anisms leading by the feedback principle to the development of secondary hypocoagulation became involved in the reaction [5, 6].

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LIFTING REFLEX OF ALBINO RATS AFTER LONG SPACE FLIGHT (EFFECT OF WEIGHTLESSNESS AND ARTIFICIAL GRAVITY)

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The lifting reflex (LR) of animals is a variant of vestibulospinal reflexes. It is stimulated by progressive vertical movements and is manifested as a relatively stable system of motor responses. In most warm-blooded animals during downward movement from their natural position extension of the limbs and raising of the trunk are observed [3, 4, 6, 7].

TABLE 1. Range and Character of Investigations

Satellite	Duration of flight, days	Number of animals tested								Parameter tested and method of investigation			
		flight			control					LPLR		RJR	Motion picture
					SC group			AHC group					
		intact	delabyrinthized	exposed to artificial gravity	intact	delabyrinthized	exposed to artificial gravity	intact	delabyrinthized	MCMR	EMG		
Kosmos-936	18,5	15 (10)	5	10 (5)	5	5	5	5	5	+		+	+
Kosmos-1129	19,0	10 (5)			5			5			+	+	+

Legend. Number of animals observed additionally on zero days (immediately after landing) shown in parentheses.

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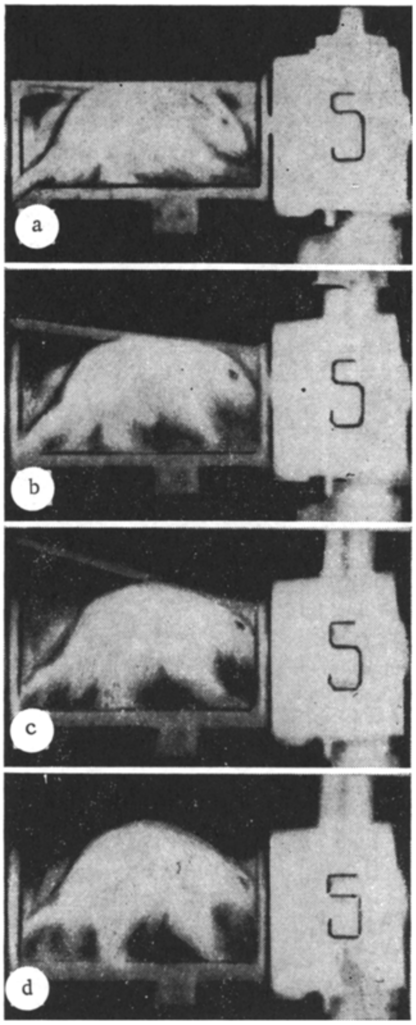

Fig. 1. Motion pictures of successive phases of LR of rat during falling in container, with lid lifted.

There is as yet no unanimity regarding the physiological mechanisms of this reflex. In rats, cats, dogs, and monkeys the LR is not elicited after total labyrinthectomy, whereas in guinea pigs it can still appear because of extralabyrinthine reception [4]. In the investigation cited above it was also shown that removal of the otoliths if the semicircular canals are preserved does not abolish LR. This suggested to the author of that paper that LR is a semicircular canal reflex. If, however, the otoliths are preserved in animals (even if only on one side), and all other parts of the vestibular apparatus (VA) were inactivated, the LR could still be elicited [6]. During brief exposure to weightlessness, it was impossible to induce LR [3, 7]. These facts were regarded as the result of loss of vestibular function in weightlessness [7] or of the reduction in muscular reactivity to progressive movements [3].

The object of this investigation was to determine what length of space flights (SF) can affect LR in animals after their return to their normal gravitational environment and what part is played in these changes (if they exist) by VA.

EXPERIMENTAL METHOD

Experiments were carried out before and after 19-day SF of male Wistar-SPF rats on the biological satellites Kosmos-936 and Kosmos-1129. Intact and delabyrinthized animals and also animals exposed to artificial gravity of 1 g on an on-board centrifuge (OBC) during SF. VA was inactivated 2-3 weeks before SF by electrocoagulation [5]. Each group of SF animals had their counterparts on earth in a synchronous control (SC), for which all the

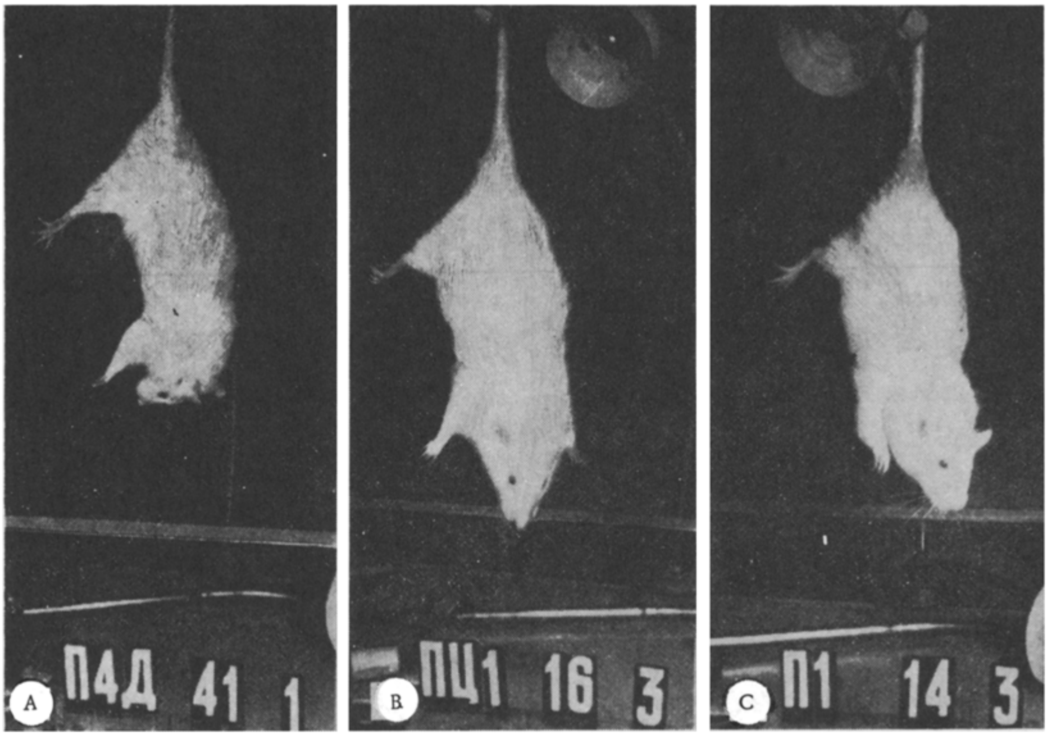

Fig. 2. RJR in animals after SF. A) Delabyrinthized rat, reflex absent; B) animal exposed to artifical gravity during SF; reflex somewhat inhibited; C) animal exposed to prolonged weightlessness during SF; reflex weak.

conditions of flight were reproduced except weightlessness, and also their counterparts in an animal house control (AHC), kept under ordinary conditions. Animals serving as the control for rats exposed to artificial gravity were spun on a short-radius centrifuge (SRC) on earth with an angular velocity equal to that of rotation of the onboard centrifuge. Conditions of flight of the biological satellite, the life support system and conduct of the experiments were described previously [2]. Before and after SF the presence and intensity of the readiness to jump reflex (RJR) was determined as the analog of LR [4]. In the course of this test the rats were held by their tail in the head-downward position and they were dropped downward suddenly. LR was investigated on a special apparatus enabling the latent period of LR (LPLR) to be recorded while the animals were thrown in a Plexiglas container along a vertical guide [1]. The upper "floating" lid of the container with a magnetic fixing device was set horizontally to touch the back of the recumbent animal. With the onset of LR the animal flexed its spine, thereby opening the lid. The magnetic fixing device created a standard resistance (175 g) when the lid opened to the muscles participating in performance of LR, compensating for the "loss of weight" by the animals during free fall, and preventing random opening of the lid as a result of jolting or vibration. By means of a system of electrical contacts, connected with an electronic seconds counter, LPLR could be determined as the time from the beginning of fall of the container until opening of the lid, with an accuracy of 1-2 msec. Investigation of LPLR by this method was carried out with respect to the mechanical component of the muscular response (MCMR). During dropping of the container, motion pictures were taken at a speed of 32-40 frames/sec.

In the experiments according to the program of the biological satellite Kosmos-1129, LPLR was determined in intact animals as the time from the beginning of fall to the first pulse on the electromyogram (EMG) recorded by bipolar needle electrodes from the ocular and gastrocnemius muscles. In these investigations the animals were placed on a horizontal platform, to which they were secured by means of straps and a halter. In all the experiments tests were carried out before SF, after landing (zero days), and during the period of readaptation after different time intervals. Data on the range and type of the investigations are given in Table 1.

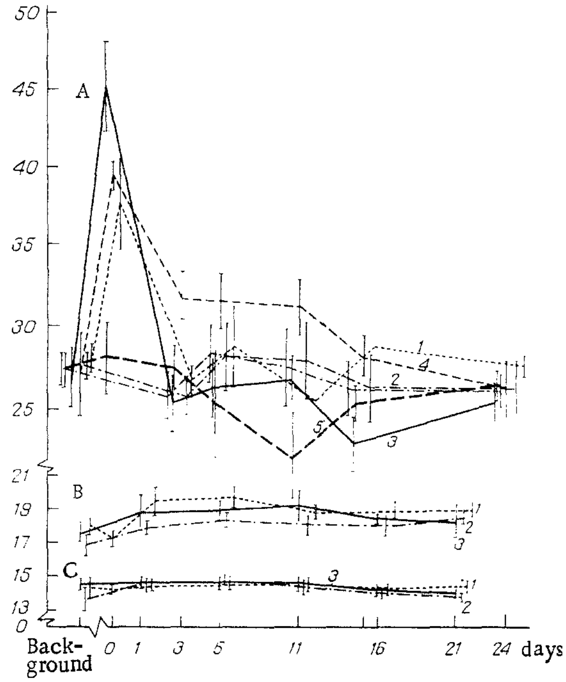

Fig. 3. Graphs of LPLR of animals of "flight" and control groups. A) Latent periods of MCMR; B) latent periods of responses of ocular muscles on EMG; C) latent periods of responses of gastrocnemius muscles on EMG. 1) SC group; 2) AHC group for intact animals exposed to weightlessness during flight and group of animals exposed to AG; 3) flight experiment; 4) spinning on SRC; 5) spinning on OBC. Abscissa, time stages of investigations: before flight (background), after landing (zero days) and subsequent days of readaptation; ordinate, time (in msec).

EXPERIMENTAL RESULTS

In the preflight period a marked RJR and movements characteristic of LR were observed in all intact animals. RJR was manifested as rapid raising of the head, stretching the forelimbs forward, and contraction of the spinal muscles with some extension of the trunk. As the container fell, the rats inside it extended their forelimbs, then their hind limbs, raised and flexed their spine into an arch, slightly lifting the lid of the container (Fig. 1). LPLR, calculated relative to this complex movement, was 26 ± 6 msec. LPLR measured from responses on the EMG of the ocular muscles, was 14.3 ± 0.4 msec, and measured from responses of the gastrocnemius muscles it was 17.8 ± 0.4 msec. For 3-4 weeks after total labyrinthectomy on the animals LR was completely absent, they were indifferent to falling in the container, and only a few of them reacted to landing (slowing down the container) by small movements of the head. In more than half of the delabyrinthized animals LR recovered 1 month after the operation. In these animals ability to rise up on the limbs and to open the lid of the container was apparent, but this response was unstable (during 10 droppings of the container a response occurred in only 4-6 cases), and LPLR was longer (47 ± 10 msec). LPLR largely depended on the initial state of the delabyrinthized animals: in restless and aggressively strained rats it was exhibited more reliably and after a shorter time, whereas in quiet and inhibited animals it could be absent altogether or recorded with the maximal duration.

After landing of the biological satellite LPLR of the intact rats determined from MCMR, i.e., from the time of lifting the lid of the container, was significantly increased. By the 3rd day of the afterflight tests LPLR was virtually indistinguishable from the original values. In rats exposed to artificial gravity and in the animals of the AHC group, no significant changes were found in the values of LPLR. Meanwhile in animals of the SC group at rest or rotated on the SRC, LPLR was increased but significantly less so than in rats exposed to prolonged weightlessness (Fig. 2A). According to the EMG data LPLR did not change significantly in any of the intact animals, whether of the "flight" group or of the ground control (Fig. 2B). RJR was preserved in all intact animals but absent in the delabyrinthized animals after the satellite had returned to earth (Fig. 3A). Its intensity differed in the different groups of animals: in rats exposed to AG and in intact animals exposed to prolonged weightlessness, RJR was weak (Fig. 3B, C).

It can be concluded from these results that after prolonged exposure to weightlessness the animals could still respond to progressive movements. However, realization of complex reflex motor acts, that constitute the basis of responses such as LR or RJR, was appreciably worsened, as shown by lengthening of LPLR and by a decrease in the scale of postural responses in RJR. Vestibular reception and the conducting pathways involved in the reflex arcs tested evidently did not suffer as a result of weightlessness. The changes discovered must be related to the final effector stage, namely muscular contraction. The use of a factor such as AG in SF normalized the LPLR values. However, this is difficult to explain simply by the direct effect of the gravitational force of 1·g created by spinning, for spinning on the ground on the SRC under the same conditions, just as accommodation in individual life-support capsules of restricted size (the SC group), led to some increase in LPLR. The normalizing effect of AG on LPLR in the present experiments was probably also associated with the particular features of spinning on OBC, when an artificial weightlessness gradient created by spinning with a short radius reached 0.3·g. This could be adequate for continuous stimulation of LR during head movements. Frequently repeated stimuli gave a training effect, as a result of which differences in the LPLR values in animals investigated before and after flight and exposed to the action of AG were not significant if MCMR was estimated.

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