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Antiorthostatic Posture As an Earth Model of the Effect of Microgravity on the Human Body

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Abstract: We examined the horizontal and vertical component of diagonal optokinetic nystagmus (DOKN) in sitting posture and in the last 15 minutes of antiorthostatic posture at −30 degrees lasting 3 hours. The antiorthostatic posture is suited to the earthy model of the fluid shifting observed in microgravity. We found that the frequency of the vertical component of DOKN is rarer in antiorthostatic posture than in sitting posture. Moreover, the amplitude of the vertical component of DOKN is lower in antiorthostatic posture than is the amplitude of the horizontal component. According to our examinations, we suppose that the frequency and amplitude of vertical OKN are directed by different cerebral structures. Furthermore, we found that the heart rate becomes slower and the diastolic pressure is augmented after antiorthostatic posture and visual stimulation.

Keywords: antiorthostatic posture; circulatory system; diagonal optokinetic nystagmus; galvanic skin resistance; heart rate; perceptive-disjunctive function

In our previous examinations, we stated that the dimension of the vertical component of diagonal optokinetic nystagmus (DOKN) decreases considerably more in hypoxia than does the horizontal component [1]. Relying on these findings, we reasoned that the tectal and pretectal gaze centers organizing the vertical eye-movement are more sensitive to hypoxia than is the horizontal eye movement directing the pontine gaze center.

In this study, we sought to explain how the cranial shifting of the body fluids alters the DOKN, the circulatory system, the galvanic skin resistance, and the perceptive-disjunctive performance. The body fluids shift to the cranial direction when the gravitational attraction prevailing on the surface of the earth does not produce an effect on humans. The centripetal force of a spacecraft and the attraction of the earth equalize each other. In the spacecraft, the equalized attraction is not exactly zero; therefore, it is called *microgravity* in the literature.

In microgravity, because of the cranial shifting of fluids (blood, cerebrospinal fluid, and lymph) astronauts develop head pains, their faces bloat, their nasal mucous membranes and conjunctivae become swollen, and the blood vessels of the head swell [2,3]. The symptoms manifested in microgravity can be investigated on Earth in both wet and dry immersion (waterbed) [4], in bed rest [5,6], or in −4, −8, and −12 degrees head-down tilt position [7]. Russian (Soviet) researchers proved that the feeling of head tension reported by their astronauts can be caused by much greater head tilt [2]. We loaded the examined persons with a −30 degrees antiorthostatic position for 3 hours, according to the Russians' prescriptions.

MATERIALS AND METHODS

We examined 15 young male volunteers (ages 19–24 years). After signing consent forms, the volunteers completed a questionnaire in which they described their previous diseases, dizziness, or addiction and whether they were right- or left-handed. Their blood pressure was measured before and after the visual and antiorthostatic loading, and their perceptive-disjunctive perfor-

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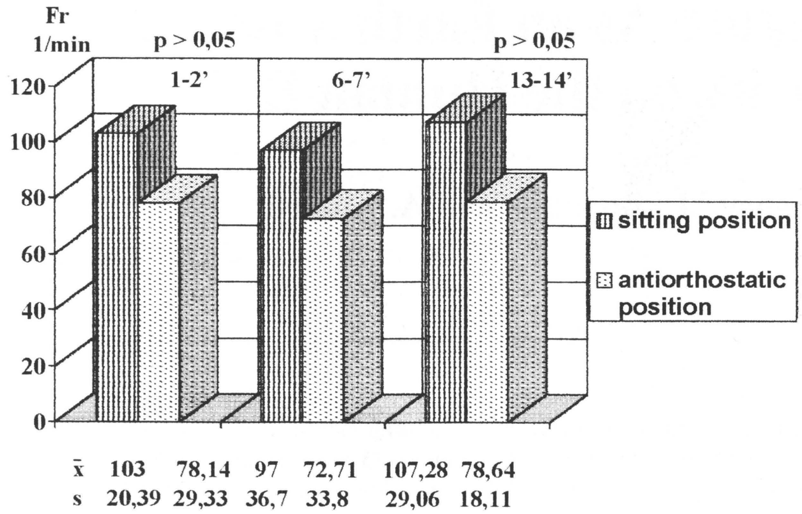

Figure 1. In the samples taken from the first and second minutes and the thirteenth and fourteenth minutes of the 3-hour-long antiorthostatic posture, the vertical component of diagonal optokinetic nystagmus is significantly rarer than in sitting position.

mances also were determined. The latter was accomplished by an instrument containing four lamps, one of which flashed 60 times in random order. When the subject volunteer had observed these flashes, he was directed to touch the right lamp with a perceptive tool. The instrument measured the time elapsed between the lighting of the lamp and the volunteer's touch and registered the number of volunteer's errors. The examinations were performed by both the right and the left hands. Three left-handed persons did not take part in this examination.

The optokinetic stimulation was performed on a screen (37-cm diagonal diameter) on which 2-cm-wide white and black stripes were moving at 45 degrees from the upper left to the lower right at a speed of 20 degrees per second by means of a computer program. The volunteers were sitting in front of the screen at a distance of 50 cm. The horizontal component of the DOKN was carried by bitemporal electrodes to a channel of the electronystagmograph. Simultaneously, the vertical component was carried from below and above the left eye to another channel. Electrocardiograms (ECGs) and galvanic skin resistance also were registered continuously.

On the first day, the optokinetic stimulation lasted for 15 minutes in sitting posture. On the second day, the volunteers lay on their backs with −30 degrees (antiorthostatic posture) for 180 minutes on an oblique table. In the last 15 minutes of this posture, optokinetic stimulation was accomplished by means of a computer screen suitably fixed to the table. The eye movement, the ECG, and the galvanic skin resistance were registered as they had been in the sitting posture on the previous day. Samples were taken from the signs of continuous stimulation in the first, the second, the sixth, the seventh, and the thirteenth and fourteenth minutes, and these data were evaluated (Fig. 1).

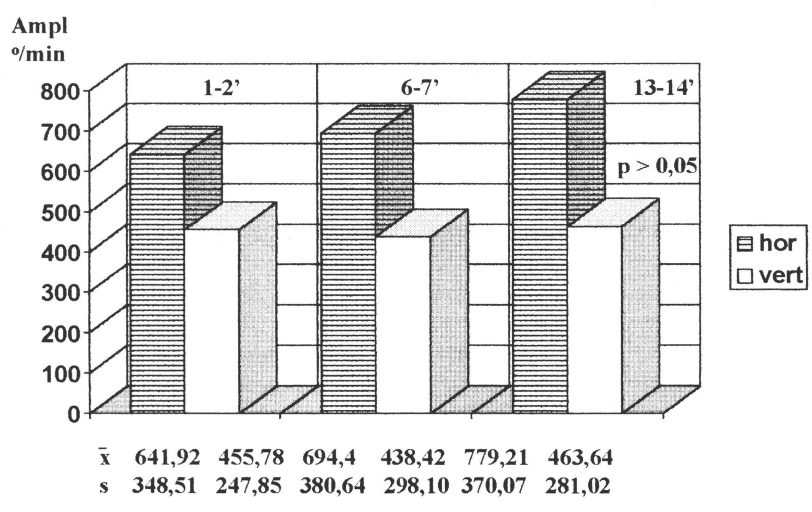

Figure 2. A significant difference is seen between the amplitudes of the horizontal and the vertical components of diagonal optokinetic nystagmus in the last sample of the last 15 minutes of the antiorthostatic posture.

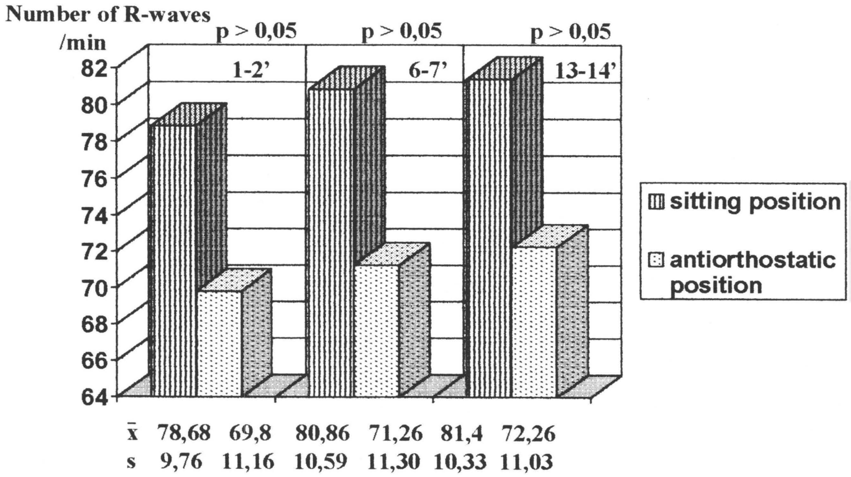

Figure 3. The frequency of R-waves decreases in the last 15 minutes of the antiorthostatic posture as compared to the diagonal optokinetic stimulation in sitting position.

RESULTS

The answers gained from the questionnaires surveying the antecedents revealed that all 15 volunteers had vomited in childhood. Three mentioned that the vomiting was elicited by the abuse of alcohol and nicotine. None of them mentioned any diseases.

The difference between the frequency of the horizontal component and the vertical component of DOKN did not change appreciably either in the sitting or in the orthostatic posture. Conversely, during the last 15 minutes of the antiorthostatic posture, the vertical component of DOKN was significantly rarer than in sitting posture.

The amplitude of the horizontal component of DOKN measured in the last 15 minutes of the antiorthostatic posture does not change greatly as compared to the DOKN measured in the sitting position. What has changed exclusively is that the amplitude of the vertical component of DOKN is lower in the last sample of antiorthostasis than is the horizontal component (Fig. 2).

ECG and eye movements were registered continuously and simultaneously both in the sitting and in the antiorthostatic posture. The frequency of R-waves decreased significantly (Fig. 3) in the last 15 minutes of the antiorthostatic posture that lasted for 3 hours (in the first, the second, the sixth, the seventh, and the thirteenth and fourteenth minutes).

The value of systolic blood pressure is not changed by the effect of visual stimulation and antiorthostatic loading as compared to the prestimulation value, but the value of diastolic blood pressure is augmented significantly (Fig. 4). Thus, the difference between the systolic and the diastolic blood pressure dwindles from the effect of stimulation of loading (i.e., the pulse pressure decreases).

The percentage of galvanic skin resistance change increased both in the sitting and in the antiorthostatic posture from the effect of DOK stimulation, but this change was not significant in statistical measurement. By the same token, the time elapsed between the lighting

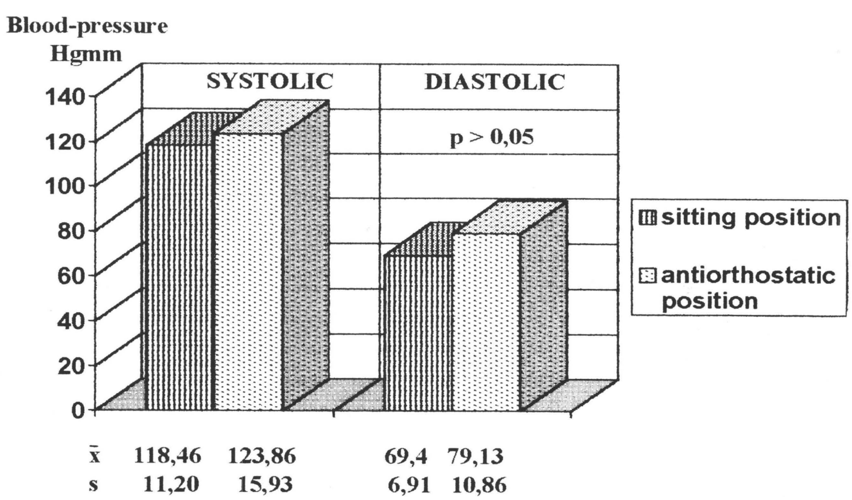

Figure 4. The diastolic blood pressure is significantly higher after antiorthostatic loading and diagonal optokinetic stimulation than in prestimulation.

and touching of the lamp (the perceptive-disjunctive instrument) did not change greatly.

DISCUSSION

In our study, we examined mainly the horizontal and the vertical component of DOKN. We ascertained that the frequency of the vertical component of DOKN decreases in the course of the antiorthostatic posture as compared to the frequency measured in the sitting posture. On the other hand, when we compared the horizontal and the vertical component of DOKN in antiorthostatic posture, the amplitude rather than the frequency decreased in the vertical component.

The results suggest that the tectal and pretectal gaze centers are much more sensitive to the antiorthostatic posture than is the pontine gaze center. This result is similar to those observed in hypoxia. As recently observed in the vertical component, in one comparison the frequency decreases and in another comparison the amplitude decreases. Explaining this difference is difficult. Possibly different fields organize the amplitude and the frequency of nystagmus in the brainstem or in the archeocerebellum.

According to our observations, the number of heart contractions decreases because of the effect of DOK stimulation. The difference between the systolic and the diastolic blood pressure decreases, because the diastolic blood pressure increases significantly.

The changes of blood circulation, which were examined comprehensively in microgravity and in the antiorthostatic posture, already have been cited. Those results were achieved by antiorthostatic (−8 degrees head-down) posture lasting for several days in patients suffering from hypotension of a different origin [8]. In the first approach, the symptoms that appeared in microgravity are attributed first to the cranial shifting of the mass of blood. The cerebrospinal fluid and the lymph, among the body fluids, also cause cranial shifting. They cause lymphostatic encephalopathy in animal experiments and in interventions in the human lymphatic system (tonsillectomy, extirpation of cervical lymphoglandulae because of tumors). The main symptoms of this effect are tumescence of conjunctivae, papilla, and retina; signs of cerebral edema; diminution of gamma-aminobutyric acid in the brain tissue; and decrease of spontaneous activity [9].

We certainly could not relate the disparities found in our examinations to the cranial shifting of the body fluids or to the so-called lymphostatic encephalopathy. In our opinion, the finding of a relationship requires further investigations.

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