ACADEMIC PRESS

Changes in masculine sexual behavior, corticosterone and testosterone in response to acute and chronic stress in male rats

S. Retana-Márquez,[a],* H. Bonilla-Jaime,[a] G. Vázquez-Palacios,[a] R. Martínez-García,[b] and J. Velázquez-Moctezuma[a]

[a] Department of Reproductive Biology, Universidad Autónoma Metropolitana-Iztapalapa, San Rafael Atlixco 186, Mexico City C.P. 09340, Mexico
[b] Waters, S.A. de C.V. Subsidiary in Mexico of Waters Corporation, Adolfo Prieto 1655, Mexico City C.P. 03100, Mexico

Abstract

Chronic exposure to stressors increases HPA axis activity and concomitantly reduces HPG axis activity. This antagonistic relationship between both these axes has been proposed to underlie the inhibition of reproductive function due to stress. Sexual behavior in males may be the most vulnerable aspect of male reproduction to acute and chronic stress and it has been suggested that alterations in sexual behavior during stress are due to the antagonistic relationship between testosterone and corticosteroids. However, only in a few studies has a correlation between the levels of testosterone and corticosterone, and sexual behavior been made. In this study, we evaluated the effects of different stressors, applied both acute and chronically, on masculine sexual behavior and whether or not these effects on sexual behavior are accompanied by changes in plasma levels of corticosterone and testosterone. Additionally, we evaluated the effect of testosterone treatment on the effects of stress on sexual behavior. Sexually experienced male rats were exposed to one of the following stressors: immobilization (IMB), electric foot shocks (EFS) or immersion in cold water (ICW). Sexual behavior and plasma levels of testosterone and corticosterone were assessed on days 1, 5, 10, 15, and 20 of stress. In a second experiment, males were castrated, treated with 3 different doses of testosterone propionate (TP) and exposed to ICW for 20 consecutive days. Sexual behavior was assessed on days 1, 5, 10, 15, and 20 and steroids were evaluated on day 20. Parameters of masculine sexual behavior were modified depending on the characteristics of each stressor. Mount, intromission and ejaculation latencies increased significantly, the number of mounts increased, and ejaculations decreased significantly in males exposed to EFS and to ICW but not in males exposed to IMB. Associated with these effects, testosterone decreased in the EFS and ICW groups on days 1, 15, and 20. However, corticosterone increased only in males exposed to ICW. In castrated males, TP treatment failed to block the effects of stress by ICW on sexual behavior and corticosterone. These results indicate that the effects of stress on sexual behavior depend on the characteristics of each stressor, and these effects, as well as the decrease in testosterone are not necessarily associated with the increase in corticosterone. The fact that testosterone treatment did not prevent the effects of stress on sexual behavior suggests that other mediators could be involved in the alterations of sexual behavior caused by stress.
© 2003 Elsevier Inc. All rights reserved.

Keywords: Sexual behavior; Corticosterone; Testosterone; Acute and chronic stress

Introduction

Reproductive activity is one of the main functions that becomes altered and inactivates during the adaptive response to stress (Johnson et al., 1992). Males under stress may exhibit suppression of testosterone secretion (Collu et al., 1984a, 1984b), spermatogenesis (Almeida et al., 2000a, 2000b) and libido (Keverne, 1979; Sapolsky et al., 1986). Since Hans Selye suggested that chronic exposure to stressors increases Hypothalamus-Pituitary-Adrenal (HPA) axis activity and concomitantly reduces Hypothalamus-Pituitary-Gonadal (HPG) axis activity (1946), attention was focused on the role of glucocorticoids in reproductive dysfunction induced by stress, and this antagonistic relationship

* Corresponding author. Departamento de Biologia de la Reproducción, Universidad Autónoma Metropolitana-Iztapalapa, Mexico City, C.P. 09340. México. Fax: +52-55-5804-4930.
E-mail address: rems@xanum.uam.mx (R. Retana Márquez).

between glucocorticoids and gonadal hormones has been consistently observed.

Studies in rats, mice and humans have shown that acute exposure (from seconds to a few hours) to stressors such as immobilization (Torrellas et al., 1981), electric foot shocks (Rivest and Rivier, 1991), cold, ether (Lesniewska et al., 1990), exercise (Elias et al., 1991), food restriction (De Boer et al., 1989), or to situations that cause anxiety in males (Schedlowsky et al., 1995), is characterized by an increase in corticotropin releasing hormone (CRH), adreno-corticotropin (ACTH), β-endorphins and corticosterone (in rodents) or cortisol (in humans). Conversely, acute stress by immobilization decreases serum levels of luteinizing hormone (LH) and testosterone (Sapolsky and Krey, 1988; Norman and Smith, 1992) in rabbits, macaques, and baboons. In hamsters (Tsuchiya and Horii, 1995a) and humans (Yap et al., 1996), acute stress does not modify testosterone or, can either decrease plasma LH and testosterone (Tsopanakis et al., 1991; Reiner et al., 1987) or increase testosterone (Oka and Hirano, 1987; Wheeler et al., 1994). In intact rats, acute exposure to stress by noise or water immersion (Armario et al., 1986), immobilization (López-Calderón et al., 1990), cold (Lennox et al., 1980), hot (Siegel et al., 1981), light (Armario and Castellanos, 1984) or surgery (Frankel and Ryan, 1981), stimulates the HPG axis, increasing LH and follicle stimulating hormone (FSH), prolactin, and testosterone levels in the plasma of stressed males.

On the other hand, chronic stress by immobilization (Collu et al., 1984a, 1984b; González-Quijano et al., 1991), intermittent electric foot shocks (Ishikawa et al., 1992), prolonged exercise (Watanabe et al., 1991), constant illumination (Persengiev et al., 1991), forced swimming in cold water (Bidzinska et al., 1993), noise, fasting (De Boer et al., 1989), surgery (Gray et al., 1978), crowding and social stress (Mormède et al., 1990; Monder et al., 1994) in rats, causes a decrease in hypothalamic CRH content, an increase in plasma levels of ACTH and glucocorticoids, as well as a general inhibitory effect on HPG axis, through decreasing LH and testosterone. The same has been observed in hamsters (Tsuchiya and Horii, 1995b). In men, prolonged physical stress due to exercise (Remes et al., 1985) or military training (Opstad, 1994), as well as sleep deprivation (Remes et al., 1985), increases plasma levels of cortisol, with a concomitant decrease in testosterone.

It is well known that an adequate display of masculine sexual behavior depends mainly on testosterone (Meisel and Sachs, 1994), whose secretion is suppressed by stress. Thus, it is possible that neuroendocrine impairments caused by stress could affect male sexual behavior directly or indirectly. However, despite the number of reports of stressors influencing the secretion of gonadotropins and gonadal steroids in males, only in a few of them has a correlation between the increase of adrenal corticosteroids and the suppression of testosterone and sexual behavior been established.

Sexual behavior in the male may be the most vulnerable aspect of male reproduction, since it is sensitive to even acute stressors. Acute stress by electrical shocks on the skin or tail pinching in rats, facilitates sexual behavior (Barfield and Sachs, 1968; Goldfoot and Baum, 1972), while acute immobilization impairs sexual behavior (Menéndez-Patterson et al., 1978). However, in these studies, a correlation between the effects of stress on sexual behavior and the levels of testosterone and corticosterone was not made. The effects of chronic stress on masculine sexual behavior have been barely studied. We have studied the effects of different stressors, applied both acutely and chronically, on masculine sexual behavior and found that sexual behavior is affected differentially, depending on the characteristics of the stressor used (Retana-Marquez et al., 1996). In Talapoin monkeys, subordinate males (social stress) show neither an increase in aggression or sexual behavior nor in the plasma titers of LH or testosterone (Keverne, 1979). The aim of this study was to evaluate the effects of acute and chronic stress on masculine sexual behavior and whether or not these effects on sexual behavior are accompanied by changes in plasma levels of corticosterone and testosterone. We also analyzed whether testosterone treatment can block the effects of stress on sexual behavior in stressed males.

General methods

Adult male Wistar rats, weighing 300–350 g were housed, five per cage (50 × 30 × 20 cm), under standard vivarium conditions. The colony room was maintained on a 12:12 reverse light cycle (lights off: 09:00) and controlled temperature (24 ± 1°C). Food and water were available *ad libitum* throughout the experiments.

Sexual behavior assessment

Males were tested for masculine sexual behavior three times in order to select those displaying ejaculation at least twice. Behavioral testing was performed under dim red lights 3 h after the onset of the dark phase of the light/dark cycle. Masculine sexual behavior was assessed by placing the male in a Plexiglas arena (45 cm diameter) 5 min before a stimulus receptive female was presented. The female rats were brought into sexual receptivity by administering estradiol benzoate (Sigma Chemical Co., St. Louis MO, USA, 10 μg/100 μl oil, SC) 44 h before sexual tests. Progesterone (Sigma Chemical Co., St. Louis MO, USA, 1 mg/200 μl oil, SC) was administered 4 h prior to testing. After the presentation of the female, tests lasted 30 min. Upon presentation of the female, the following parameters were recorded: latency to the first mount, latency to the first intromission, and latency to the first ejaculation; number of mounts (mounts with pelvic thrusting), and intromissions (mounts with pelvic thrusting and penile insertion) of the first copulatory series. In addition, ejaculation frequency (number of