Stress hormones in health and illness: The roles of work and gender

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Summary
Two neuroendocrine systems are of specific interest in the study of stress and health: the sympathetic adrenomedullary system with the secretion of epinephrine and norepinephrine, and the hypothalamic pituitary adrenocortical (HPA) system with the secretion of cortisol. These hormones have often been used as objective indicators of stress in the individual. However, through their bodily effects, they are also a link between the psychosocial environment and various health outcomes. From a series of studies of women and men, it was concluded that gender roles and psychological factors are more important than biological factors for the sex differences in stress responses.

The stress responses have been important for human and animal survival and for protection of the body. However, in modern society, some of these bodily responses may cause harm rather than protection. The catecholamines have been linked to cardiovascular disorders such as hypertension, myocardial infarction and stroke, cortisol to cardiovascular disease, Type 2 diabetes, reduced immune function and cognitive impairment.

An adequate balance between catabolic (mobilization of energy) and anabolic processes (growth, healing) is considered necessary for long term health and survival. In modern society, which is characterized by a rapid pace of life, high demands, efficiency and competitiveness in a global economy, it is likely that lack of rest, recovery and restitution is a greater health problem than the absolute level of stress.

1. Stress hormones

Two neuroendocrine systems have been of specific interest in the study of stress and health: the sympathetic adrenomedullary (SAM) system with the secretion of two catecholamines, epinephrine and norepinephrine, and the hypothalamic pituitary adrenocortical (HPA) system with the secretion of cortisol. In response to sympathetic stimulation, epinephrine and norepinephrine are rapidly secreted into the blood stream with pronounced effects on the cardiovascular system and the release of energy (glucose, free fatty acids). Cortisol secretion is regulated by...
the adrenocorticotropic hormone (ACTH) from the pituitary gland and reaches a peak in blood about 30 min after an acute stress exposure. Cortisol influences the metabolism in the cells, the fat distribution and the immune system, and cortisol levels are controlled by a feedback system in the hypothalamus and the hippocampal formation. The stress hormones can be measured in blood and urine, and cortisol also in saliva. They have often been used as objective indicators of stress in the individual. However, through their effects on various bodily systems and functions, they also provide a link between the individual’s perception of the psychosocial environment and various health outcomes.

2. Sensitivity

Numerous studies have demonstrated the sensitivity of epinephrine secretion to various kinds of mental stressors in the laboratory, and also to stress in natural settings (Frankenhaeuser, 1983; Lundberg, 1984). Norepinephrine, which is involved in blood pressure homeostasis, is more sensitive to physical demands and body posture. As a consequence, among white-collar workers, who are mainly exposed to mental demands, epinephrine levels are raised about 50% at work compared with work-free conditions, whereas norepinephrine does not increase at all or very little (Lundberg and Johansson, 2000). Among blue-collar workers performing manual tasks and being physically active, epinephrine as well as norepinephrine levels increase significantly—epinephrine by about 100%, and norepinephrine by about 50%. Cortisol levels habituate rapidly to regular work conditions and do not generally increase during daily work. However, cortisol secretion increases in response to novel conditions, emotional challenge, fear, anxiety and helplessness, and during heavy workload (Kirschbaum and Hellhammer, 1989; Folkow, 1993). For example, among women regularly working more than 50 h per week, cortisol levels have been found to be twice as high in the morning compared with women with a more moderate workload (Lundberg and Hellström, 2002). In response to intense stress, such as child birth, women’s catecholamine and cortisol levels may increase more than ten times the pregnancy level (Alehagen et al., 2001). Thus, stress hormone levels are highly sensitive to environmental demands and may change quite dramatically.

Epinephrine levels increase in response to pleasant as well as to unpleasant stimulation (Levi, 1972), whereas cortisol seems to be more sensitive to negative emotional conditions (Henry, 1992; Folkow, 1993; Kristenson et al., 2004). However, cortisol levels also seem to be reduced under certain conditions. For example, in a study of five-year-old preschool children investigated at their day care center and compared with each child’s corresponding home level, it was found that indicators of sympathetic arousal, such as systolic blood pressure, heart rate and catecholamine output, were significantly elevated, whereas cortisol levels were reduced (Lundberg et al., 1993). It was presumed that stimulation from playing with other children and participating in various activities at the day care centers induced sympathetic arousal, but that these pleasant conditions reduced cortisol levels. In another study of male and female white-collar workers (Lindfors and Lundberg, 2002), it was found that individuals high in psychological well-being had significantly lower cortisol levels at work compared with individuals lower in well-being. However, very low cortisol levels are also associated with burnout and post-traumatic stress disorders (Yehuda et al., 1996).

3. Gender differences

Up to the early 1970s, almost all studies of stress-hormone responses had been performed on men. Reasons for this were tradition, convenience, the 'nuisance' of women’s biological rhythms, the risk of harming pregnant women and the general assumption that men and women would respond similarly to stress. However, when researchers in Marianne Frankenhaeuser’s group in Stockholm started to compare the stress responses of men and women under standardized conditions, systematic differences were found. In response to performance stress in the laboratory, men increased their epinephrine response significantly (50–100%). By contrast, women did not respond at all or very little, despite the fact that women performed as well or even better on the various tasks (Frankenhaeuser, 1983). In response to a more intense real-life stressor, such as an important examination, female students did show a significant increase in epinephrine output, but still less than their male colleagues (Frankenhaeuser, 1983).

In a series of studies (Lundberg, 1996), different hypotheses regarding gender differences were tested, such as type of stressor (performance stress versus emotional and interpersonal stress), type of education, gender roles (masculinity, femininity) and the role of sex hormones (testosterone,
5. Health-promoting or health-damaging effects?

Various responses to stress exposure have been important for human and animal survival and for protection of the body. The acute responses to stress involve elevated blood pressure, increased heart rate, redistribution of blood from the gastrointestinal system to the muscles and the brain, release of energy (fat, glucose), suppression of reproductive functions, increased blood coagulation, suppressed pain sensitivity, and cognitive changes. These responses are important for successful coping in both humans and animals in response to an acute physical threat. In modern society, however, stress is more often of a psychological or psychosocial rather than a physical nature, which means that some of the bodily responses may give rise to harm rather than protection.

In order to describe whether stress responses are beneficial or harmful, the Allostatic Load Model has been proposed (McEwen, 1998). ‘Allostasis’ refers to the ability of various physiological systems to adapt to the environmental demands imposed by change. According to this model, rapid activation of
the allostatic systems is necessary for successful coping with a stressor. However, rapid shut-off of any such response is important for rest and recovery. As a consequence, repeated activation of responses without time for rest and recovery as well as sustained activation, will cause overexposure to stress hormones, high blood pressure, and high levels of blood lipids, thereby increasing the risk of various health problems. Also, lack of an adequate response—as a result, for example, of exhaustion of any one system—may cause health problems due to an imbalance between different systems or compensatory over-activation of a particular system.

An adequate balance between catabolic processes (mobilization of energy), induced by stress hormones such as epinephrine, norepinephrine and cortisol, and anabolic processes (repair, healing, growth), induced by steroid sex and growth hormones, is necessary for health and survival. In modern society, which is characterized by a rapid pace of life, high productivity, efficiency, and competitiveness in a global economy, it is possible that lack of rest, recovery and restitution is a greater health problem than the absolute level of stress on and off the job.

6. Concluding remarks

Thus, a reasonable balance between activation and rest is necessary for health and survival. The human body is rather resistant to short-term demands, but in a long term perspective, we need periods of rest and recuperation to activate anabolic processes—both short-term periods of recovery, such as a lunch break or an evening rest, and longer periods, such as weekends or vacation. Regular moderate physical exercise is also known to contribute to such anabolic effects and to a more flexible stress system. One of the most important rest periods is sleep, when a number of important anabolic processes are activated (Åkerstedt, 1997).

Several countries, such as Sweden and Norway, have seen a dramatic increase in absenteeism during the last 10 years, particularly among women, due to health problems. These include burnout, depression, muscular pain, headache, gastrointestinal problems, and so on. Most of these disorders have been regarded as stress-related, and described as ‘medically unexplained symptoms’. It is possible that the more rapid pace of modern life, increased workload, and continuous adjustment to changes and new demands have contributed to a change in the balance between catabolic and anabolic processes. However, as demonstrated by Eriksen et al. (2004), subjective health complaints are not restricted to modern civilization but are also frequent among individuals living under primitive conditions.

References


