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Effects of microgravity on characteristics of the vertical gaze fixation reaction (vGFR)

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Introduction. The purpose of the studies was to explore effects of long-duration space flight on characteristics of the pitch gaze fixation reaction (vGFR). **Methods.** The investigation involved cosmonauts – the members of 180-d Mir missions. Test sessions were performed four times before launch, three times during space flight (SF – FDs 24, 105 and 147), and twice after landing (R+2 and +5). During the test sessions, the human subjects were to perform the task of rapid pitch gaze fixation (vGFR) on targets at a distance of ±16 angular degrees upwards and downwards from the center. Targets were presented in a random order. It is known that this coordination of eye and head movements is governed by several feedback loops, vestibular afferenation being the leading one. Characteristics of eye and head movements were recorded using the MONIMIR system (Austria). **Results.** Before launch, during performing of this task latent periods of eye movements made up from 240 ms up to 280 ms and head movements – from 335 ms up to 400 ms. Hence, difference in the latency of the two movements varied within 95-160 ms. Time of gaze fixation amounted to 600-650 ms in two cosmonauts and to 1040 ms in the third cosmonaut. Their reactions to targets upwards from the center were 115 ms quicker on the average as compared with the reactions to targets appearing downwards from the center. Within the period of recording (1200 ms), two cosmonauts succeeded in gaze fixation on the target in 88-91,7% of cases and the third – in 100%. During the compensatory eye counterrotation one corrective saccade was registered in 50-60% in each of the cosmonauts. In flight, the saccade latent periods did not change; however, the head movement latency increased by 100-120 ms on the average. Difference in the latency of head and eye movements altered on the same pattern reaching 150-200 ms. The mean velocity of head movements showed a significant decrease (by 20-40%), too. These changes were particularly evident in reactions to the targets appearing downwards from the center. The maximal velocity of eye movements both in their saccadic and counterrotation's phases slowed down in SFs with changes being more pronounced during upwards vGFR. As in the case with the head movements, maximal changes in the saccade velocity recorded in the first month reaching 55-60% and being smoothed over by month 4 in space flight to 40-43%. Time of gaze fixation in flight extended by 400-600 ms and more being longest on FD-105. The number of reactions completed by gaze fixation in 1200 ms was reduced considerably in space flight amounting by FD-105 only 33-58 %. Corrective saccades during eye counterrotation's phase were met much more frequently during SF (70-100% on FD-105). The Kvor during counterrotation's phase increased greatly in SF reaching 4,3 on the FD 105 (instead of 1,0±0,03 before flight). - After landing, most GFR characteristics returned to baseline values, however, on R+2 the time of gaze fixation was still 730-770 ms at most and regained the preflight values (550-620 ms) only on R+5. **Conclusions.** Changes in the GFR characteristics recorded in the course of long-duration SF point out to serious disturbances within the VOR system due to, apparently, an altered vestibular activities.

The studies represent a part of the joint Russian-Austrian Program (Austromir RLF) performed in SFs on the MIR Station.

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Introduction

Changes in sensori-motor functions occur consistently and regularly during different duration spaceflights. Weightlessness causes disturbances in the main proprioceptive systems – vestibular, weightbearing and muscular due to the changes in motor control systems. These changes are expressed in orientation of motor control systems to the other, more stable afferent systems, such as vision. At the same time numerous investigations performed on primates and human showed that weightlessness causes the changes of all the parameters of visual observation, and the vertical movements, based on otolyth's afferentation, suffer most of all (Kornilova et.al., 1979, 1982, 1987; Kozlovskaya et.al., 1985, 1986). One of the main sensori-motor reactions, based on vestibular afferentation is gaze fixation reaction (GFR) on a target presented to the peripheral visual field. Difficult coordination of saccadic and slow movements of eye and head precisely organized in time is provided on the whole by vestibular afferentation and is controlled by the vestibular-cerebellum system. So, as it was shown before, this reaction is adequate and high informative method for studying of vestibular function in weightlessness, and number of its temporal and amplitude characteristics reflect the changes of excitability of constituents of vestibular system.

Investigations were carried out within the framework of Russian-Austrian experiment «Monimir». The impellent problem carried out by examinees consist in fast gaze fixation on the visual target suddenly appearing in a peripheral field of vision on distance 160 sm. The visual

targets submitted by red light-emitting diodes in the size in 0,5 angular degree, were showed in the casual order in a horizontal and vertical plane on distance of 16 angular degrees from the center. Peripheral targets were showed after gaze fixation on the central target which again was included after end peripheral GFR. Movements of eyes registered using the method of standard electrooculography (EOG), movements of a head – a method of the videoanalysis. All hardware maintenance of experiment has been developed by the Austrian experts.

It is necessary to note, that in all previous researches executed on monkeys and the human, characteristics of horizontal GFR were investigated. For this reason in our research characteristics both horizontal, and vertical reaction were defined.

Research has been in full executed on 9 members of space flights by duration from 180 till 430 day and one participant 7-day's space expedition on " MIR" station. However in connection with changes in programs of the data computer analysis for today it was possible to process the data only from three participants of the experiment which has been carried out in flight by duration in 180 day.

Methods

Testings at the given cosmonauts were carried out 4 times before flight, in flight (for 25, 105 and 135 day) and after its end (on 2 and 5 postflight day). During processing were analyzed temporal and accuracy characteristics of reaction, namely: the latency of movements of eyes and head, their duration, amplitude and velocity; calculated size of koefficient of vestibulo-ocular reflex, the providing stabilization of gaze on a target while the answer of eye and head not completed.

The data processed with the help of the software "BSANALYS", developed by the Austrian experts. However in connection with changes in the program after end of the first stage of longterm flight, in which 7 cosmonauts participated (expedition "MIR - 15") duration of 180 day, standard use of the program appeared impossible. In result processing and the analysis only 3 participants of experiment have been lead: two – completely and one – till 135 day of flight.

Results

Despite of it, results appeared demonstrative. Before flight all astronauts carried out GFR standardly. Reactions to horizontal and vertical targets essentially did not differ. The first, with the latent period 205-230 msec arose saccadic movement of eyes aside targets. Through 60 - 70 msec turn of a head in the same party began. During this second phase of reaction, the gaze reached the purpose then the head continued movement in the same direction, and compensatory movement of eyes with the velocity equal to velocity of head movement that provided stabilization of gaze on a target at even uncompleted impellent answer.

In weightlessness temporal and accuracy characteristics of reaction essentially changed. The general time of gaze fixation at all surveyed grew by 80 % and more. Velocities of movements of eyes and heads aside targets decreased, at the same time velocity of compensatory eye movements increased.

The koefficient of VOR, making before flight 1,0 ± 0,03, by the end of the first month of flight increased, reaching in a phase of compensatory movements of eyes values in 1,4 (at performance gGFR) and 4,3 (at

The data of the present research were reported by E.S.Tomilovskaya in the co-authorship with M.Berger, F.Gerstenbrand and I.B.Kozlovskaya at 4 conferences including international, and have caused the big interest of experts. It is represented to the extremely important to process all available material being unique. We very much hope, that joint efforts we will manage to make it.

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