ANALYSIS OF SOME FORMS OF MOTOR ACTIVITY IN THE SKELETAL MUSCLES OF SLEEPING DOGS DURING POSTNATAL DEVELOPMENT

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Sleeping puppies in the early stages of postnatal development show: 1) fibrillary motor activity of the skeletal muscles (FMA), 2) jerky (JMA), and 3) protracted motor activity (PMA). FMA, JMA, and PMA occur more frequently in the early stages of postnatal development than in puppies at intermediate ages in which motor rest is recorded for most of the time during sleep. In adult dogs they are recorded only episodically. The appearance of FMA, JMA, and PMA is evidently connected with the duration of the expiratory pause and the creation of a temporary state of hypoxemia. With a slight increase in the duration of the expiratory pause, FMA arises, and a maximal increase produces PMA.

During early postnatal development the skeletal muscles perform constant thermoregulatory tonic activity if the external environmental temperature is below the indifferent zone. After the formation of antigravity responses and, in particular, after standing the tonic activity of the skeletal muscles is transformed into the fast tetanic type essential for locomotion [1-5, 7-11]. In mammalian fetuses and in the early postnatal period motor activity of the jerky (JMA) type, characterized by a fast, jerky motor response, takes place during sleep.

Besides activity of the JMA type, sleeping dogs in the early postnatal period also show two other forms of motor activity, which will be analyzed in this paper.

EXPERIMENTAL METHOD

The experimental animals were 18 physiologically mature puppies aged from 1 to 16-18 days (i.e., before the ability to stand on all four limbs), 15 puppies aged from 16-18 days to $2^1/_2$-3 months (i.e., before the final establishment and stabilization of locomotion), and in five fully grown dogs. The puppies were taken from the mother after feeding and placed in a cotton wool "nest". When they had been in the "nest" for 5-10 min their temperature was close to the indifferent zone within which puppies sleep. Motor activity was observed and recorded for 2 h. The month-old puppies and adult dogs were adapted to the environment in the evening (from 7-9 p.m.) after five or six visits to the laboratory. After a preliminary walk and meal the dogs fell asleep on a soft surface at room temperature without the formation of a special "nest". Motor activity was recorded between 20-30 min and 2 h later depending on the duration of sleep in the period of observation. The electromyogram (EMG) was recorded on a Disa myograph from the cervical and spinal muscles and the extensors of the hind limbs by means of monopolar needle electrodes. As a result of analysis of at least 70 EMGs the distribution of the degree of participation of the various muscle groups in corresponding forms of motor activity was obtained. The frequency of participation was expressed in percent. In another series of experiments using a Kaiser electroencephalograph the EEG activity in the

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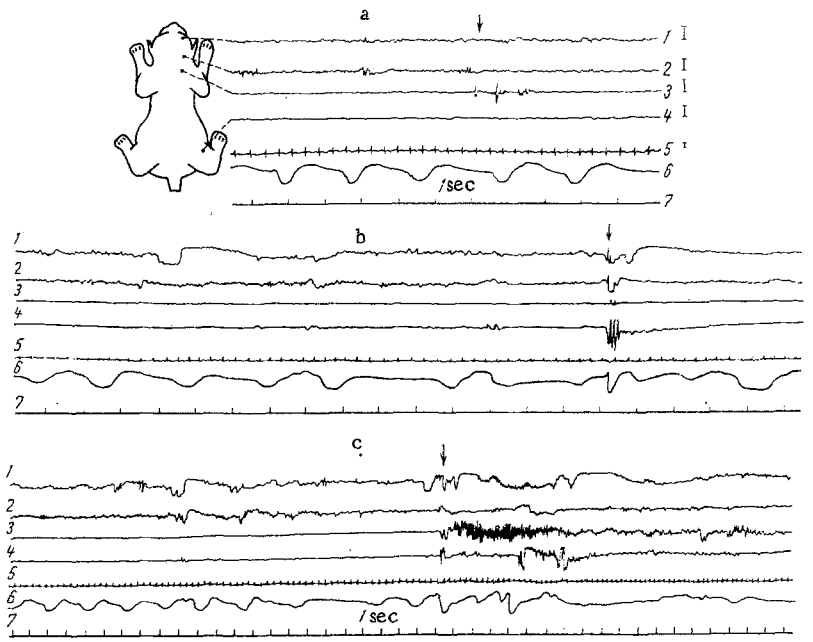

Fig. 1. EEG, EMG, ECG, and respiration of a puppy of the first age group during FMA (A), JMA (B), and PMA (C): 1) EEG (frontal leads); 2) EEG (parietal leads); 3) EMG of cervical muscles; 4) EMG of extensor muscles of hind limbs; 5) ECG; 6) respiration; 7) time marker 1 sec.

frontal and parietal leads, EMG activity (channel 2), and ECG activity in standard lead II were assessed. Respiration was recorded by means of a type RPP-1 rheopneumographic transducer [6]. Altogether 760 records of motor activity were analyzed.

EXPERIMENTAL RESULTS

Analysis showed that puppies in the early postnatal period sleeping after feeding exhibit three forms of natural motor responses: superficial fibrillary twitching of the skeletal muscle, described as fibrillary motor activity (FMA; Fig. 1a); jerky motor activity (JMA; Fig. 1b); and prolonged motor activity (PMA; Fig. 1c). FMA occurred as fast superficial twitches in individual regions of the skeletal muscles: the facial part of the head and the muscles of the trunk and limbs. The FMA is reflected electrophysiologically in Fig. 1a as consecutive action potentials in the cervical muscles, 200-300 μV in amplitude, with intervals ranging from 30-40 msec to 1.5 sec. Each period of FMA lasted from between 300-400 msec and 5-6 sec. FMA took place mainly in single groups of muscles and much less frequently in all the muscles. The frequency with which particular forms of motor activity were found in the various skeletal muscle groups is shown in Fig. 2. Below the age of 16-18 days (group 1) FMA was recorded 7-10 times per minute.

It is clear from Figs. 1 and 2 that the forms of motor activity described above appeared either only locally, in single muscle groups, or as a generalized motor response. The last type, when all muscle groups recorded in the experiments were involved in the response, was seen most frequently during PMA (Fig. 2c). PMA accounted for 50% of all the other forms of motor activity. The generalized JMA type of response was much less frequent (24%; Fig. 2b). Rarest of all (17.1%) was the generalized type of FMA (Fig. 2a). During FMA (Fig. 2a), EMG activity of single muscle groups was most frequent: of the cervical muscles in 26.1%, extensors of the hind limbs in 26.1%, of the spinal muscles in 2.3%, of the cervical and spinal muscles in 5.6%, and of the cervical muscles and extensors of the hind limbs in 17.1%. PMA could be accompanied by JMA, which either preceded it or followed it (Fig. 2). There was no change in the EEG activity during FMA (Fig. 1a). During JMA (Fig. 1b) paroxysmal activity occurred in the frontal and parietal leads of the EEG. The greatest intensification of the EEG took place during PMA, beginning with paroxysmal activity, as occurred during JMA. PMA appeared only if the expiratory pause was long (Fig. 1c), while JMA (Fig. 1b) was associated with a shorter expiratory pause. FMA (Fig. 1a) corresponded to

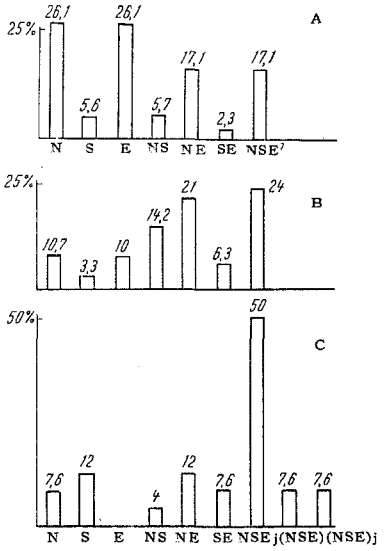

Fig. 2. Graph of distribution of participation of muscle groups in FMA (A), JMA (B), and PMA (C): N) cervical muscles; S) spinal muscles; E) extensors of hind limbs; NS) simultaneous participation of cervical and spinal muscles in activity; NE) simultaneous participation of cervical muscles and extensors of hind limbs in activity; NSE) simultaneous participation of cervical and spinal muscles and extensors of hind limbs in activity; j(NSE) variant in which PMA preceded by JMA; (NSE)j variant in which PMA precedes JMA.

the shortest duration of the expiratory pause. The occurence of FMA, PMA, and JMA was thus related to the duration of the expiratory pause during sleep. An increase in its duration led to the formation of a temporary state of hypoxemia, and to stimulation of the carotid sinus and cardio-aortic chemoreceptors, as a result of which these forms of motor activity took place by a reflex mechanism through the corresponding nuclei in the brain stem.

At ages between 16-18 days and 2.5-3 months (group 2), in connection with the transformation of the slow type of activity into fast tetanic activity, all the types of motor activity mentioned above were found less frequently. For instance, at this age FMA was found once in 3-5 min. In adult dogs, FMA, JMA, and PMA occur only episodically or not at all. These transformations are connected with maturation of the inhibitory neurons and synapses in the central nervous system during postnatal development [4, 5, 9].

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