Meanwhile injection of DSIP before ADB formation led to a fall of the corticosterone level from 4.73 ± 0.5 to 3.64 ± 0.7 μg%. ADB formation after preliminary administration of DSIP was accompanied by a smaller rise in the plasma corticosterone level than during ADB without administration of DSIP (Table 3).

The time course of brain electrical activity of the rats receiving DSIP before ADB compared with that during ADB alone indicates reorganization of brain function in these situations in the diametrically opposite direction. The spectrum of theta-activity in the hippocampus in rats in a state of ADB (in boxing posture) was increased like it was after administration of ACTH and glucocorticoids in stress-inducing doses. The value of the coefficient of coherence for the delta-rhythm between hippocampus and septum was increased 15 min after injection of DSIP, and coefficients of correlation of limbico-reticular structures were increased 30 min after injection.

Investigation of intercentral relations between brain structures on the basis of the results of correlation analysis of the EEG thus revealed the consolidating character of action of the endogenous and exogenous stress-inducing level of ACTH and glucocorticoids and the uncoupling character of the action of DSIP on brain structures. Comparative analysis of the action of glucocorticoids and ACTH (stress factors) and of DSIP as a factor increasing resistance to stress, showed that DSIP is a regulator of brain function which differs in principle in the character of its action from stress factors.

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MECHANISM OF EXERCISE HYPERVENTILATION: A HITHERTO DISREGARDED FACTOR

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Mechanisms of hyperventilation during exercise remain unexplained [1-3, 9]. Exercise is not accompanied by any significant change in the partial pressures of CO_2 or O_2 in arterial blood [1-2, 9]. The influence of the cerebral cortex on the respiratory center explains only the initial, stepwise intensification of respiration [7]. The results of studies of afferent influences from working muscles are highly contradictory so far as the explanation of exercise hyperventilation is concerned [5, 6]. The present investigation was motivated by the following observation, made in clinical pratice. A bilateral lesion of the respiratory fiber tract of the spinal cord below C1, along which impulsation spreads from the res-

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Fig. 1

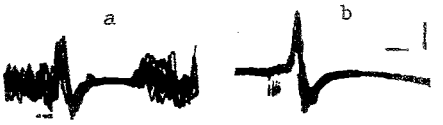

Fig. 2

Fig. 1. Facilitation of inspiratory discharges of the diaphragm during long-term (10 sec) tetanic stimulation (500 Hz) of the contralateral bulbar pyramid: a) before stimulation; b) during stimulation of pyramid. Calibration: 0.5 mV, 1 sec.

Fig. 2. Activity of diaphragm in response to stimulation of contralateral bulbar pyramid: a) during inspiratory volley (dots indicate time of stimulation); b) after transverse section of both pyramids above site of stimulation (during artificial ventilation of the lungs). Stimulation by short series of 3 (a) or 4 (b) pulses with frequency of 460 or 600 Hz respectively. Each trace formed by 5-8 sweeps of the beam. Calibration: 1 mV, 10 msec.

piratory center to motoneurons of the respiratory muscles, makes the patient unable to breathe automatically – respiration stops during sleep, and unless the patient is artificially ventilated, he will die. However, voluntary respiration remains intact – while awake, the patient can breathe at will [8]. Hence it follows that impulsation spreading along the corticospinal (pyramidal) tract, by which voluntary movements are performed, may influence spinal motoneurons of the respiratory muscles, not through the respiratory center but bypassing it. Direct connection of the pyramidal tract with the spinal centers of the respiratory muscles has been established by experiments on animals [4], although its functional role is not yet clear: in animals it is impossible to study automatic and voluntary respiration separately. The observations cited above suggested that impulsation arising in the corticospinal tract during exercise increases the excitability of motoneurons in the spinal cord, innervating the respiratory muscles and bypassing the respiratory center, and as a result responses of motoneurons of the respiratory muscles to inspiratory impulses from the respiratory center are facilitated, and the augmented discharge of these motoneurons causes increased ventilation of the lungs.

To test this hypothesis the investigation described below was undertaken.

EXPERIMENTAL METHODS

Experiments were carried out on five adult cats anesthetized with pentobarbital (30 mg/kg, intraperitoneally). Electrical activity of the diaphragm, a respiratory muscle not taking part in postural activity, was recorded. Bipolar wire electrodes (interelectrode distance 10-15 mm) were sutured on the abdominal side to the thoracic part of the left or right side of the muscle. To stimulate the corticospinal tract, the pars basilaris of the occipital bone was removed and bipolar needle electrodes (diameter of tip 30 μ, interelectrode distance 1 mm) were inserted into the bulbar pyramid to a depth of 200-300 μ from the ventral surface of the medulla. The electrodes (except the tips) were insulated with Viniflex. The pyramidal tract was stimulated by square pulses 0.2 msec in duration, with a frequency of 400-600 Hz, applied either continuously for 10-20 sec or in short series of 3-4 pulses of the same frequency.

EXPERIMENTAL RESULTS

Data showing ipsilateral activity of the diaphragm before and during continuous tetanic above-threshold stimulation of the contralateral bulbar pyramid with a frequency of 500 Hz are given in Fig. 1. Stimulation of this kind increased the amplitude of inspiratory discharges by 50-100%. The duration of the volleys was increased in some experiments. Stronger stimulation not only facilitated inspiratory discharges, but also evoked responses of the diaphragm to volleys of impulses from the pyramid itself (Fig. 2).

During stimulation of the bulbar pyramid not only the corticospinal tract, but also other descending pathways controlling activity of the diaphragm could also have been involved

in the response. They all lie at a depth of 1.5-2 mm below the ventral surface of the medullary pyramid, i.e., dorsally to the corticospinal tract, and occupy the most ventral part of the pyramid. To rule out any participation of these pathways in the response now described, both pyramids were divided down to a depth of 2.5 mm from the ventral surface. This caused immediate respiratory arrest, and artificial ventilation of the lungs was used during the rest of the experiment. After division, the surface layer of the caudal part of the pyramids, 0.6-0.8 mm thick, 2-2.5 mm wide, and 4 mm long was dissected from the underlying structures and a vinyl chloride membrane was placed beneath it. As will be clear from Fig. 2, stimulation of the dissected part of the contralateral pyramid evoked the same responses of the diaphragm as before isolation of the pyramids. Consequently, the effects of stimulation of the bulbar pyramid observed in these experiments can be explained only by activity of the corticospinal tract.

It can be tentatively suggested that the following factor, not hitherto taken into account, plays a role in hyperventilation during exercise. Impulsation arising in the corticospinal tract during exercise is directed toward motoneurons of the respiratory muscles, bypassing the respiratory center, and it increases their excitability. As a result, the response of motoneurons of the respiratory muscles to inspiratory impulses, reaching them from the respiratory center, is facilitated. The augmented discharge of these motoneurons causes increased ventilation of the lungs.

Until recently attempts have been made to explain hyperventilation during exercise by increased activity of the respiratory center. This investigation has shown that an increase in excitability of the motoneurons of the respiratory muscles themselves, arising independently of the respiratory center, may play an essential role in the mechanism of hyperventilation during exercise.

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