

Physiology of Stress & Meditation

How are the mind's reactions translated into physical, bodily, reactions? There are many avenues by which stress impacts on physical function and health including⁵⁰⁸ hormones, autonomic (more about this later), changes in metabolism (especially related to lipids, insulin and the chemicals of chronic inflammation), blood coagulation (what some doctors call "stickiness"), the immune system (especially with regard to increased susceptibility to infection) and of course psychological issues themselves such as anxiety, risk-taking and substance abuse. The most important of these pathways are called the stress response systems, which mechanisms designed to handle emergencies, so let's have a closer detailed look at these.

Two Main Stress Response Systems

There are two main stress response systems in our body that are controlled by the brain and strongly influenced by our mind;

1. the sympatho-adrenal response system (SAM), responsible for what is popularly known as the "fight or flight" response
2. the hypothalamic pituitary adrenal axis (HPA).

These two systems regulate the cardiovascular system, availability of metabolic energy and immune activity which are major influencers of our health.

SAM-The Mechanism of Flight or Fight

Over hundreds of millions of years of evolution the human organism, like all mammals, has developed a number of different and highly successful survival mechanisms. Possibly the most important is the reflexive ability to run away. Or, when that doesn't work, to fight it out against any particular threat to survival that might occur. This has come to be called the "fight or flight response", a term first coined by researchers in the 1920's^[i].

This is how it works: As soon as we perceive something that threatens our safety a signal is sent from the front part of our brain to a centre deep in the brain called the amygdala. The amygdala then sends a "triple zero" call to the part of the brain that activates the SAM. Within seconds it acts to prime the heart in order to support the increased demands of either running away from the danger or fighting it out. A chemical called norepinephrine (also known as noradrenaline) is released from nerve endings (which exist at almost every organ in the body) as well as from the adrenal medulla, a gland that sits at the top of each of our kidneys, which then squirts the same chemical directly into the blood stream. When the noradrenaline reaches the target organ (from either nerves or bloodstream) it is converted to adrenaline which then activates specific mechanisms in the target organ's cells and blood vessels. This causes a very specific set of changes to occur in the body to prepare it for either the "fight" or the "flight". Much of this involves diversion of blood flow from abdominal organs and skin toward muscles (which are necessary to propel the body away from danger) and the brain (which must now work very fast to calculate how best to cope with the emergency). These changes include:

1. Increased heart rate
2. Increased blood pressure (there are SNS nerve endings in the blood vessel walls)
3. Increased rate of breathing to maximize the availability of oxygen to the muscles and brain

4. Decreased skin temperature as blood is shunted away from skin toward the muscles of the limbs and the brain that organizes the movement of those muscles
5. The diameter of the pupil in the eye increases to let more light in, so that as much visual information as possible about the environment can be collected for the brain to process
6. Electrodermal activity of the skin increases. This one we don't really understand! It relates to the fact that the skin can conduct a small amount of electrical current and when we become stressed the skin's ability to conduct electricity increases. It was originally thought to be due to increased sweat production since sweat is salty and therefore conducts electricity however this explanation has now been disproven. Although a mystery, electrodermal activity is in fact a highly reliable indicator of stress, or what the psychophysicologists term "increased arousal".

All of these changes are designed to assist us in successfully performing in the fight or flight that our mind has anticipated will occur. Blood flow to organs like the stomach, kidneys and any other system is reduced because their function is not essential to coping with the immediate crisis. Even urine production is reduced so that fluids are retained in the body to ensure that there is enough blood volume to maximize the efficiency of the heart. This explains why, after a fright, we may appear pale (due to blood diverted from the skin to the muscles), our heart is racing (due to the adrenalin hit), our eyes might be wide open (to assist in collecting as much visual information as possible) and limbs are jittery again due to the adrenalin causing our muscles to be hypersensitive to any signals telling it to move quickly. The butterflies in our belly are due to the loss of blood flow there causes odd sensations in the lining and the wall of the stomach and intestines. These physiological reactions are the basis of the "adrenaline rush".

Interestingly, there is also some evidence to indicate that this mechanism may not only be activated by stress but also by certain kinds of pleasure, if that pleasure is associated with stimulation rather than relaxation. Hence the connection between fun, extreme sports and "adrenaline junkies".

The relaxation response

There is in fact a reflex that directly opposes the fight or flight response. It has come to be known as the "relaxation response" or "rest and digest". When physiological studies of relaxation methods have been done to specifically assess the changes, this is what happens:

1. Decreased heart rate and blood pressure
2. Decreased respiratory rate
3. Increased galvanic skin resistance (also known as electrodermal activity)
4. Diversion of blood flow away from the skeletal muscles toward the organs of digestion and the skin, causing skin temperature increases in the palms of the hand and feet
5. Decreased diameter of the pupils

The relaxation response is designed to make the body slow down, so that blood flow is diverted back to the major organs in the abdomen to allow for better digestion. The brain reduces its level of activation and the person as a whole comes to feel relaxed and calm. This is not unlike the sluggish feeling we get after a large meal. Our physiology is trying to get us to stay still and rest so that it can digest and metabolise its food properly.

The HPA-Prolonged Stress

The HPA is the other part of the body that deals with threats and so is often called upon to deal with stress. It takes longer to activate and requires more extreme circumstances for it to be triggered in comparison to the SAM. It also primes the body for fight or flight, synergising the effects of the SAM systems, usually taking 20 to 30 minutes from onset of the stressful event (rather than the few

seconds that the SNS takes) and often lasting much longer; hours, days or sometimes even weeks and months.

Once activated the HPA triggers a surge of the stress hormone, cortisol. Cortisol is a very potent molecule that accesses and influences many parts of the body. One of cortisol's main effects is to liberate stored energy by inhibiting the action of insulin. That's why prolonged activation of the HPA leads to raised blood glucose and lipids thereby contributing to atherosclerosis which itself causes the "plaques" that appear in coronary arteries that then lead to heart attacks.

Cortisol also crosses into the brain where it can reduce the production of a neurotransmitter called serotonin. Since depression and negative mood are associated with low serotonin levels, chronically raised cortisol levels. This might explain the association between being chronically stressed and the sense of unhappiness and even depression that people under prolonged stress are known to be prone to.

Overactivation of the Stress Response can Damage Health

Selye proposed that the "fight or flight" reflex (or "stress response") can be triggered in modern situations that are not threatening to survival (such as in the work place) but are much more frequent. For instance, prolonged or repeated activation of the SAM by stress causes wear and tear on blood vessels, promoting development of atherosclerotic plaques and thereby increasing the risk of heart attack, stroke and peripheral vascular disease. Thus repeated activation of the SAM may result in the body's own defence mechanisms to damage its health.

The notion that a reflex designed to protect our wellbeing could, in the wrong circumstances itself become a cause of disease is a disconcerting concept. Does our modern lifestyle with its many minor but constant stresses trigger our SAM and HPA in such a way that they are constantly activated, albeit at a low level? This would explain why our risk of developing one or more of the many lifestyle diseases such as hypertension, heart disease, stroke, diabetes and even cancer is increased by on-going and chronic stress.