SEXUAL DIMORPHISM OF THE STRESS RESPONSE WITH A NORMAL AND ALTERED PHOTOPERIOD

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The question of sexual dimorphism in resistance and ability to survive, although of great immediate importance, has not attracted the attention it deserves from research workers [1]. The greater sensitivity of females to disturbing external environmental factors has led most experimental workers not to use females for their work, and for that reason the characteristic features of adaptive systems of the female have virtually not been investigated. In our view, comparative studies of reactivity of females and males to physiological stressors [2, 9] are essential in order to elucidate the phenomenon of sexual dimorphism in resistance and ability to survive.

In connection with the chronobiological approach to the problems of resistance, human migration movements, and the changing circadian rhythms of human adaptive systems [5], it was decided to study the stress response in females and males under conditions of a normal and altered photoperiod.

EXPERIMENTAL METHOD

Experiments were carried out on 86 male and 93 female noninbred albino rats weighing 220-290 g. The rats were kept in small cages (30 × 27 × 25 cm), four to a cage. The response of the animals to successive removal of their customary partners from the cage at intervals of 4-5 min was used as a model of emotional stress. The intensity of stress response was assessed by measuring changes in the corticosterone concentration in the adrenals and blood plasma by a spectrophotofluorometric method. The stress response was studied during exposure of the animals to a standard (12 h of light and 12 h of darkness) and an altered photoperiod. For this purpose, the animals were exposed for short (3 days) and long (20 days) periods of continuous lighting by luminescent lamps and of darkness.

EXPERIMENTAL RESULTS

Removal of the partners was a powerful stressor for females, as shown by an increase in the corticosterone concentration in the adrenals by 104.30% ($p<0.001$) and in the blood by 115.35% ($p<0.001$). These changes correlated with anxious behavior of the animals left in the cage. Males were found to be less sensitive to the removal of partners from the cage. Their response showed dissociation between corticosterone synthesis and secretion, as shown by an increase in its concentration in the adrenals by 84.56% ($p<0.001$) and the absence of any significant changes in its level in the blood (Fig. 1a). Consequently, whereas in females emotional stress leads to intensification of both synthesis and secretion of corticosterone, in males the response is confined to intensification of synthesis of the hormone.

During continuous exposure to light for 3 days the stress response of the females was inhibited: the corticosterone concentration in the adrenals was virtually unchanged and in the blood it was increased, but not significantly ($p>0.05$). In males the amplitude of the stress response of the adrenals was about the same as during exposure to the standard photoperiod, but because of an increase in the basal level of the hormone, the absolute values of the stress level of corticosterone were higher in the animals of the "light" group. Nevertheless, the concentration of the hormone in the plasma during stress not only was not increased, but had a tendency to fall (Fig. 1b).

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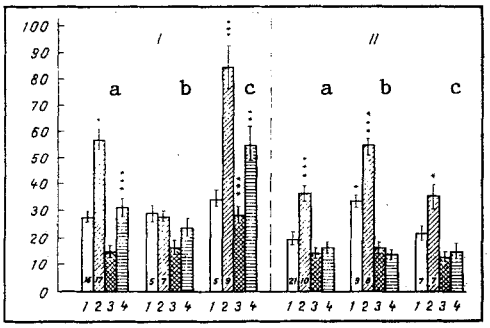

Fig. 1

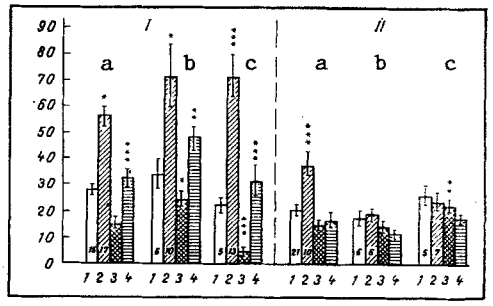

Fig. 2

Fig. 1. Stress response during standard photoperiod (a), during 3 days of continuous light (b), and 3 days of darkness (c). Ordinate, corticosterone concentration (in μg/g in the adrenals, in μg% in blood plasma). 1, 2) Corticosterone in adrenals: 1) control, 2) stress; 3, 4) corticosterone in plasma: 3) control, 4) stress. I) Females, II) males.

Fig. 2. Stress response during standard photoperiod (a) and during long-term exposure to light (b) and darkness (c). Legend as to Fig. 1.

In females exposed for 3 days to continuous darkness, the basal corticosterone level in the plasma was increased by 90.82% ($p<0.001$). The sensitivity of these animals to emotional stress increased as regards both the amplitude of the response (adrenals) and its absolute values (adrenals, plasma). For instance, the corticosterone concentration in the "dark" group of females during stress amounted to 85.09 ± 8.76 μg/g in the adrenals and 55.21 ± 7.26 μg% in the plasma. In animals kept under standard conditions, these parameters of the stress response were 57.39 ± 4.29 μg/g and 32.13 ± 3.6 μg% respectively (Fig. 1a, b).

By contrast with the females, exposure of males to continuous darkness for 3 days was not reflected either in the basal level of the hormone or in the characteristics of the stress response. The stress response of the adrenals was about the same as in animals kept under conditions of a standard photoperiod, whereas in the blood, the corticosterone level was virtually unchanged (Fig. 1a, c).

There is no question that a short period of exposure to an altered photoperiod contains elements of stressor action. Accordingly, the greater sensitivity of females to these conditions makes a noteworthy addition to the facts, already known, of their increased reactivity to emotional stress.

Adaptation to long continuous light (20 days) was accompanied in females by elevation of the basal plasma corticosterone level by 59.38% ($p<0.05$). Against this background the stress response was typical and was manifested as an increase in the synthesis and secretion of corticosterone by 112.22% ($p<0.05$) and 100.29% ($p<0.01$) respectively (Fig. 2b). Adaptation of the females to darkness was reflected as lowering of the basal plasma corticosterone level by 68.9% ($p<0.001$), which did not affect the sensitivity of animals of the "dark" group to stress. Moreover, the amplitude of the stress response in connection with lowering of the basal corticosterone level amounted to 228.2% ($p<0.001$) in the adrenals and to 565.7% ($p<0.001$) in the plasma, which was significantly higher than these parameters in the control stressed animals (Fig. 2c). Because of the importance of stress responses to life, this rapid recovery of normal sensitivity of the females to stress action under conditions of an altered photoperiod must be regarded as a positive, advantageous fact. This rapid adaptability is evidently responsible for the extraordinary reactivity of females to changes in the photoperiod, which is manifested even in the early stages of adaptation.

In males, during prolonged exposure to light, the stress response of the adrenals was sharply inhibited. For instance, whereas in animals kept under conditions of a standard photoperiod the corticosterone concentration in the adrenals increased by 84.56% ($p<0.001$), but only by 3.88% in animals of the "light" group (Fig. 2a, b). Similar inhibition of the stress response in males also was observed during long-term exposure to darkness (Fig. 2c).

Depression of reactivity to stressors is regarded by some workers as a positive phenomenon, evidence of the economic value of adaptive reactions [3, 6], but by others as a decrease in adaptive capability [7, 8]. Regardless of the qualitative interpretation which can be placed on it, the absence of normal sensitivity of males to stress under conditions of an altered

photoperiod is evidence of the protracted nature of the adaptive processes, which is linked with inertia of the adoptive systems, manifested even in the early stages of adaptation.

The experiments thus revealed sexual dimorphism in responses to stress, the quantitative and qualitative characteristics of which closely resemble those of responses to natural physiological stressors, acting constantly on the body.

Adaptive systems of females are extraordinarily reactive with respect to emotional stress and to short-term changes in the photoperiod, with the result that the times of adaptation to an altered photoperiod are shortened. This was manifested as restoration of the typical stressor response for females during long-term exposure to light and to darkness. In males, a distinctive refractoriness toward weak stressors was observed, lengthening the periods of adaptation to an altered photoperiod, as was shown by depression of the stressor response typical of males during long-term exposure to light and to darkness.

The extraordinary reactivity of females and refractoriness of males to physiological stressors, which the present experiments revealed, evidently helps to maintain the adapative systems of females in a state of constant training, whereas those of males are kept "out of training." For these reasons, females are evidently more resistant than males to the action of powerful stressor agents, and ultimately this increases their chances of survival. Evidence in support of this hypothesis is given by the increased resistance of the organism to various diseases which can be achieved through reactions of training and activation induced by weak and moderately strong stimuli [4].

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