48.5
Nausea	%13.3
Vomiting	%3.6