POSSIBLE PATHWAYS FOR THE EFFECT OF VIBRATION ON MOTOR ACTIVITY OF CHICK EMBRYOS

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Changes in the motor activity of chick embryos under the influence of vibration were discovered. During the first days of incubation (6th day), weakening of motor activity was observed, followed by strengthening starting on the 8th day. A study of changes in the absorptive properties of the skin and muscles of the developing embryo during this period gave results suggesting that these tissues play the role of vibration receptor in the period before maturation of the special structures of the inner ear.

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My previous investigation [7, 8] showed that sounds of different frequencies influence spontaneous movements of chick embryos from the earliest stages of embryonic development. Since vibration effects accompanying exposure to sound, causing mechanical oscillations in the liquid surrounding the embryo, may play an important role in this process, in the present investigation a special study was made of the action of vibration.

EXPERIMENTAL METHOD

Experiments were carried out on 320 White Leghorn hen embryos starting from 6th day of incubation and continuing until the end of development. The experimental conditions were described previously [1, 7, 8]. Vibration waves were generated by an electromagnetic relay, the tripping frequency of which (40/sec) was assigned by means of a type ZG-11 audiofrequency generator. Waves from the relay were transmitted to the bench on which the embryo rested. The vibration stimulus was applied for 5 sec every 25 sec.

To determine the possible participation of the skin and muscles in the reception of vibration, changes in the functional properties of these tissues were studied by D. N. Nasonov's method [6], by which the reaction of the tissues to vibration stimuli can be detected [4]. After exposure to vibration for 10 min the embryos were removed from the eggs and stained in 0.1% neutral red solution. In the early stages of development (6th-10th day) the embryos were stained in toto, while from the 12th to the 18th day only the lower limbs were stained. Since, as the experiments showed, the dye penetrates only into the skin and not into muscle tissue, a series of experiments were carried out in which the leg muscles were stained after removal of the skin. Staining was carried out for 10 min after which the dye was extracted with acidified alcohol for 24 h. Photometry of the extracts was carried out with the FÉKN-57 photoelectrical colorimeter. The extinction was related to dry weight of the embryo and its tissues. In all series of experiments the changes were calculated as percentages of absorption of dye by the tissues exposed to vibration compared with the control, taken as 100%.

EXPERIMENTAL RESULTS AND DISCUSSION

The experiments showed that at the age of 6 days the embryos respond to vibration by a reduction of motor activity. If normal activity is taken as 100%, during exposure to vibration it averaged 83.0±8.7%. The effect of vibration on 77% of the embryos was inhibitory, and on the remaining 23% stimulatory. However, starting from the 8th day of incubation the stimulatory action of vibration on motor activity began to predominate. Although the total duration of spontaneous movements also begins to increase somewhat at this time under normal conditions, it increased much more during the action of vibration.

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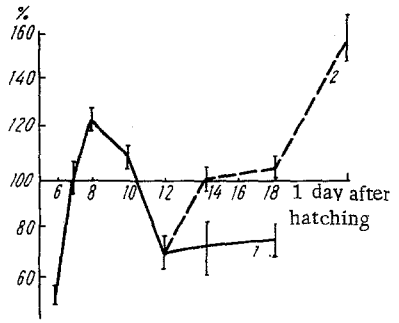

Fig. 1. Changes in absorption of dye by the skin (1) and muscles (2) under the action of vibration. Abscissa, days of incubation; ordinate, changes in absorption of dye (in percent of normal).

This increase in activity on the 8th day of incubation averaged 105%, and it was found in 60% of embryos (an inhibitory action was found in only 40%.

The activating action of vibration was stronger still by the 10th-12th day. At this time the motor activity of the embryos was increased to 113-119% by the action of vibration compared with the background activity. Meanwhile the number of embryos in which vibration gave a stimulatory effect also increased, reaching 72% on the 12th day. By the 14th-18th day the increase in total motor activity was greater still (128.8±9.6%).

Since the action of vibration can be detected in the earliest stages of embryonic development, before specialized sense organs have appeared, an attempt was made to determine the response of the skin and muscle to vibration by means of vital staining (these experiments were carried out jointly with G. I. Grigor'eva). The data given in Fig. 1 show that absorption of neutral red changes during embryonic development. On the 6th day of incubation, absorption of the dye by the skin of embryos exposed to vibration was much less than its absorption by the skin of intact embryos. However, by the 8th day absorption of the dye by the skin had begun to increase after vibration, its value being 125±6% ($P < 0.05$) compared with normal. It remained increased on the 10th day of incubation. Not until later, starting on the 12th day, was a decrease in absorption of dye by the skin observed once more.

A different picture was observed following the action of vibration on muscle. From the 12th to the 18th day of incubation a gradual increase in absorption of dye was observed. From a negative value on the 12th day of incubation (70%; $P = 0.001$), absorption gradually increased to reach a positive value by the 18th day (105±6%). A sharp increase in the intensity of dye absorption was found following the action of vibration in the muscles of a day-old chicken, to reach 160±7% compared with the control ($P = 0.01$).

As a result of these experiments, changes in motor activity of the chick embryos were found under the influence of vibration. The effects of vibration were seen before the specific structures of the inner ear sensitive to vibration (the sacculus) had completed their anatomical differentiation and were capable of functioning, but when reflexes to tactile stimulation had begun to appear [2, 3, 9]. It was accordingly suggested that the skin structures may have a possible role in the reception of vibration waves.

The vital staining experiments showed that absorption of dye is considerably increased by the action of vibration on the 7th-10th day of incubation, i.e., when tactile reception is becoming established. The evidence thus suggests that vibration effects on the tactile receptors of the skin are present in chick embryos during the early period of ontogenesis. This hypothesis appears all the more probable because the phenomenon of polymodality of the mechanoreceptors of adult animals is well known [5]. It is even more likely during the period of prenatal development.

However, whereas changes in motor activity of chick embryos in the early stages of development evidently are entirely dependent on tactile reception, in the later period of incubation changes in motor activity may also depend on maturation of the structures of the inner ear [10, 11], and also of muscle receptors, for an increase in the absorptive properties of muscle tissue under the influence of vibration was also found toward the end of the embryonic period.

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