AGE RELATED CHANGES OF VISUAL EVOKED POTENTIALS IN MILITARY JET PILOTS DURING HYPOXEMIC HYPOXIA

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I have no financial relationships to disclose.

I will not discuss any off-label use in my presentation.
Exposure to High Altitude leads to impaired central nervous system functions induced by Hypobaric Hypoxia.

Sensory systems, and mainly visual system are reported to be severely affected by Hypoxia.
The first tissues to be affected by the lack or the drop of Oxygen are nervous tissues, above all the brain, the visual system and the auditory system.

The reduction of Oxygen supply generates in the eye an indistinct color perception and a narrowing of the visual field, as well a loss of central vision and contrast sensitivity.
At an altitude of 3,000 m, where barometric pressure is roughly 525 mmHg, we notice the occurrence of the physiological effects caused by hypoxemic hypoxia related to respiratory system (hyperventilation), cardiovascular system (increased HR) and blood.
Considering the mentioned outcomes, some Authors have dealt in the past with the issue of possible changes met by the visual and central nervous systems in hypoxemic conditions, through the investigation of Visual Evoked Potentials (VEPs) in Hypobaric Hypoxia environment.
The current study anyhow was undertaken to assess the effects just of Hypoxemic Hypoxia on the transmission of the visual signal through the Visual Evoked Potentials (VEPs) analysis, simulating a condition of breathing at an altitude of **18,000 feet (5,486 m)** through the administration of a reduced Oxygen mixture (**O₂ = 10%**).
PURPOSE

This time, above all, we have focused on the different response in younger vs. senior subjects, in order to consider potential age-related changes.
VEP is a Visual Evoked electrophysiological Potential that, using signal averaging, can be extracted from EEG activity recorded at the scalp. It can be elicited by various stimuli, usually pattern reversal or diffuse flash. In clinical practice, the reversing checkerboard is probably the most common and useful stimulus. VEP can provide important diagnostic information about the functional integrity of the visual system.
Electrodes scalp placement and recording parameters were performed according to the International Society for Clinical Electrophysiology of Vision.

Standard silver-silver chloride electrodes are recommended for recording VEPs.

The electrode impedance should always be below 5 kOhm or equal for reducing electrical interference.
METHODS

The VEPs were recorded in both eyes monocularly (Right Eye first, followed by Left Eye). breathing at sea level (SL) a mixture of gases containing 20.95% \textcolor{ForestGreen}{oxygen} and 78.08% \textcolor{OliveGreen}{nitrogen}. 
A group of 98 jet pilots who had formerly been exposed to hypoxia at high altitude (male, acclimatized, 20/20 UCVA/BCVA healthy, mean age 26-49 years) was split into 2 age subgroups:

A) **26-36 years**
B) **37-49 years**

Visual Evoked Potentials (VEPs) were first recorded at Sea Level (760 mmHg) and then at simulated High Altitude (HA) of 18,000 feet (380 mmHg), breathing a reduced Oxygen mixture (10%) inducing after 15 minutes 70% of SaO2 monitored by pulsioximeter.
METHODS

The analysis was carried out using two different kinds of stimulus (15' and 60' of arc pattern-reversal checkerboard).

The absolute Latencies and the Amplitudes of negative (N1) and positive (P1) waves were recorded.

The results obtained through VEPs analysis in the two study groups were compared each other using Student’s T-test.
Distance of the subject's eye from pattern reversal screen → 57 cm

15° of arc checkerboard pattern → Foveal stimulation

60° of arc checkerboard pattern → Parafoveal stimulation
The results obtained from the VEPs analysis in the two study subgroups were compared taking into account the average values found in the VEPs analysis with both kinds of stimuli (15 and 60 minutes of arc) for each single eye. A value of $p<0.05$ was considered statistically significant.
RESULTS

Group A (26-36 yrs)

In these subjects, with stimulus at 15', an increase of the Amplitude of 1.57 microvolt (+18%) occurred; with stimulus at 60', the increase was 1.8 microvolt (+19%). The increase of Latency, which also occurred during both stimuli, was equivalent to 2.09 ms (+1.9%) at 15' and 1.83 ms (+1.7%) at 60'.
RESULTS

**Group B** (37-49 yrs)

In this group, there has been a decrease of the Amplitude of 1.50 microvolt (-12%) at 15' and of 1.54 microvolt at 60' (-13%), while the Latency increased of 1.8% (+1.96 ms at 15' and +2.23 ms at 60').
RESULTS
RESULTS

GROUP A

Amplitude (μV)

15' 60'

Stimulus

GROUP B

Amplitude (μV)

15' 60'

Stimulus

Latency (ms)

100 102 104 106 108 110 112

Normoxia Hypoxia

Normoxia Hypoxia

*
GROUP A

**Amplitude**

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<th>VARIATION</th>
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<tr>
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<td>9,97</td>
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**Latency**

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**GROUP B**

### Amplitude

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### Latency

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Increase of latency delay = reduction of transmission quality of the triggered fibers
Amplitude reduction = lowered quantity of triggered fibers (small fibers are more sensitive to hypoxia than larger ones)
This outcome implies the existence of a physiological relationship between brain activity and the consequential changes of metabolism and blood flow as well as the: Neurovascular Coupling
Neurovascular Coupling

1. Neuronal activity produces a local increase of blood flow in the CNS, but it seems to be weakened during hypoxia.

2. In this condition we notice the impairment of the neurovascular compensation.

3. Visual stimulation is a strong modulator of blood flow in retina and optic nerve but it's decreasing during the aging.

4. Why this does not occur significantly at 15' suggests also the existence of a greater resistance of the parvocellular ways to hypoxemic sufferance.
DISCUSSION

Hypoxia acts simultaneously on both cerebral & retinal activity.

This complex sequence of events involving neurons and the supporting tissue Glia might explain the better resistance in younger pilots of their central nervous system to the hypoxic damage.
CONCLUSION

Our study highlighted the different electrophysiological response to hypoxia between younger and senior subjects.

Several biochemical and physiological mechanisms may explain this different outcome.

The mentioned findings allow us to assume that VEPs analysis is a simple, objective, non-invasive and reliable procedure for assessing the metabolic condition of the central nervous system.
Thanks for your kind attention!

Questions?