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INFLUENCE OF MOBILITY RESTRICTION ON HABITUATION OF THE VESTIBULAR APPARATUS

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Recently specialists in space medicine have shown great interest in a compre- /1005*
hensive study of hypokinesia as one of the factors in space flight. Prolonged restriction of mobility causes disruptions in the activities of various functional systems: cardiovascular [3,15], respiration [10], support-muscular (1,11,13), blood [5, 18], metabolic [14]. Hypokinesia affects the bioelectric activity of the brain [6,13] and human psychic functions [2,11].

The vestibular function likewise undergoes definite changes taking the form of deterioration in tolerance of angular and rectilinear acceleration [17,19]. However the bedrest method of hypokinesia, aside from the actual restriction of motor activity, also alters the direction of gravity in respect to the longitudinal axis of the body (the so-called orthostatic factor), which by its very nature may prove to be the cause of many disorders. This situation may be avoided in experiments with laboratory animals where the horizontal orientation of the body does not really change when they are placed in hypokinetic cages.

The most important feature in the study of the vestibular function under hypokinetic conditions appeared to be an investigation of the reactivity of the vestibular apparatus to repeated angular acceleration or the so-called habituation phenomenon, a process which is based upon vestibular training.

The experiments were conducted on 16 vigorous adult rabbits of both sexes weighing 3.0-3.5 kg. They were divided into two groups of eight. Animals in the experimental group were kept in hypokinesia for 30 days, achieved by placing them in special cages that severely restricted mobility [8]. The controls were kept in ordinary vivarium conditions. Nystagmus was induced by the action of negative angular acceleration 40°/sec produced by a platform revolving at 360°/sec located on the axis of a TSLS-3 laboratory centrifuge. Previous to the experiment the animals were equipped with a special costume and placed on the revolving platform of the centrifuge.

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*Numbers in the margin indicate pagination in the foreign text.

The horizontal semicircular canals were situated in the optimal stimulation position (head affixed at the pivotal center at an angle of 40-45° to the horizontal plane). To eliminate sight during rotation the animals were blindfolded.

The experiment pattern was as follows: at first the animals were subjected to a single counterclockwise rotation (pretest to the left). Then there were 20 clockwise rotations at 5 minute intervals followed by a single counterclockwise rotation (posttest to the left). Clockwise rotations 1 and 20 were designated respectively as clockwise pre- and posttests. The animals of the experimental group were subjected to a similar effect at the end of 30-day hypokinesia.

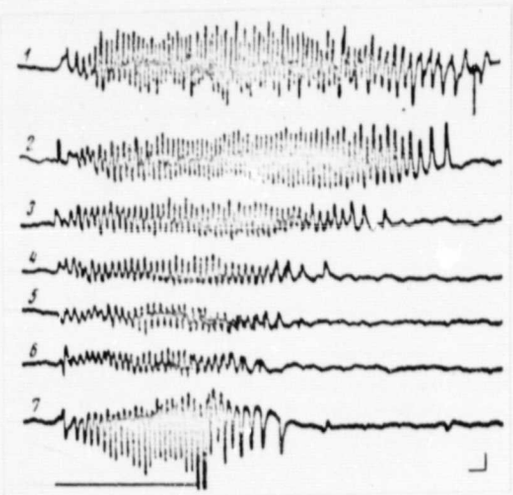

Fig. 1. Nystagmic reaction in rabbits of control group. 1, 7 - nystagmus at counterclockwise pre- and posttests. 2 to 6 - nystagmus at clockwise tests #1, 5, 10, 15, 20. Heavy straight line at bottom - duration of angular acceleration. Calibration: 1 sec, 100 mv

For recording electronystagmograms /1006 we sewed into the corner of one eye electrodes in the form of silverplated multistrand wires with fluoroplastic insulation, the other ends applied to the skull subcutaneously and soldered to a polyrod connection. This was attached to the skull with styroclear. The electronystagmogram was made on an Elema-Schönander mingograph with a time constant of 2.5-5 sec. At the same time a reinforced signal was fed into an SDR-41 recorder (Nihon Cohden) and recorded by means of a PW-1 block with a transmission band of 0-60 Hz. Quantitative processing of the electronystagmogram was done with magnetic tape on a central electronic computer M-220.A following a specially designed program. These electronystagmographic parameters were considered: total number of nystagmic jerks, length of all reactions, average frequency, amplitude, length and speed of fast and slow nystagmic phases (in microvolts/sec).

Control Study. With repeated rotation in one direction the nystagmic reaction of the eyes shows changes in all indices. From one revolution to the next there is a gradual decrease in the average values of speed of the slow phase of nystagmus, amplitude,

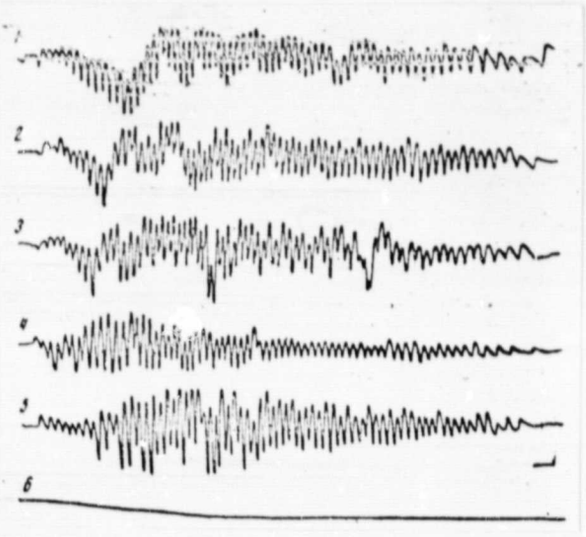

Fig. 2. Nystagmic reaction of rabbits to 31 days hypokinesia. 1-5 nystagmus reaction to clockwise tests #1, 5, 10, 15, 20. 6 - indication of platform rotation speed. Calibration: 1 sec, 100 microvolts

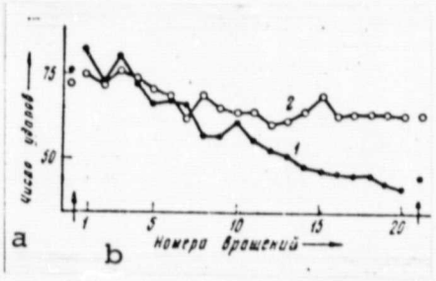

Fig. 3. Graphic representation of change in total number of nystagmic jerks in normal (1) and hypokinetic (2) rabbits reacting to 20th clockwise revolution with negative acceleration of 40°/sec. Arrows show counterclockwise pre- and posttests for both groups of animals. Graphy plotted on average arithemetic values.

Key: a. Number of jerks.
b. Rotation numbers.

the schedule described above.

frequency, total number of nystagmic jerks, length of reaction (Fig. 1). These changes have an undulating character.

Among the selected nystagmic indices those showing the most significant changes are the speed of the slow phase and the total number of jerks. In respect to the latter index the level of significance was already unusually high at the 8th clockwise rotation test ($P<0.01$) and at the 20th ($P<0.001$). Changes in average frequency are less indicative. At the 12th clockwise test the level of significance corresponds to the first threshold of reliability ($P = 0.05$), but on the 20th test the difference was not reliable ($P>0.05$). A comparison of the counterclockwise pre- and posttests likewise revealed a reliable difference between them with the exclusion of the average frequency (Table 1).

Hypokinetic Animals. During the first 3 days following their being placed in mobility-restricting cages the animals presented serious motor restlessness. They usually calmed down on days 3-4. Toward the end of the experimental period the rabbits lost weight, on the average 0.3-0.4 kg (~10%). On day 31 they were taken from the cages, dressed in the costume and subjected to the rotational tests on the schedule described above.

Their nystagmic reaction to the left and right rotation pretests were practically the same as for the controls (Table 1). However with repeated clockwise revolu-

TABLE 1. ELECTRONYSTAGMIC INDICES FOR CONTROL (UPPER VALUES) AND HYPOKINETIC RABBITS (LOWER VALUES) AT COUNTERCLOCKWISE AND CLOCKWISE PRE- AND POSTTESTS BASED ON AVERAGE VALUES AND LEVEL OF SIGNIFICANCE P

a Показатели нистагма	b Вращение вправо			c Вращение влево		
	d Претест	e Постгест	P	d Претест	e Постгест	P
f Скорость медленной фазы в μv/сек	2230±95 2153±115	918±198 2015±120	$<0,001$ $>0,25$	2190±115 2200±193	1120±100 2010±114	$<0,002$ $>0,25$
g Общее количество ударов	82,6±4,7 74,6±7,5	42,5±5,8 63,8±7,7	$<0,001$ $>0,25$	75,6±8,2 71,6±5,4	45,3±6,0 64,3±6,4	$>0,01$ $>0,25$
h Продолжительность реакции в сек.	29,8±1,8 27,0±2,3	18,3±1,2 26,9±2,7	$<0,001$ $>0,5$	30,1±4,1 2514±2,1	20,4±1,6 23,4±1,6	$<0,05$ $>0,25$
i Средняя частота в сек.	2,8±0,14 2,7±0,18	2,3±0,23 2,3±0,18	$>0,05$ $>0,1$	2,6±0,13 2,8±0,15	2,2±0,16 2,8±0,15	$>0,05$ —

Key: a. Nystagmic indices
b. Rotation clockwise
c. Rotation counterclockwise
d. Prestest
e. Posttest
f. Slow phase speed in microvolts/sec
g. Total number of jerks
h. Length of reaction in seconds
i. Average frequency in seconds

tions there was a striking difference between these two groups of animals. In the first seven rotation tests the nystagmic reaction of the hypokinetic animals and controls did not differ in any noticeable way. The difference appeared at test 8: /1007 the reaction of the controls decreased from one rotation to the next in a progressive way, while in the hypokinetic animals it stayed at practically the same level. Not one of the 8 hypokinetic animals showed any noticeable reduction in reaction to the selected nystagmic indices (Fig. 2, 3).

Evaluation. One might expect, that mobility restriction might reduce the activity of the vestibular receptors which normally react to a change in position of the head or whole body in space as a result of their "non-use". The latter, as is well known, leads to a weakening of afferentation and the buildup of a stimulation deficit in the centers that correspond to this afferentation [16]. Activity of the vestibular receptors may also be affected by changes in the water-salt exchange and the hemodynamics noted, as a rule, in animals under conditions of mobility restriction [8,9, 20]. Results of experiments have shown, that 30-day hypokinesia had no effect on the intensity of the nystagmus itself: slow phase speed, total jerks and length of reaction in the animals were the same as before hypokinesia and practically the same as for the controls (Table 1). This suggests, that in relatively prolonged hypokinesia there is no noticeable change in the spastic processes on the way from the receptors of the semicircular canals through the vestibular nuclei and reticular formation

of the brainstem to the oculomotor nuclei. This situation points to the maintenance of control by the cerebellum, brainstem and cortex of the large hemispheres.

At the same time restriction of motor activity led to the disappearance of the habituation of the vestibular system in respect to repeated angular acceleration. /1008 At this time it is hard to explain the reason for this phenomenon. The most significant changes for rabbits in hypokinesia have been established in the endocrine system [12]. By the end of a month's hypokinesia the amount of corticosteroids and catecholamines in the blood plasma, adrenal glands and hypothalamus had dropped 2-4 times on the average and there was a significant increase in the electric stimulation thresholds of the posterior hypothalamus indicating a reduction in its excitability [7].

Is not such a sharp reduction in the adrenal function the reason for the disappearance of habituation in hypokinesia? This hypothesis is based on the general thesis concerning the lead role of the adrenergic system in adaptation-accommodation reactions of the organism and especially in the function of the reticular formation of the brainstem, whose role in the phenomenon of habituation is well known [4].

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