The Endocrine response to Stress

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The Physiology of Stress

To understand the stress response, we must process a fundamental knowledge not only of psychology but of physiology as well.
The Physiology of Stress

• A series of neural and chemical reactions meant for physical survival

• If you can begin to understand the physiology of stress, then you can begin to use this knowledge to augment your own health and well-being.
Hans Selye, considered by many as the father of the study of stress, developed the idea that a direct relationship exists between chronic stress and excessive wear and tear throughout the body.
Psychophysiology

- *Psychophysiology* is a term to describe the body’s physiological reaction to perceived stressors suggesting that the stress response is a mind-body phenomenon.
Stress

Body
- headaches
- frequent infections
- taut muscles
- muscular twitches
- fatigue
- skin irritations
- breathlessness

Mind
- worrying
- muddled thinking
- impaired judgement
- nightmares
- indecisions
- negativity
- hasty decisions

Emotions
- loss of confidence
- more fussy
- irritability
- depression
- apathy
- alienation
- apprehension

Behavior
- accident prone
- loss of appetite
- loss of sex drive
- drinking more
- insomnia
- restlessness
- smoking more
Physiological Systems Involved in the Stress Response

• The nervous system
• The endocrine system
• The immune system
The Nervous System and the Endocrine System

• The sympathetic N.S is responsible for the responses associated with the fight-or-flight response

• This physical arousal is stimulated through the release of catecholamines
  – epinephrine (adrenaline)
  – norepinephrine (noradrenaline)
Stress Hormones

- Breathing rate increases
- Blood flow to skeletal muscles increases
- Heart rate increases
- Blood pressure in arteries increases
- Blood sugar levels increase
- Intestinal muscles relax
- Pupils dilate
The Endocrine System

• The endocrine system is a network of four components:
  – glands, hormones, circulation, and target organs
The Endocrine System (continued)

• The glands most closely involved with the stress response are the:
  – pituitary
  – thyroid
  – adrenal
The Nervous System and the Endocrine System

- Join together to form metabolic pathways or axis
- There are four pathways:
  - the ACTH axis
  - the somatotropic axis
  - the vasopressin axis
  - the thyroxin axis
The ACTH Pathways

The Stress Response
- Increased neural excitability
- Increased cardiovascular activity
- Heart rate, stroke volume, cardiac output, blood pressure
- Increased metabolic activity
  - Gluconeogenesis: turning glycogen into sugar for energy
  - Protein mobilization
  - Decreased antibody producer
  - Muscle wasting
  - Fat mobilization: for breakdown into sugar
- Increased sodium retention (salt)
- Increase in neurological sweating
- Change in salivation
- Change in GI system tonus and motility
The ACTH Pathways

- Exacerbation of herpes simplex
- Increased ketone body production
- Appetite suppression
The Somatotropic Axis

somatotropin-releasing factor (SRF) from the hypothalamus stimulates the anterior pituitary within this axis. The anterior pituitary responds to the SRF by releasing growth hormone (somatotropic hormone)
The role of growth hormone in stress is somewhat less clearly understood than that of the adrenal cortical axis. However, research has documented its release in response to psychological stimuli in human beings (Selye, 1976), and certain effects are suspected.

Selye (1956) has stated that growth hormone stimulates the release of the mineralocorticoids. Yuwiler (1976), in his review of stress and endocrine function, suggests that growth hormone produces a diabetic-like insulin-resistant effect, as well as mobilization of fats stored in the body. The effect is an increase in the concentration of free fatty acids and glucose in the blood.
The Thyroid Axis

The thyroid axis is now a well-established stress response mechanism. From the hypothalamus is released thyrotropin-releasing factor (TRF), this stimulate the anterior pituitary to secrete TSH. From here, the tropic thyroid-stimulating hormone (TSH) is released into the systemic circulation. TSH ultimately stimulates the thyroid gland to release two thyroid hormones: triiodothyronine (T3) and thyroxine (T4). Once secreted into the systemic circulation system.
The Thyroid Axis

In humans, psychosocial stimuli have generally led to an increase in thyroidal activity (Levi, 1972; Makara et al., 1980; Yuwiler, 1976). Levi has stated that the thyroid hormones have been shown to increase general metabolism, heart rate, heart contractility, peripheral vascular resistance (thereby increasing blood pressure), and the sensitivity of some tissues to catecholamines. Hypothyroidism has been linked to depressive episodes. Levi therefore concludes that the thyroid axis could play a significant role as a response axis in human stress.
Since the early 1930s, there has been speculation on the role of the posterior pituitary in the stress response. The posterior pituitary (neurohypophysis) receives neural impulses from the supraoptic nuclei of the hypothalamus. Stimulation from these nuclei results in the release of the hormones vasopressin (anti diuretic hormone, ADH) and oxytocin into the systemic circulation. ADH affects the human organism by increasing the permeability of the collecting ducts that lie subsequent to the distal ascending tubules within the glomerular structures of the kidneys. The end result is water retention.
The Posterior Pituitary Axis and Other Phenomena

Corson and Corson (1971), in their review of psychosocial influences on renal function, note several studies that report significant amounts of water retention in apparent response to psychological influences in human beings. Although there seems to be agreement that water retention can be psychogenically induced, there is little agreement on the specific mechanism. Corson and Corson (1971) report studies that point to the release of elevated amounts of ADH in response to stressful episodes. On the other hand, some studies conclude that the antidiuretic effect is due to decreased renal blood flow. Some human participants even responded with a diuretic response to psychosocial stimuli.
Nevertheless, Makara et al. (1980), in their review of 25 years of research, found ample evidence for the increased responsiveness of ADH during the stress response. ADH is now seen as one of the wide range of diverse, stress-responsive hormones.

Oxytocin, the other major hormone found in the posterior pituitary axis, is synthesized in the same nuclei as ADH, but in different cells. Its role in the human stress response is currently unclear but may be involved in psychogenic labor contractions (Omer & Everly, 1988) and premature birth, as well as the stress response, particularly for women (Taylor, 2006).

Various investigations have shown that both interstitial cell-stimulating hormone (Sowers, Carlson, Brautbar, & Hershman, 1977), also known as luteinizing hormone, and testosterone (Williams, 1986) have been shown to be responsive to the presentation of various stressors.
According to several studies, there are sex-related differences in testosterone responses to stress. Testosterone levels in males decrease under psychosomatic or psychic stress & even with the anticipation of stressful events, whereas testosterone concentrations in females rise.
The Posterior Pituitary Axis and Other Phenomena

It remains unclear whether the drop of testosterone levels in exposure to mental stress is caused by decreased LH secretion or whether an adequate response at the pituitary level is not present. An additional impact factor might be the increased glucocorticoid secretion observed in stressful situations (due to increased corticotropin-releasing hormone production), which may be responsible for down regulated testosterone biosynthesis in the Leydig cell.
Glucocorticoids suppress the reproduction in several ways: by inhibiting GnRH release, reducing pituitary sensitivity to GnRH, and reducing the sensitivity of gonads to LH. Furthermore, GCs can reorient behavior away from reproduction. Similar to the effects on growth, GCs’ effects on reproduction have little impact over the short-term, but long-term stress can cause complete reproductive shutdown. Stress has even been implicated as a factor in human infertility (Homan., Davies, & Norman, 2007; Wischmann, 2003).
The Posterior Pituitary Axis and Other Phenomena

Finally, the hormone prolactin has clearly shown responsiveness to psychosocial stimulation as well (see Makara et al., 1980, and more recently, Zimmermann et al., 2009). The role of prolactin in disease or dysfunction phenomena, however, has not been well established. Attempts to link prolactin with premenstrual dysfunction have yet to yield a clear line of evidence. The specific role of prolactin in stress related disease needs further elucidation.
Three Stages of Effects Associated with the Stress Response

- Immediate effects of stress
- Intermediate effects of stress
- Prolonged effects of stress
Immediate Effects of Stress

- Sympathetic nervous response
- Epinephrine and norepinephrine released
- Time: 2 to 3 seconds
- Like a phone call or instant message
Intermediate Effects of Stress

- Adrenal response
- Epinephrine and norepinephrine release from adrenal medulla
- Time: 20 to 30 seconds
- Like an email
Prolonged Effects of Stress

• ACTH, vasopressin, and thyroxine affect various metabolic processes
• Time: minutes, hours, days, or weeks
• Like an “overnight delivery”
Other Stress-Related Hormones

- DHEA
- Serotonin
- Melatonin
A Decade of Brain Research

• Use of MRIs to measure conscious thoughts
• Repeated exposure to cortisol increases aging process of brain
• Repeated exposure to cortisol damages/shrinks brain tissue
• Damage due to repeated exposure to cortisol appears to be irreversible
• We are “wired for stress” for physical threats yet all threats set the alarm
Insomnia and Brain Physiology

• Various neurochemicals are released in the brain during episodes of stress that can greatly affect one’s quality of sleep.

• The brain chemistry equation for sleep involves many neurochemicals including a delicate balance between serotonin and melatonin.
Insomnia and Brain Physiology (continued)

• As daylight decreases, melatonin levels increase to help promote sleep.

• Various factors affect serotonin levels, including light, food chemistry (carbohydrates), pharmaceutical use, and emotional stress, which in turn affect melatonin levels and hence the quality of sleep.
THANK YOU FOR ATTENTION