Vascular and Cardiac Effects of Stress in Albino Rats of Different Sex and Age Groups

T. G. Anishchenko, O. V. Semyachkina-Glushkovskaya, V. A. Berdnikova, Ya. V. Kuznetsova, and A. S. Kuznetsova

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 153, No. 1, pp. 13-16, January, 2012
Original article submitted July 16, 2010

Stress exposure induced similar cardiac effects in male and female infantile rats, but vascular reactions to stress in males were more pronounced than in females. In mature male rats (but not in females), both cardiac and vascular responses to stress decreased in comparison with infantile animals. In adult rats, cardiac effects of stress were more pronounced than the vascular response; females demonstrated greater cardiac response and less significant vascular reactions than males. Aging was accompanied by a decrease in the cardiac response and increase in the vascular reaction to stress. These changes were more significant in females than in males. In contrast to infantile and adult animals, old females demonstrated greater vascular response to stress than male rats. The observed sex-dependent changes in the ontogeny of vascular and cardiac response to stress are discussed in light of sex- and age-related peculiarities of hypertension development.

Key Words: *sex; age; vascular and cardiac effects of stress*

The age and sex are considered as independent risk factors for the development of hypertension. At the early and intermediate stages of ontogeny, male sex is a risk factor for this disease. Age-related elevation in blood pressure and dysfunction of the cardiovascular system (CVS) during critical periods of ontogeny is more pronounced in boys than in girls [3]. In the middle-age group, hypertension is more often diagnosed in men than in women. However, in the older age group, hypertension is more typical of women than of men [8]. The age- and sex-related peculiarities of hypertension development experimentally reproduced in rats [1] suggest that changes in CVS function during ontogeny depend on animal sex [4,11]. Stress exposures markedly affect the function of CVS; therefore, stress-induced responses of CVS can be used as a prognostic criterion for the development of hypertension in people of different sex and age [6,7,9]. Little is known about the effect of age and sex on cardiovascular stress-reactivity in animals. This work was designed to study the vascular and cardiac effects of stress in infantile, adult, and old female and male rats.

Department of Human and Animal Physiology, N. G. Chernyshevskii Saratov State University, Russia. ***Address for correspondence:*** glushkovskaya@mail.ru. O. V. Semyachkina-Glushkovskaya

MATERIALS AND METHODS

Experiments were performed on albino rats of the following three age groups: 6-week-old rats (infantile animals; 10 females and 10 males; mean body weight 52 and 66 g, respectively); 7-month-oldrats (adult animals, 9 females and 9 males; mean body weight 220 and 260 g, respectively); and 25-month-old rats (old animals, 8 females and 8 males; mean body weight 300 and 360 g, respectively). The animals were subjected to 60-min restraint stress (RS). BP was measured on a PowerLab/400 ML401 multichannel measuring-and-computing complex via a catheter. BP and HR were recorded during RS and over 60 min after it.

The results were analyzed using Statistica 5.0 software (Wilcoxon test, Mann–Whitney test, ANOVA-2, and Duncan's test). The differences were significant at $p<0.05$.

0007-4888/12/1531-0009

RESULTS

The mean BP (BP_M) did not depend on animal sex and underwent similar changes in females and males (as shown in our previous experiments [1]). BP_M in infantile and old rats was higher than in adult animals: 102±2 mm Hg in adult animals *vs.* 122±2 mm Hg in infantile ($p<0.05$) and 133±4 mm Hg old specimens ($p<0.05$). HR did not depend on animal sex and age (365±6 and 376±5 bpm in females and males, respectively). The cardiovascular sensitivity to RS was sex-dependent in animals of each age group. Ontogenetic changes in this parameter differed in females and males. The amplitude and duration of tachycardia during RS were practically similar in females and males (Fig. 1, *a*). However, the vascular effect of stress in infantile males was much greater than in females (Fig. 1, *b*). A significant increase in BP_M in males was observed not only during, but also after RS. In infantile females, a small increase in BP_M was revealed only over the first 10 min of RS. The increased vascular stress-reactivity in infantile males (as compared to that in females) can be related to a lower concentration of NO and is associated with reduced resistance to experimental hypertension [1].

Aging was accompanied by a decrease in cardiac and vascular effects of stress in males, but not in females. The amplitude and duration of stress-induced tachycardia in adult females were greater than in males (Fig. 2, *a*). The vascular effects of stress were also reduced in adult males. A significant increase in BP_M in these animals was observed only during the first 10 min of RS (Fig. 2, *b*). The hypertensive response to RS practically did not differ in adult and infantile females. BP_M in adult females was elevated only during the first minute of RS (Fig. 2, *b*). Therefore, the cardiovascular stress-reactivity in adult rats is characterized by the predominance of the cardiac component over the vascular component, particularly in females. These data are consistent with the results of observations on humans [2,5]. The reduced vascular reactivity in females during RS (as compared to that in males) can be related to a higher concentration of NO and is associated with high resistance to renal hypertension [1].

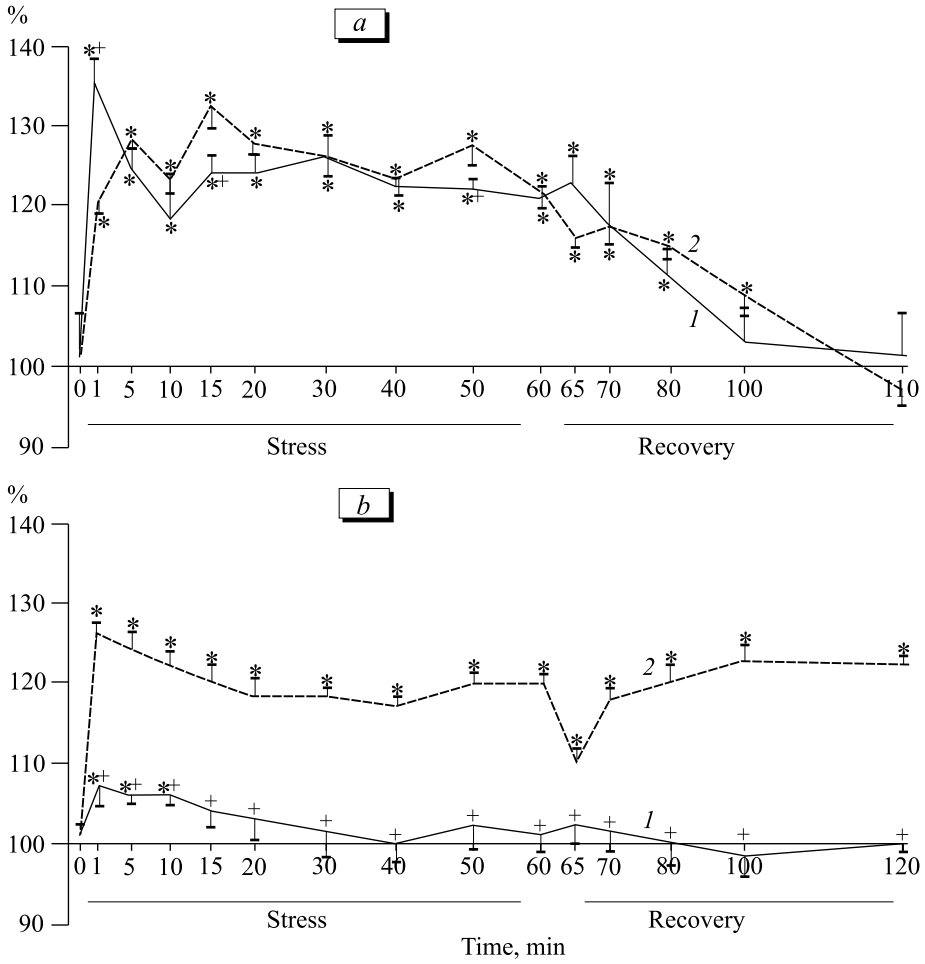

Fig. 1. HR (*a*) ***and*** BP_M (*b*) in infantile females (*1*) and males (*2*) during stress. Here and in Figs. 2 and 3: $p<0.05$: *compared to the baseline; +compared to males.

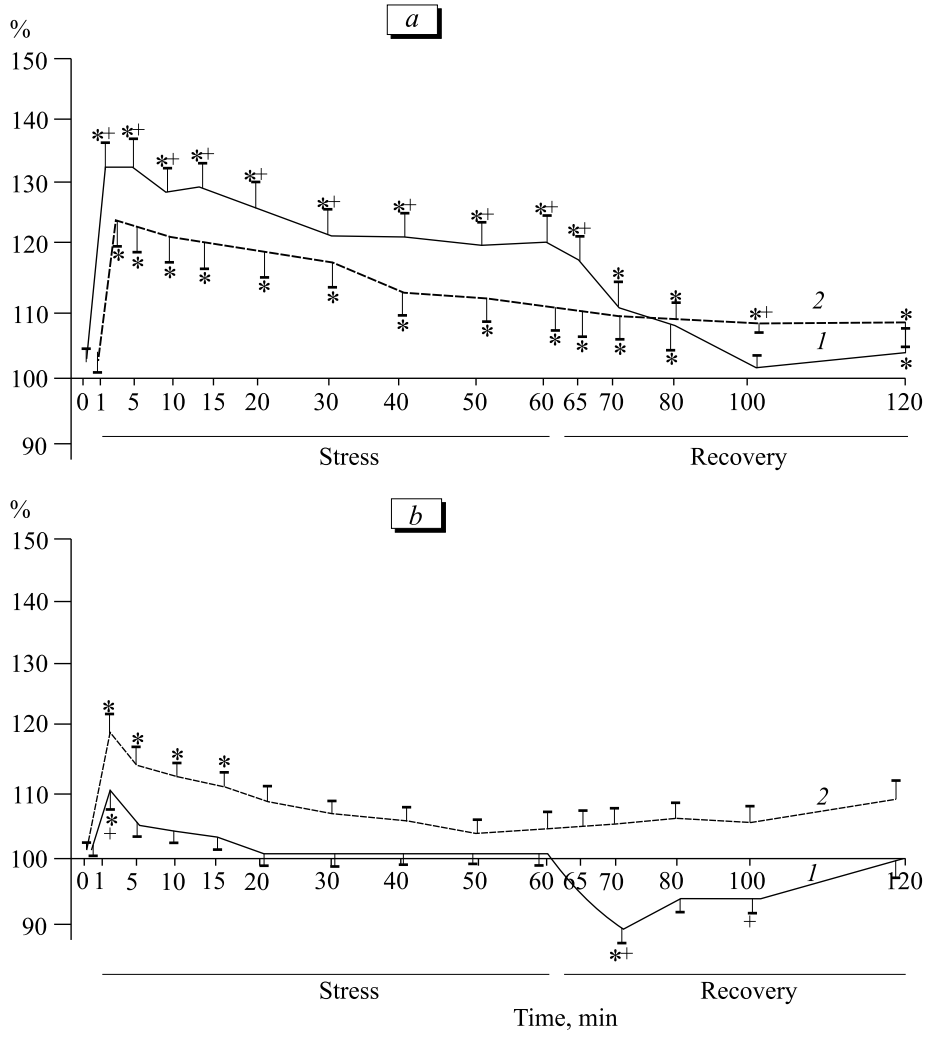

Fig. 2. HR (*a*) and BP_M (*b*) in adult females (*1*) and males (*2*) during stress.

In old rats against the background of elevated baseline BP_M (similar in females and males), a decrease in the chronotropic effect and increase in the hypertensive effect of stress were seen. Similar changes are observed in aging humans [6,7,10]. In contrast to infantile and adult animals, old females and males did not respond to RS by a significant increase in HR (Fig. 3, *a*). Moreover, male rats had bradycardia during the recovery period. Potentiation of the vascular component (particularly, in females) manifested in an increase in the amplitude and duration of hypertensive reactions. In males, elevated BP_M was recorded until the 40th minute of RS, while in females BP_M was elevated not only during, but also after RS (Fig. 3, *b*). In contrast to infantile and adult animals, old females demonstrated more pronounced vascular effects of stress than males. It is probably related to a more significant activation of the sympathetic nervous system in females [8] and decrease in NO concentration during aging [1]. Inversion of sex-related differences in the vascular effect of stress during aging is associated with inversion of sex differences in the resistance to experimental hypertension [1]. The dynamics of BP_M under stress conditions was adverse in old rats. BP_M in old females and males during RS was 169±3 ($p<0.05$) and 167±5 mm Hg ($p<0.05$), respectively. BP_M in adult females and males during RS was 113±3 ($p<0.05$) and 123±5 mm Hg ($p<0.05$), respectively. BP_M in infantile females and males during RS was 145±2 ($p<0.05$) and 154±2 mm Hg ($p<0.05$), respectively.

We conclude that age and sex differences in the cardiovascular stress-reactivity in animals and humans reflect sex-specific variations in CVS properties during ontogeny, which determines the resistance to hypertension.

This work was supported by the Federal Target Program “Scientific and scientific-pedagogical personnel of innovative Russia in 2009-2013” (NK-30P, project No. P1257).

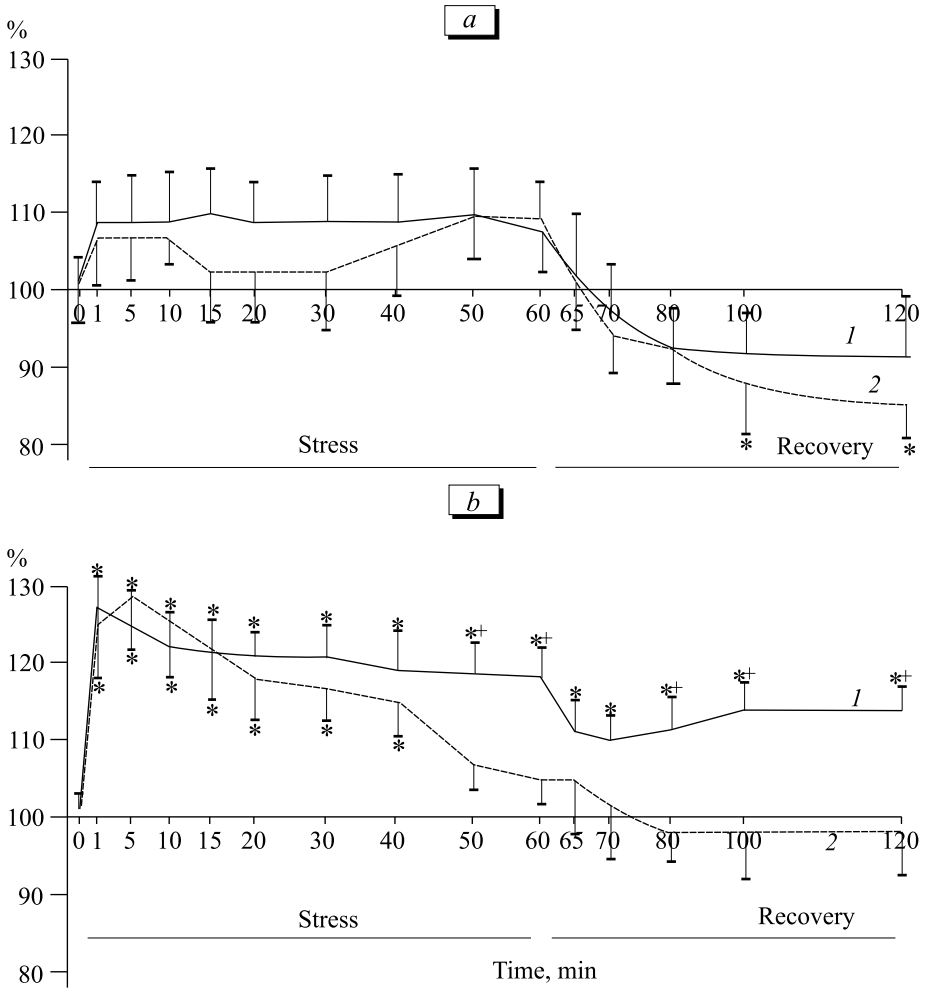

Fig. 3. HR (*a*) and BP_M (*b*) in old females (*1*) and males (*2*) during stress.

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