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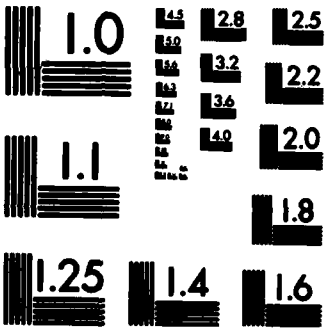

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EFFECT OF PARTIAL RESTRAINT OF MOTOR ACTIVITY ON BASIC PHYSIOLOGICAL PROCESSES IN MONKEYS

by

I.D. Bogina, N.A. Rokotova, et al

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О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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EFFECT OF PARTIAL RESTRAINT OF MOTOR ACTIVITY ON BASIC PHYSIOLOGICAL PROCESSES IN MONKEYS

I.D. Bogina, N.A. Rokotova, Ye.S. Rogovenko, R.L. Sheykin

Investigations on the study of the effect of the partial restraint of motor activity on basic physiological processes, the behavior and functional state of the nervous system of monkeys are being conducted in our laboratory for the extent of two years. The need for such kind of studies was dictated by the fact that in prolonged flights in space under conditions of weightlessness, the partial fixation of man and animals becomes the standard form of existence during the greater part of the flight.

From the presently available literature data, it is well-known that if the monkeys are fixed only for the period of the experiment in order to measure their blood pressure, to record the respiration and pulse rate, and for the investigation to take the blood or gastric juice [1-4], then results of the first studies proved to be very nonuniform. Observed in the monkeys are sudden oscillations in the magnitudes characterizing a certain reaction, which disappear only after a considerable number of experiments when the animals get accustomed to the procedure of fixation.

According to data published in the press by a group of American scientists [5, 6, 7] who conducted observations on monkeys which completed flights on ballistic rockets, the conditions of very rigid fixation, in which the animals were found in a swaddled state for 24-69 hours, caused no significant changes in the body temperature,

respiration rate and heart-beat rate. The EKG and EEG data also did not indicate serious deviations from the normal state of the animals. It must be noted that the monkeys gradually got accustomed to the conditions of the rigid fixation. Training of the monkeys was begun with short-term experiments, and as the monkeys became accustomed to the binding in the capsule, the duration of the experiment was increased to 24 hours and more. However, the authors point to the fact that some of the monkeys were unable to become accustomed to to endure conditions of the rigid fixation. Observed in the animals is a sharply marked agitation, increasing the temperature of the body and increasing the respiration and pulse. Such monkeys became unsuitable for further experiments.

Mason and Lilly [6, 7] observed the monkeys under conditions of partial restraint of movement. They placed the animals into special fixator-seats, in which the monkeys lived from 4-6 weeks to 14-15 months. According to data of the authors, the monkeys endured well the conditions of partial fixation and by the 4-5th day completely became accustomed to the new conditions of existence. As a result of the prolonged stay in a sitting position, in the animals a certain weakness of the muscles was developed, and edemas of the rear limbs were observed.

In the very beginning of our investigation we used the fixator-seats of the design of these authors, but subsequently used was the fixing device developed by us in the laboratory of R.L. Sheykin, which proved to be more convenient and portable.

The fixator-seat of Mason adn Lilly is a bulky device of plexiglass in the form of a cube, inside which consists of the body and shoulder belt of the monkey. The head is brought out into a hole on the upper side of the cube and is secured by blocks at the neck. The pelvis and rear limbs of the monkey are brought out into the hole on the rear side of the cube, to which the seat is attached. The body of the monkey is secured by an abdominal block, and the rear limbs are set onto pedals [foot levers]. On the upper side of the cube there are holes for the hands, through which the monkey takes food and brings it to the mouth. In such conditions the reactions of searching and scratching so natural for monkeys are

difficult.

The fixator of the Sheykin design is based on another principle. The animal is fixed with a belt and collar fastened to vertical braces secured by a common base. Depending on the nature of the monkeys, either a seat (for macaques) or footboards (for Capuchin monkeys) are attached to the braces. In such conditions the animal can move his limbs freely or change position. With prolonged fixation in the Sheykin device, edemas of the rear limbs and weakness of the abdominal muscles were not observed.

In setting about the experiments with fixation of the monkeys, we posed the problem of tracking how the prolonged partial restraint of motor activity affects the daily rhythm of the behavior of the monkeys, their feeding excitability and the appearance of a reference reflex. Results of the first series of experiments conducted by I.D. Bogina, O.P. Bolotina, T.M. Kucherenko, N.A. Rokotovaya, Ye.S. Rogovenko, and R.L. Sheykin on four monkeys showed that only during the first 2-4 days of the fixation were there observed in the monkeys an insignificant decrease in the activity of sleep and an oppression of the reference-research reflex. The feeding excitability of the monkeys, determined by the quantity eaten during days of feeding, for the whole extent of the fixation (from 10 days to 3.5-4 months) remained high, and by the end of the experimental period the animals gained weight. The daily inspection of the state of health of the fixed monkeys did not reveal any pathological deviations.

After freeing the animals from the fixing device, certain difficulties in walking were observed: the monkeys moved their rear limbs with uncertainty and sometimes stumbled. Sitting on the shelf, they tried to take the position in which they were found in the fixator: the legs hung down, and they held onto a stick of the cage. After a prolonged fixation (four months), disturbances in the orientation in space were noted, and they were expressed in the fact that with jumping from one shelf to the other or from a shelf to the wall of the cage the monkeys could not estimate distance correctly. In such cases either they did not jump to their goal and fell down, or the jump was too great, and the animals banged against the wall

of the cage. But all these consequences of fixation were short-term and after 2-3 hours passed. A female monkey was placed next to a male,who had been in the fixator-seat for 3.5 months, several days after he was freed. The sexual function of the male after the fixation remained normal. The baby animal born to the pair was completely vigorous and at present is growing well and developing.

In continuing our investigation, we pursued the goal of making certain that animals who for a prolonged time are in conditions of restraint of the motor activity can serve as a valuable object for studying other factors acting on the organizm during space flights. To do this, it was necessary to trace not only the general behavior of animals under conditions of fixation, but also to study in them certain physiological processes - levels of their indices, limits of fluctuations and stability.

The task of the second series of experiments was the study of the daily respiration rhythm, heart activity and bioelectrical activity of the brain of fixed monkeys.

The experiments were conducted on three monkeys: two Capuchin and one macaque. Used in the second series were fixing devices of the Sheykin design equipped with devices necessary for the recording of respiration, motor activity, EKG, and EEG.

The objective recording of the frequency of respiration and motor activity in two fixed Capuchin monkeys was accomplished by an instrument specially designed for this purpose by Sheykin. The instrument consists of a tape-transport mechanism, two identical amplification and recording channels, a circuit for marking time, and an electromechanical time relay.

The recording of the respiration rate was done by sensors sewn into a special coat made from elastic cloth and tightly fitting the trunk of the monkey. The sensors, in the form of thin rubber tubes filled with carbon powder, were positioned by three rings around the thorax of the monkey. All three sensors were connected in parallel into one of the arms of the bridge circuit. The obtained potential was amplified by a single-stage amplifier of dc voltage, and connected at the output of the amplifier was a low-impedance ink pen writer of a magneto-electric system, which ensures

deviation of the pen in proportion to the force of the signal.

The motor activity of the animal was recorded on the second similar channel by means of carbon sensors connected with the moving parts of the fixator (the fastening of the collar and belt by which the monkeys are restrained).

The recording was produced on a paper tape with a width of 35 mm. The time marking was conducted once every two seconds with the tape movement rate of 3 mm/s. The time relay made it possible to switch the instrument on and off with the assigned periodicity. The motor activity had an effect on the recording of respiration only when there were great movements of the animal, which practically did not disturb the count of the number of respirations.

The recording of respiration was conducted around-the-clock during the 1, 2, 3, and 15 days of fixation. The average rate of respirations with the average error of deviation was calculated for the following time periods: from 0700 to 1700 hours, from 1700 to 2200 hours and from 2200 to 0700 hours the following day. Such a division of time into periods was expedient because the monkeys were located in the room of the laboratory, and, naturally, during the working hours there were more external irritants affecting the animals than in the evening hours, when work in the laboratory was completed. Furthermore, it was of interest to compare the respiration rhythm of the monkeys in the awake state and during sleep.

The data obtained showed that changes in the respiration rate were mainly associated with the motor activity of the animals. Figure 1 gives the respiration rate of the fixed monkeys during the first three days of fixation (Fig. 1, A) and during days two weeks after the beginning of the experiment (Fig. 1, B). As is evident from the figure, the respiration rate in the monkeys under restrained conditions varied from 32 to 47 per minute. A certain decrease in the respiration rate was observed during the nighttime hours when the monkeys were sleeping. Recordings conducted two weeks after the beginning of the fixation did not reveal substantial differences from the data obtained at the beginning of the experiment. Figure 2 gives recordings obtained for the monkey named Caroline during daytime hours when the monkey was awake (Fig. 2, A) and at nighttime,

when the monkey slept (Fig. 2, B). As is evident on the figure, the respiration rate in the sleeping animal differed by a more sparse rhythm and less amplitude.

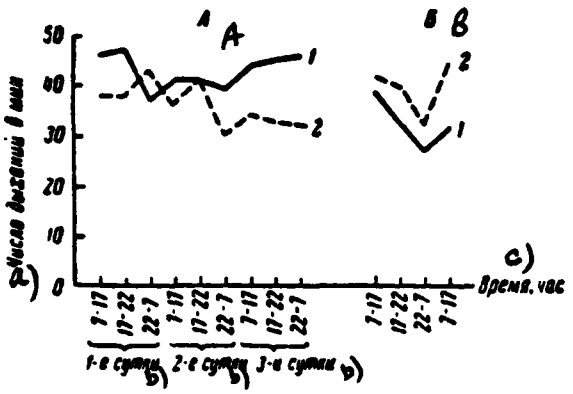

Fig. 1. Respiration rate in the restrained monkeys. A - respiration rate in the first three days of fixation; B - respiration rate two weeks after the beginning of fixation; 1 - respiration rate in the Capuchin monkey by the name of Caroline; 2 - respiration rate in the Capuchin monkey by the name of Yurkiy. Key: a) number of respirations per minute; b) days; c) time, hours.

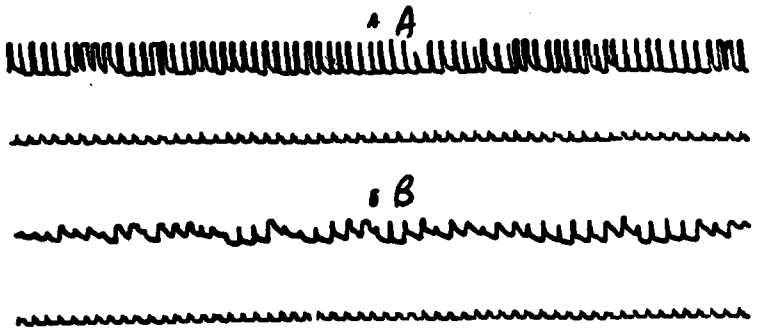

Fig. 2. Recordings of respiration rate of the Capuchin monkey named Caroline at a different time of the day. A - recording of respiration made during awake period of animal (at 1500 hours); B - recording of respiration made during sleep period of animal (at 0400 hours); upper curve - recording of respiration; lower curve - time mark (2 seconds).

Monitoring of the heart activity (pulse rate) of the restrained monkeys was done by data of an EKG, which was recorded simultaneously with the recording of the bioelectrical activity of the brain. The EKG was recorded by plate electrodes with the skin surface of the middle third of the forearms. The biotics of the brain were taken bipolar by needle electrodes, which were inserted each time before the beginning of the recording subcutaneously into the right occipital region. Here the monkeys were subjected to a more rigid restraint

by means of a special head holder, which is made of plexiglass in the form of an animal's head with holes for the ears and soft packing along the edges. The head holder was fastened to the fixator and covered the head of the monkey on both sides so that the animal could not move the head. After the securing of the electrodes (needle and plate), the fixator and monkey were placed into a darkened screened chamber where the animal was kept for 35-40 minutes, after which recordings of EKG and bioelectric activity of the brain were made. A rhythm light with a frequency of 5, 10 and 15 Hz was applied to the eyes as an external irritant.

As the conducted experiments showed, the pulse rate at rest varied from 120 to 160 beats per minute in the macaque and from 200 to 250 beats/min in the Capuchins. Under the effect of the external irritant (strobing of the eyes), the pulse rate was slightly increased. In the macaque, for example, the pulse rate was increased up to 200 beats/min. For the extent of the whole period of fixation, the pulse rate in all the animals did not change substantially.

The bioelectrical activity of the cerebral cortex of restrained monkeys can be characterized in the following way: in the macaque, at rest, observed is an alpha-like rhythm with a frequency of 8-12 oscillations per second and a mean amplitude of up to 90-95 μV. The strobing of the eyes in certain experiments causes a distinct retardation of this rhythm. For the Capuchins the most characteristic is the beta-like activity with a frequency of 25-35 oscillations per second and a mean amplitude of 70 μV. Figure 3 gives the recording of the EKG and bioelectrical activity of the brain in the Capuchin monkey Yurkiy with a strobing of the eyes at a frequency of 10 Hz. In the majority of the experiments on Capuchins, as is evident on the figure, with the strobing of the eyes there were observed responses synchronous to the rhythm of the light which ocurred according to the type of "secondary responses" of the cortex in the nonanesthetisized animals.

The nature of the bioelectrical activity of the brain in all the monkeys during the entire time of tay in the fixator was not considerably changed, and any ...ic... ors of pathological activity was not noted.

The respiratory rhythm and pulse rate in monkeys of the macaque and Capuchin species have been studied quite fully, and numerous data on these indices are available in literature. It is well-known that in the macaque, in the norm the pulse rate varies within 120--140 beats/min, and in Capuchins the pulse is more frequent, approximately 180-220 beats/min. The respiration rate in monkeys varies from 36-38 to 40-42 per minute.

Fig. 3. EKG and EEG in Capuchin monkey named Yurkiy with strobing of the eyes at a frequency of 10 Hz. 1 - EKG; 2 - EEG; 3 - mark of stimulation; 4 - time mark (0.1 s).

The data obtained by us indicate that for monkeys under conditions of partial restraint, the respiration, heart beat and bioelectrical activity of the brain are maintained within the norm for the extent of the whole period of partial restraint of the motor activity.

If we compare results of our investigations with the data available in literature, then it becomes evident that the chronic fixation has certain advantages as compared with the restraint of movements for short periods. Probably, in the investigations of the American scientists, the very situation of the experiment (form of the capsule, fastening devices, experimenters, and so on) caused in some animals, with each time, ever greater negative reactions and, ultimately, such monkeys had to be rejected. Evidently, in virtue of these reasons, in the works of Startsev, Utkin and Avdzhian there are references to the fact that in order to obtain stable indices of blood pressure, respiration, pulse, and other reactions, a considerable number of experiments is required on the monkeys.

If the monkey remains under restrained conditions for a long time (several days and more), then the acclimatization of the to the existence with restaint of movements approaches rapidly, since eliminated are the factors causing the constant stimulation of the monkey in the form of preparations for th experiment. We explain

this by the stability of the basic physiological processes in our animals, which set in already in the first hours of restraint.

Results of the conducted experiments allow us to consider that animals under conditions of prolonged restraint of motor activity can be used for studying different problems of space biology and physiology as a valuable object of investigation.

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