EFFECT OF CHANGES IN BODY POSITION IN SPACE ON MUSCLE TONE IN NEWBORN INFANTS*

T. G. Antinova

UDC 612.74-053.31-06 : 612.76

An electromyographic method was used to study the effect of stimulation of the otolith system on muscle tone in the newborn infant. Changes in the position of the body relative to the horizontal plane by as little as 10° were found to produce changes in total electrical activity of the muscles, the direction of the reactions depending on the initial level of electrical activity: if low it is increased, if high it is weakened. Muscles of the spine are most sensitive to changes in body position.

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Many studies have been made of vestibular influences on muscle tone in the USSR and elsewhere [2, 4, 8, 9, 11]. Although the vestibular system is known to mature sooner than other systems, postural and tonic labyrinthine reflexes have been obtained in ontogenesis only in rabbits [5]. In observations on 26 newborn infants during the first few hours of life, Magnus [11] found no labyrinthine tonic reflexes in a single case. Minkovsky [12] found cervical tonic reflexes in fetuses at the age of 2-5 months, but could not detect labyrinthine reflexes. Similar results have been obtained with more mature fetuses [6]. No other investigations of this problem conducted on infants could be discovered.

The object of the present investigation was to study participation of the otolith system in the organization of postural activity in the child and, in particular, to determine the relationship between the level of background electrical activity and activity of various muscles in relation to reflex influences arising from the otolith system.

EXPERIMENTAL METHOD

Potentials were recorded from muscles of 30 healthy infants aged from a few hours to 8 days and weighing 2500-4000 g. The otolith system was stimulated by tilting the platform on which the child was placed through 10, 15, 20, 25, and 30° relative to the horizontal plane. To exclude cervical tonic reflexes and reflexes of the semicircular canals, the head and neck were fixed relative to each other by swaddling clothes. The electromyogram (EMG) was recorded not less than 1 min after tilting to avoid any response to acceleration [13].

Potentials were detected by bipolar electrodes from the biceps and triceps brachii muscles, the spinal muscles, and the flexor digitorum communis. The potentials were amplified by means of a type UBNK-V 4-channel ac amplifier, made at the experimental workshops of the Institute of Experimental Medicine. The calibration potential of 50 μV caused a deflection of 10-20 mm of the recording beam of the screen. The level of muscle tone was estimated by summation of amplitude of all oscillations during 1 sec. Counts were made at least 4 times in different sections of the EMG†. The mean of these values was defined as the total bioelectrical activity and expressed in μV. The potentials during motor activity were one order higher and were not taken into account.

*This investigation was started the at Research Institute of Obstetrics and Gynecology, Academy of Medical Sciences of the USSR.

† The recording on film was magnified 6 times by means of a type P-10 enlarger.

Laboratory of Higher Nervous Activity of the Child, I. M. Sechenov Institute of Evolutionary Physiology and Biochemistry, Academy of Sciences of the USSR, Leningrad. (Presented by Academician V. N. Chernigovskii.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 68, No. 8, pp. 12-15, August, 1969. Original article submitted September 14, 1967.

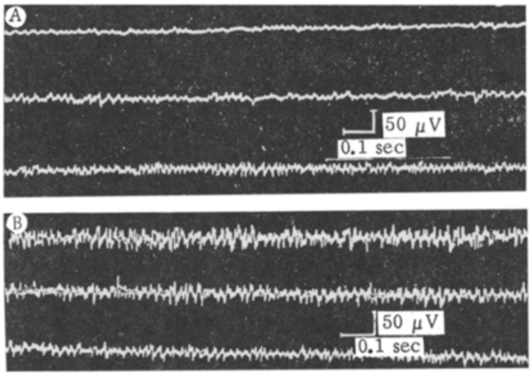

Fig. 1. EMG of spinal muscles (A) and biceps brachii muscle (B). Top curve) body in horizontal position; middle curve) tilted through 15°; bottom curve) tilted through 30°.

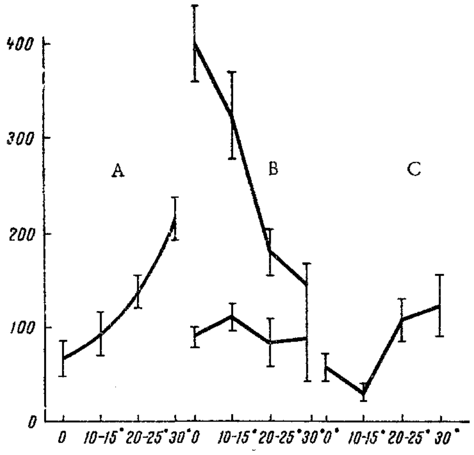

Fig. 2. Dynamics of changes in total electrical activity with a change in body position in space. A) Spinal muscles; B) biceps brachii muscle; C) flexor digitorum communis. Abscissa, change in body position (in degrees); ordinate, total electrical activity (in μV/sec).

EXPERIMENTAL RESULTS

Before stimulation of the otolith system, the background level of muscle activity was recorded in the infant lying still for a long period. This activity remained constant throughout the period of observation (the total activity of the individual sections of the EMG did not differ by more than 70 μV), but it varied widely from one child to another, and in the same child during different observations (from 10 μV [the noise level] to 700 μV). The greatest variability of the total background activity was observed for flexor digitorum communis and biceps brachii, the least for the spinal muscles. The background activity of the triceps brachii muscle was much lower than that of all other muscles investigated, and gave no statistically significant changes during the action of the stimulus. The extreme variability of muscle tone in newborn infants has been described previously [1, 13], and is attributed to many factors, including shock during birth. The background activity level in infants aged one month is practically constant [7].

Adequate stimulation of the otolith system produced either an increase or a decrease in the total electrical activity. Considering the variability of the background, an attempt was made to determine the presence and degree of correlation between the initial level of activity in the muscle and the direction of the response to changes in the body position relative to the horizontal. To calculate the coefficient of correlation, the total electrical activity with the child in the horizontal positions was divided conventionally into low (total activity not exceeding 100 μV), average (between 100 and 400 μV), and high (400 μV and over). A qualitative assessment was made of the changes during stimulation of the otolith system: increase or decrease in activity compared with the background. When the level of background activity was high, total activity was more frequently weakened during stimulation, and vice versa. The coefficient of correlation was 0.33. The use of the ξ^2 test showed that correlation between the level of background activity and the direction of the response to otolith stimulation was present in the case of tilting through angles of 10-15° and 25-30°.

Because responses occurred in different directions and because two well-marked relationship were found between the mean level of background activity and the direction of the response, after calculation of the quantitative ratios the results could be divided into two groups depending on the initial level of electrical activity. Cases in which total background muscle activity did not exceed 200 μV/sec were included in the first group, and cases with a higher level of activity (200-700 μV) in the second group. The most definite responses to changes in body position relative to the horizontal plane were observed with the spinal muscles (Fig. 1A). A slight increase in total electrical activity was observed after tilting through 10°, but compared with the background EMG the difference was not statistically significant. After tilting through 25-30° activity increased and the difference became statistically significant (Fig. 2A). Since the background activity of the spinal muscles as a rule did not exceed 200 μV, and was higher than this level in only 4 children, the curves for low and high levels were not compared, although it should be noted that in all these cases a lowering of background activity was observed during stimulation, and was especially marked during tilting through 10-15°, after which the total activity returned almost to its initial level.

The number of EMGs recorded from the biceps brachii muscle with a high initial level of activity was approximately half. The decrease in activity was also approximately half. The decrease in activity in the muscles began with tilting through 10° and became particularly marked at 25° (Figs. 1B and 2B). When the background activity was weak, no definite changes were observed in response to stimulation of the otolith system (Fig. 2B).

The total electrical activity of the flexor digitorum communis muscle, in cases when it did not exceed 200 μV, was reduced by tilting through 10-15°, but increased sharply after tilting through 20° and exceeded the background level (Fig. 2C).

The investigations of Koella and Nakao [10] on decerebrated cats showed that the detection of cervical tonic reflexes is directly dependent on the initial level of muscle activity and is possible only if a sufficiently strong flow of impulses from the proprioceptors occurs during stretching. In newborn infants, immaturity of the pyramidal system and the state of increased excitability of the segmental apparatus of the spinal cord facilitate widespread irradiation of excitation and account for the state of increased background activity of the muscles, in which changes in muscle tone can be detected under the influence of stimulation of the otolith system without any additional stretching of the muscles. In cases when total background activity was insufficient for a particular muscle, no clear manifestation of the response to a change in body position was observed. This also explains the absence of significant changes in the triceps brachii muscle.

The greater sensitivity and uniform direction of the responses of the spinal muscles, i.e., antigravity muscles in the adult, to changes in body position in newborn infants must be noted. The dependence of direction of the response on the initial level of activity can be explained by the presence of special mechanisms maintaining muscle tone at a certain average level, most suited for postural activity of the newborn infant.

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