ROLE OF CONTACT WITH SUPPORT IN THE TUMBLING REACTION OF ALBINO RATS DURING FREE FALL

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KEY WORDS: free fall; tumbling reaction.

Tumbling by animals during free fall consists of a chain of successive movements as a result of which the animal can land on its feet. The physiological mechanisms responsible for this reaction are not yet absolutely clear. It can be accepted that labyrinthectomized animals, if vision is excluded, lose their ability to tumble during free fall. In all experiments to study tumbling, it has to be pointed out that investigators have invariably attempted to exclude the influence of extralabyrinthine factors. Meanwhile observations [2] have shown that in labyrinthectomized monkeys, after a long period of compensation, signs of discoordination were observed during jumping, but they disappeared as soon as the limb or tail made contact with a stationary support. It has been found [1, 3] that if, on the transition to a state of weightlessness, the animal succeeded in grasping surrounding objects, the discoordinated movements usually observed came to an end. Contact between limb or tail and a stationary support causes a passive displacement of the contacting member and evokes a flow of proprioceptive signals.

It was accordingly decided to study the effect of contact with a support which moves together with the falling animal on the tumbling reaction.

EXPERIMENTAL METHOD

In the experiments of series I an apparatus consisting of a metal rod 250 mm long, along which moved a Porolon tube, of the same length or a little shorter, was used. The upper end of the rod was fixed to a bracket, the lower end was free. The Porolon tube initially was mounted on the rod and held in that position by a catch on the fixer. After release, the tube easily slid downward along the rod and fell on a safety net after a free fall of 1 m. Usually the rats held on to this Porolon tube with all their limbs. The weight of the Porolon tube did not exceed 20 g.

In the second series of experiments a metal frame (70 × 40 cm) was placed horizontally 1.5 m above the safety net. In its center a second frame (25 × 10 cm) was fixed by diagonal struts, with fine netting stretched over it. This net, stretched on the metal ring, created a support on which the rats could hold with all four limbs, in the supine position. In another variant of the experiment, tension in the net was created only by a system of threads, on release of which the net ceased to be taut and could be crumpled.

Experiments were carried out on male Wistar and Wistar-SPF albino rats weighing 200-250 g. Movements were recorded on 35-mm "Konvas" motion picture film at a speed of 32-40 frames/sec. The total number of experiments was 60.

EXPERIMENTAL RESULTS

If the Porolon tube was fixed at the top end of the guide rod, the rat placed on the Porolon, and left to itself, after a short time it either slid downward along the tube, hanging by its forelimbs, and then fell, or it turned perpendicularly to the axis of the tube and hung on all four limbs with its spine downward, and then either let go of the tube or pushed it away and started to jump. In most cases, if the rat fell from the stationary tube it tumbled and its paws assumed a convenient position for landing on the support (Fig. 1A).

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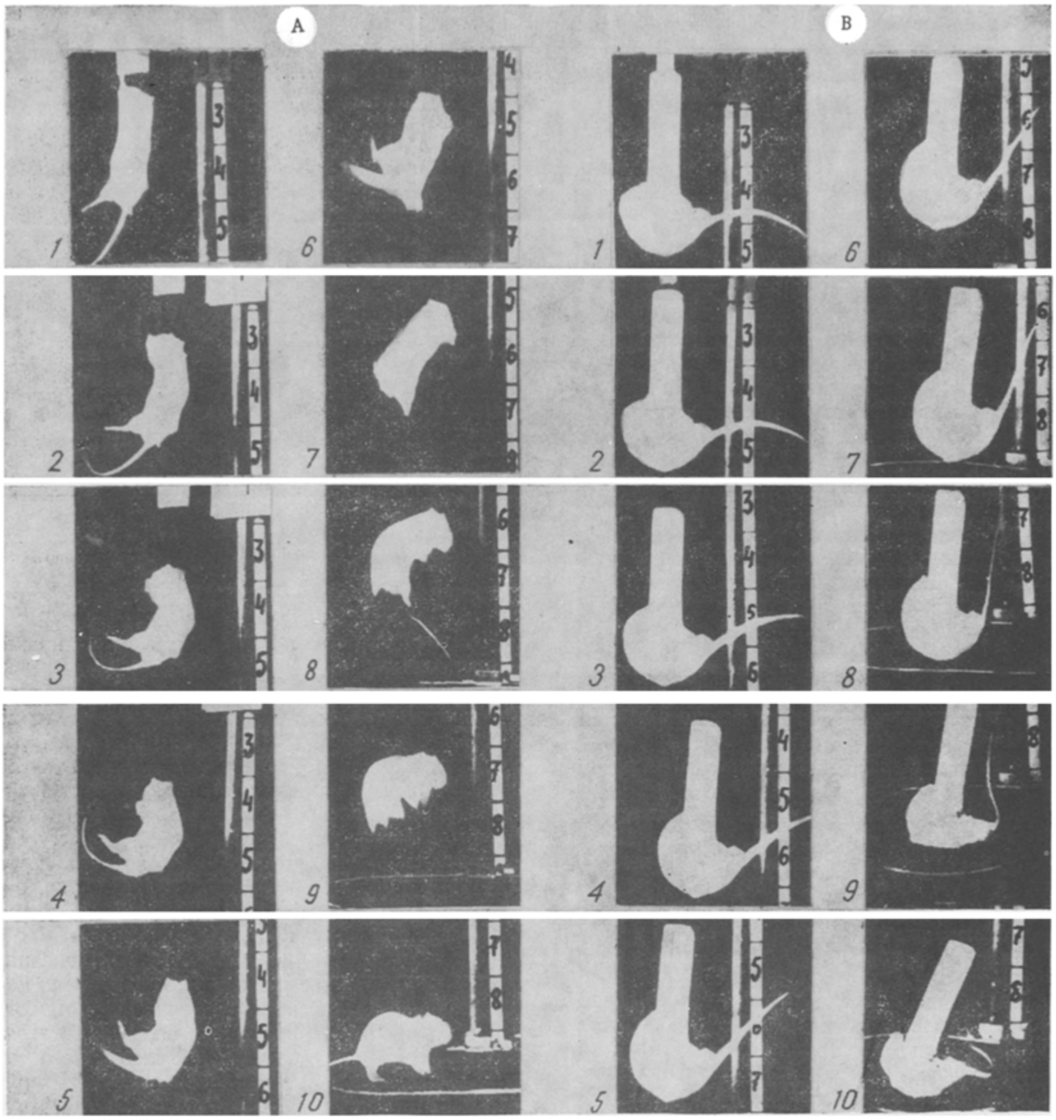

Fig. 1. Motion pictures of rat during free fall: A) falling without support; B) falling with support; 1-10) successive phases of fall.

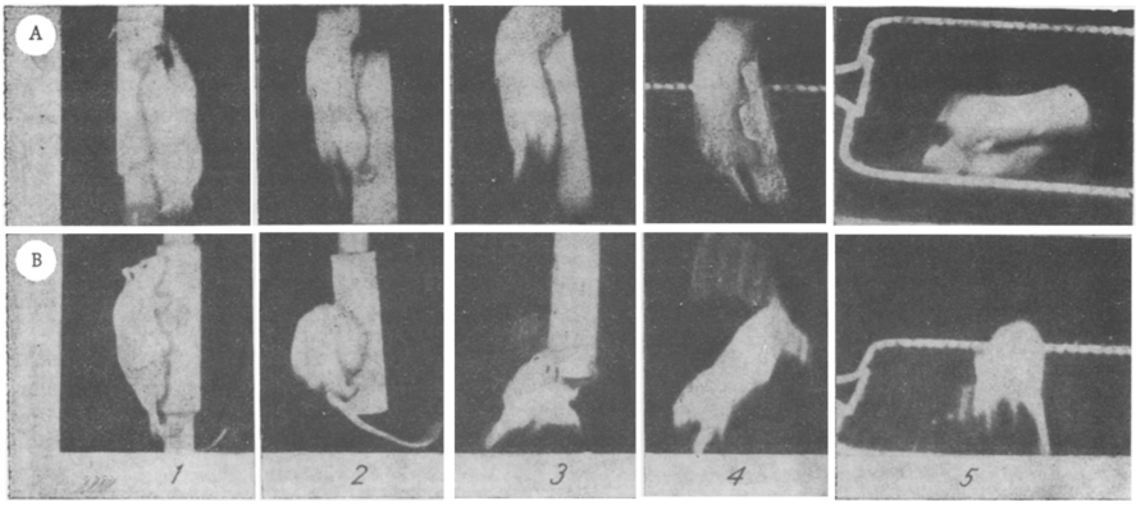

Fig. 2. Rat falling freely together with support: A) falling without contact with stationary object; B) falling with tail touching guide rod; 1-5) successive phases of falling.

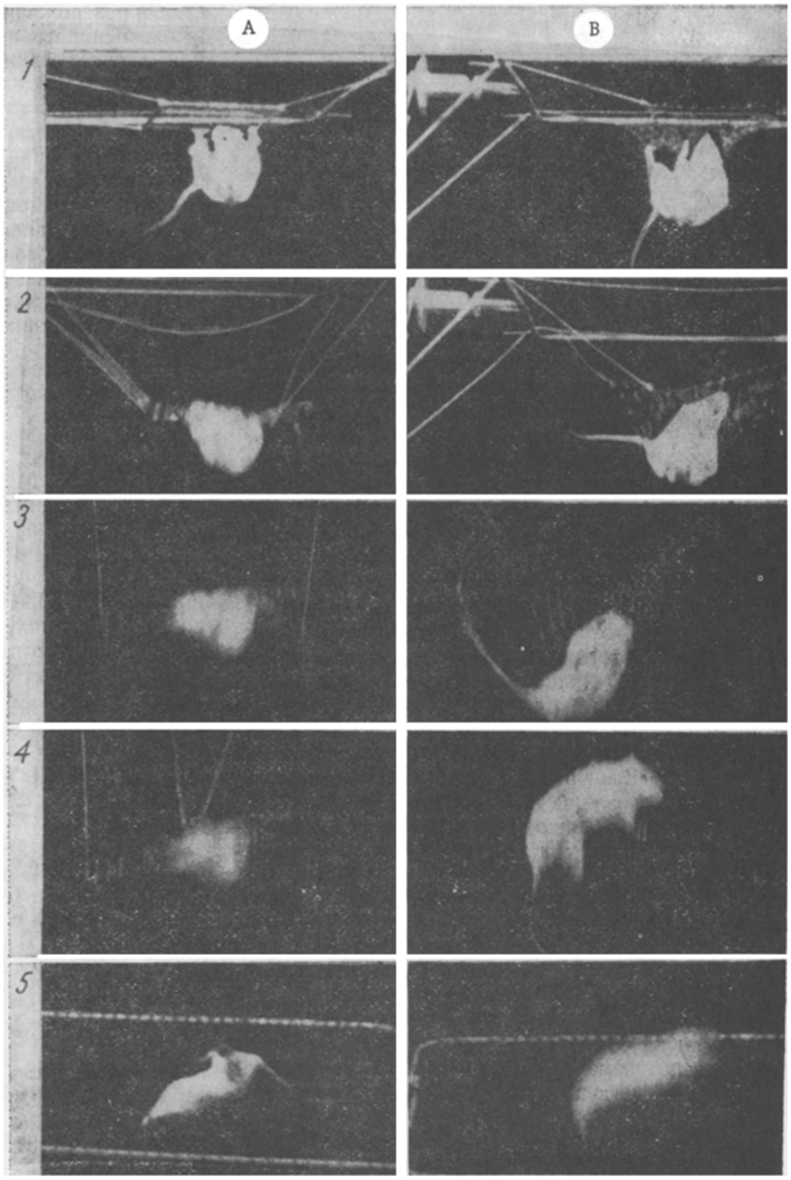

Fig. 3. Rat falling freely from spine downward position: A) falling with net tightly stretched; B) falling with crumpling net; 1-5) successive phases of falling.

When the rats fell together with the Porolon tube the tumbling reaction was completely inhibited. The rats pulled the tube toward them and fell with hardly any change in their initial position. Even when falling on the net, the animals continued to hold on to the Porolon tightly for some time. An increase in the height of fall, a change in the posture before falling (spine downward, tail downward, on the side), and also the addition of visual control did not affect the character of fall: the tumbling reaction was always inhibited. Motion pictures of a rat falling together with the Porolon tube, which it is holding, are illustrated in Fig. 1B (1-10). The animal falls spine downward, in a posture actively stimulating the onset and performance of a tumbling reaction, but no tumbling takes place. Throughout the fall the tumbling reaction is inhibited.

A similar picture can be seen in the motion pictures in Fig. 2A (1-5), when the rat commences its free fall with its tail downward from the vertical posture. While falling and holding on to the support tightly, it does not even attempt to tumble, in order to land on its paws. If, however, in the initial phases of falling the rat touches the stationary guide rod with its tail (Fig. 2B) or paw, it abandons the Porolon tube and lands on its paws.

If rats holding on to a fine-mesh net, stretched tightly on a metal ring, are dropped together with this ring, during the fall they continue to hold on to the net. No tumbling reaction takes place and the animals fall on their back (Fig. 3A). If, however, the net is not stretched tight on a metal ring initially, but is fixed with threads, and if in the initial phase of the fall, its tension is reduced, the net crumples and the rats readily tumble and land on their paws (Fig. 3B).

In all the experimental situations described above, when the tumbling reaction was inhibited, the rats actively and tightly held on to the support. That this was so can be seen from the next variant of the experiment. The Porolon tube or net stretched on the ring were dropped together with the animal on a thin cord (shorter than the path of the animal's free fall), which suddenly arrested their fall. However, the animals held on to the support in their initial position and continued to hang above the safety net for a short time longer, without jumping down.

Labyrinthectomized animals were used in a series of control experiments. In the experiments with the tightly stretched net and also in the experiments with the crumpled net, these rats fell on their back.

It can be concluded from the results that the presence of contact with a support, even under free fall conditions, inhibits the statokinetic reactions which usually ensure normal landing of the animal.

LITERATURE CITED

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INTERCONNECTIONS BETWEEN NUCLEI OF THE RESPIRATORY CENTER

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The morphological and functional structure of the respiratory center (RC) is very complex and its neuronal composition heterogeneous. RC is formed from nuclei and separate groups of respiratory and reticular neurons, which are located at different sites in the medulla and make contact with neurons of other functional systems, performing nonrespiratory functions. Meanwhile RC works remarkably accurately and is responsible for various energy-producing and plastic processes in the body. The discovery of interconnections between its component formations is a particularly important task [1-12]. However, in most investigations of RC its responses to various changes in the internal and external environment have been examined, but not interaction between its component nuclei.

In the investigation described below interconnections of neurons of the gigantocellular nucleus (GN) with neurons of the nucleus solitarius and nucleus ambiguus were studied.

EXPERIMENTAL METHOD

Experiments were carried out on 64 mature cats anesthetized with pentobarbital (45 mg/kg, intraperitoneally). The methods of stimulating structures of RC and of recording the EMG of the respiratory muscles and electrical activity of the neurons were described previously [3]. Sites whose stimulation evoked an inspiratory ("inspiratory sites" – IS) or an expiratory ("expiratory sites" – ES) effect in the region of GN were stimulated. It was assumed that integration of afferent impulses [4] arriving in the medial zone of RC took place in the stimulated sites, followed by their transformation into respiratory impulses, to be transmitted to

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