

Review Article

Physiology of Stress and its Managements

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Abstract

Today stress has become a major problem. Most of the people can be seen in the state of stress. Even young children are not an exception. It is essential to understand the physiology of stress if we wish to cope with the stress. The stress response involves the involvement of both nervous as well as endocrine systems. Though research on stress has provided invaluable insight and increased our understanding about the physiological and metabolic complications of stress. Stress affects most of the body systems. Though stress management has still remained a big challenge, we can manage stress by making some little changes in our lifestyle.

Keywords: ACTH; Corticoids; HPA axis; Stress; Stressor; Stress hormones

Introduction

‘Stress’ is the word which is known to everyone. We often use the term in our daily lives. Stress is not a situation or a condition during an adverse condition, as it is generally assumed. In fact, it is a way by which the body overcomes a demanding or undesirable situation. Whenever we are in some unfavourable condition (whether it is physical or mental) our body tries to maintain the homeostasis (internal milieu) and protect itself from such events adopting some ‘changes’. Stress is a series of events our body follows to cope with such situations. Selye used the term ‘stress’ to represent the effects of anything that seriously threatens homeostasis of the body [1]. Both external and internal factors affect the homeostasis of the body.

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Though stress is commonly associated with disagreeable states and experiences, but it is not always the case. Stress is simply a response to physical and emotional demands. Whenever we feel stressed this usually means that the demands of the situation exceed all our available resources. Generally when we talk about the stress in our lives we are talking about ‘stressors’.

Any factor or event that causes stress is called a stressor. Stressors can be of many types: physical or physiological changes in the body, changes in the environment, life events or behaviours. Even an unreal (imaginary) situation can act as a stressor and could be the reason of stress. In fact in most of the cases it is just an imagination which is the cause of a stress. Hence, it is very important how we perceive an event or a situation.

Types of Stress

Depending on the nature, duration and impact on the body, stress can be categorized into different categories:

Good and bad stress

Do all types of stress are harmful or have negative impact on the body. The answer is “NO”. All types of stress are not harmful. There are stressors which can be fun, exciting and motivating. Such stresses usually called Good stress or Eustress not only help in restoring our energy but also improve heart function and increase our stamina and strength. They sharpen our thinking and enhance mental ability. Distress on the other hand, is the stress which has negative or bad impact on the body. It is the stress which causes anxiety or a feeling of displeasure. Distress normally has a negative impact on our performance and can lead to mental as well as physical problems.

Acute stress, episodic stress, and chronic stress

Acute stress is the stress that occurs for a short period of time. It comes on quickly and also goes quickly. It is usually short lived. Acute stress is generally recognized with symptoms such as anger, anxiety, irritability and acute periods of depression. Some time it may bring thrill, pleasure and excitement in our lives. When acute stress is felt too frequently it is called episodic stress. Episodic acute stress in some people occurs due to a series of stressful challenges occurring one after another in their lives. When a stress persists for longer duration it is called chronic stress. Chronic stress is brought about by the long term exposure to stressors. Chronic stressors may not be as intense as acute stressors but they are more harmful than acute stressors. This is because the effect of chronic stress is the accumulated effects of stressor for a long time. Chronic stress not only affects the physical health but is equally harmful for mental health. The effects occur due to accumulated stress.

Stress Response

Whenever the body is exposed to a stressor, which may be a real or just imagined a response is elicited to overcome it. The response is not uniform in all individuals. Besides the intensity and duration of the stressor several other factors such as age, gender, personality,

physical and mental health and past experiences of the person also influence the stress response. Hans Selye developed General Adaptation Syndrome (GAS), a profile of how organisms respond to stress [1]. There are three stages in stress response: 1. Alarm 2. Adaptation and 3. Exhaustion or recovery. Alarm is the first stage that involves the 'fight-or-flight' response. This is the stage which enables us to deal with the difficult (adverse) situations. The body is prepared either to face the perceived threat, or to escape from it. This stage invokes various reactions in the body such as release of stress hormones: cortisol, nor adrenaline and adrenaline from the adrenal glands, increased heart rate, rise in blood sugar level, increase in blood pressure, etc.

If the stressful situation isn't resolved the body uses all its resources (for example, continuous secretion of stress hormones to provide energy to deal with the situation) to adapt to the stressful situation. This is the adaptation stage. This results in various types of physical (sleep problems, general tiredness, muscular pains, indigestion, allergies, minor infections like common colds etc.), mental (lack of concentration), emotional (impatience and irritability) and behavioural problems (smoking and drinking).

If the body's compensation mechanisms have succeeded in overcoming the stressor's effect there follows the recovery stage. But if the body has used up its resources and is unable to maintain normal function it leads to exhaustion stage. If exhaustion stage persists for a long time it can cause long term effects where the individual is at risk of suffering from more serious health conditions. It may lead to depression, hypertension and coronary diseases.

Mechanism of Stress

Following a stressful event the body acts at different levels to cope with the stressor. This is achieved through two major changes in the body: 1. change in pattern/amount of the release of the energy and 2. change in the distribution of energy. Several events occur to bring these changes. All such events are collectively called stress or the stress response. Stress is a multidimensional phenomenon which involves both nervous and endocrine system.

The first step in stress response is the perception of the threat (stressor). Whenever there is some stressor - real or imagined, it acts at the level of brain. In the brain, it is the hypothalamus which perceives the stressor. When the hypothalamus encounters a threat it performs some specific functions: 1. activates autonomic nervous system (ANS) 2. Stimulates Hypothalamic Pituitary Adrenal (HPA) axis by releasing Corticotrophin Releasing Hormone (CRH) and 3. Secretes arginine vasopressin (Antidiuretic Hormone ADH). Autonomic nervous system consists of sympathetic (arousal) and parasympathetic (relaxed) nervous system. The ANS regulates visceral activities like circulation, digestion, respiration, temperature regulation and some vital organs.

The sympathetic system accounts for the flight-or-flight response. In response to a stressor catecholamines: epinephrine (adrenaline) and norepinephrine (nor adrenaline) are released at various neural synapses. The release of these catecholamines causes several changes like increase in the heart rate and force of myocardial contraction vasodilatation of arteries throughout working muscles and vasoconstriction of arteries to nonworking muscles; dilation of pupil and bronchi and reduction of digestive activities in the body. All these changes are required to prepare the body for fight-or-flight response. The effects

of these hormones - epinephrine and nor epinephrine last for few seconds. The functions of parasympathetic nervous system are opposite to that of sympathetic nervous system and help in energy conservation and relaxation.

CRH acts at the anterior pituitary gland an endocrine gland located in the brain. Pituitary gland is also called 'master gland', as it controls the secretion of other endocrine glands in the body. On stimulation by CRH, anterior pituitary secretes Adrenocorticotropin Hormone (ACTH). According to Scantamburlo et al., arginine vasopressin modulates the effect of CRH on ACTH secretion [2].

ACTH released from anterior pituitary gland in response to CRH stimulates adrenal glands located on the kidneys. There are two parts of adrenal - the outer part called cortex and the inner part known as medulla.

ACTH stimulates adrenal cortex to release corticoids (glucocorticoids and mineralocorticoids). The major function of glucocorticoids is to release energy, which is required to cope with the ill effects of stressor. The energy is released by conversion of glycogen into glucose (glycogenolysis) and also by breakdown of fats into fatty acids and glycerol (lipolysis). In addition to this corticoids have several other functions such as: increased urea production, appetite suppression, suppression of immune system, exacerbation of gastric irritation, associated feeling of depression and loss of control. These are the symptoms generally seen in a person under stress. Mineralocorticoid (aldosterone) promotes Na^+ retention and elimination of K^+ . It increases blood pressure by increasing blood volume. The medulla part of the adrenal gland secretes epinephrine and norepinephrine. The functions of these hormones are the same as that of those secreted from nerve endings of sympathetic nervous system. These hormones secreted by adrenal medulla, reinforce the functions of sympathetic nervous system. The release of these hormones from adrenal medulla acts as a backup system to ensure the most efficient means of physical survival. The effects brought out by epinephrine and norepinephrine from the sympathetic nervous system may be termed as immediate effects and the effects brought out by those of adrenal medulla are intermediate effects.

The basic function of vasopressin or ADH synthesised by hypothalamus and released by posterior pituitary is to regulate fluid loss through urinary tract. This is achieved by reabsorption of water. In addition, ADH also has a prominent role on regulation of blood pressure during stress when the homeostasis of the body is disturbed in addition to release of energy second major change occurring during stress is distribution of energy to a particular organ that needs it most. This is achieved by increasing blood pressure. This occurs either through enhanced cardiac output or through constriction of blood vessel.

In addition to HPA axis some other hormones such as Growth Hormone (GH) and thyroid hormones also play significant role in stress. Growth hormone is a peptide hormone, released from anterior pituitary gland. GH is a stress hormone that raises the concentration of glucose and free fatty acids [3]. It has been observed that, in human beings psychological stimuli increase the concentration of thyroid hormones [4,5]. Thyroid releases thyroxin and triiodothyronine. These hormones also have some significant function in stress [4]. The main function of thyroid hormones is to increase overall metabolic rate or Basal Metabolic Rate (BMR). Thyroxin also increases heart rate and also the sensitivity of some tissues to catecholamines.

Though, serotonin and melatonin are not considered as stress hormones yet they are associated with mood. A decrease in the levels of these hormones is thought to be related to depression.

Impact of Stress on the Body

When the body is unable to cope with the stress or if stress persists for long time (chronic stress) it affects the body in several ways. The effects of stress are not limited to one or two organs, or systems. Stress affects the body in many ways. Stress affects both physical as well as mental health. The impact of stress on the body may not be the same in all people. It may vary depending on factors like the genotype, sex, age, physiological conditions and past experiences of the person. But some of these effects are common to every individual. Most of the effects are due to increased concentrations of corticoids and adrenaline. Some major effects on the body systems are as:

Effect on digestive system

Disturbed eating habits, acid reflux, diarrhoea or constipation are the common symptoms seen in stressed persons. Stress can also be related to obesity which is linked to a host of other health problems. Though there is no clear evidence that stressful life events promote the development of diabetes in children or in adults but hormonal changes occurring during acute and chronic stress can affect glucose homeostasis in both healthy people and in those with diabetes. Several studies have reported a negative effect of acute stress on maintenance of blood glucose concentrations in patients with type 1 and type 2 diabetes [6].

Extreme stress can also be associated with diabetes. This is because excessive cortisol can affect the activity of insulin. The body can also become resistant to insulin. This can lead to diabetes.

Effect on circulatory problems

Several studies have shown a strong association between stress and cardiovascular diseases [7-10]. According to Esch et al., stress plays a significant role in susceptibility, progress and outcome of cardiovascular diseases [8]. Psychological stresses are associated with cardiovascular diseases to the extent that cardiovascular diseases are among the most important group of psychosomatic diseases [10]. Cardiovascular diseases due to stress-induced mechanisms are mediated primarily through increased adrenergic stimulation [11]. Both adrenaline and cortisol (increased during stress) affect heart and blood pressure. Too much adrenaline makes blood pressure to go up which in turn affects the functioning of the heart since the heart has to pump harder and faster. This can produce coronary heart disease, strokes and sudden cardiac arrest. Stress has been reported to be a predictor of incidents of Coronary Heart Disease (CHD) and hypertension among both men and women [12,13]. According to Tropy et al., stress can cause increased oxygen demand on the body spasm of the coronary (heart) blood vessels and electrical instability in the heart's conduction system [14]. Chronic stress also leads to increased blood cholesterol levels. The persistent high levels of cholesterol and other fatty substances in the blood may cause atherosclerosis and sometimes may be a reason for heart attack. Cortisol also plays a role in accumulation of abdominal fat leading to obesity. Occupational stress also has significant influence on onset of CHD [15].

Suppression of immune system

The persistent activation of Hypothalamic Pituitary Adrenal (HPA) axis in chronic stress response probably impairs the immune response leading to several types of infections. Studies have shown that people under chronic stress are more susceptible to viral illnesses like flu and common cold as well as other infections [16].

The high levels of stress hormones suppress the release of cytokines, chemicals secreted by Th cells (T helper cells - a type of T lymphocytes). Cytokines regulate both cell-mediated and humoral immune response in the body. Two types of cytokines are released from Th cells. Th1 cytokines stimulate cytotoxic T cells and Natural Killer cells, cells that are involved in direct killing of target intracellular pathogens (cell mediated immune response) while Th2 cytokines stimulate B cells to produce antibodies (Humoral immune response). Chronic stress may dysregulate Th1 and Th2 cytokines that can lead to suppression of both cell mediated and humoral immune response [17]. In addition to Th1 and Th2 chronic stress also affects proinflammatory cytokines, cytokines involved in inflammatory process. According to Miller stress may continue to promote proinflammatory cytokine production indefinitely. Proinflammatory cytokines feed back to the CNS and produce symptoms of fatigue, malaise, diminished appetite, and listlessness, which are the symptoms usually associated with depression [18].

Studies have also been carried out to study the association of stress with AIDS. Leserman et al., found that faster progression to AIDS was associated with higher cumulative stressful life events, use of denial as a coping mechanism, lower satisfaction with social support and elevated serum cortisol [19]. According to Kołodziej stress or stressful life events are considered important in terms of impacting the key biological markers of the disease, viral load and CD4 cell count [20].

Some other effects of stress hormones

In addition to the above mentioned effects, cortisol also alters bone mineral density, thus affecting the development of new bones in the body. In young children stress may retard their growth. In some cases stress could also be a cause of cancer. The persistent activation of the Hypothalamic Pituitary Adrenal (HPA) axis in the chronic stress response and in depression probably impairs the immune response and contributes to the development and progression of some types of cancer [21]. Studies have indicated that stress can promote breast cancer cell colonization of bone.

Stress also interferes with the reproductive system both in men and women. Since sex life depends on the fitness of both body and mind, chronic stress may decrease libido and may even cause erectile dysfunction or impotence in men. In case of chronic stress testosterone levels can drop to an extent that can interfere with spermatogenesis (sperm production). In women stress can affect the menstrual cycle. It can lead to irregular, heavier or more painful periods.

In addition to its direct effect on health, stress also produces some behavioural changes. People living in stressful environments are more prone to smoking, which could lead to respiratory disorders and may even lead to cancer. Similarly, stressed people are more vulnerable to alcohol consumption, which has its own consequences.

Stress Management

Though it may not be possible to avoid stress completely from our life, but it can be managed by following some simple steps.

The first step in managing stress is to identify the factors which cause the stress. The factors are not same in all individuals but vary from person to person. For example, 'planning for a new job' may cause stress to some people but not to others. For most of the students examinations come with lot of stress. Some people have the habit of taking things very seriously and this may be the reason for stress in their lives. Family conflicts are a major cause of stress. Similarly, many people are very much afraid of facing any type of challenges in life and find themselves in trouble whenever they are given any challenging task. Some people find it difficult when they have to travel or even when they have to attend some party or function. So it is very important to know what causes stress in your life. Once you identify the sources, then you can plan to manage them. You can manage your stress level by making some little changes in your daily routine and sparing some time on yourselves. Some of the life style changes are:

Check your diet

A good diet is essential to keep you mentally and physically healthy. During stress your eating habits are very much disturbed and this can cause nutritional deficiencies that could further stress your body. Stress causes the body to use more nutrients than usual hence a good diet is required during stress because a poor diet may cause deficiencies leading to more stress and health problems. A balanced low-Glycaemic Index (GI) diet can keep your blood sugar stable and can help you to deal with stressful situations in a better way. A low-glycaemic index diet helps to maintain steady glucose levels which your brain requires to enable it to work efficiently and deal with everyday life. During stress, stress hormone lowers the immunity and the body becomes more susceptible to cold and other infections. Foods rich in vitamins and antioxidants can help you to boost your immune system. Vitamin B and D are needed to have a healthy immune system during stress. Hence a balanced diet containing low fat dairy products, fresh fruit and vegetables, pulses, nuts, seeds and sufficient amount of water can help you to cope with the ill effects of stress. 'Fast foods' such as pizza, burger, pastries etc., must be avoided as they not only increase cholesterol in the body but could also make you obese leading to various types of diseases.

Make regular exercise a part of your life

Keeping yourself active not only reduces the stress but also helps in easing stress. There are several ways by which exercise helps. Exercise is one of the most common and most easy ways of reducing stress. Regular exercise is the way to keep yourself physically as well as mentally active and healthy. Physical exercise not only reduces stress hormones- adrenaline and cortisol released during the stress response but also stimulates the body to release serotonin and endorphins which help in relieving stress and boosting mood. Physical exercise loosens tight muscles and relaxes the body. It improves your breathing and helps in relaxation. For a good health, a sound sleep is very much required. When you do physical exercise it tires you physically which leads to a sound sleep. A good sleep is the key to keep your worries out and keeping you cool. Exercise keeps you active and being active is a way of getting relaxed. It keeps away stresses and

strains of everyday life. People doing regular exercise are found to be less stressed. It is not always to go in gym for exercise; even walking is a great way to improve your mental health and general fitness. Exercise also lowers cholesterol and boosts the immune system. Regular exercise improves heart, lungs and circulation.

A little time for meditation and yoga

Meditation is a training to focus your mind on a particular activity thought or object that improves the concentration and awareness. It is a very powerful tool for stress management. Regular meditation induces deep physical and mental relaxation thus reversing the effects of the body's fight-or-flight responses to stress. Meditation helps in several ways. The benefits of meditation are wide and varied. It helps to slow the heart rate, relax muscles, relieve tension and activates the release of serotonin and dopamine so called 'happy hormones'. Focusing on your breathing, a simple form of meditation helps to take your mind off your worries. When your mind is turned off from your problems, you feel relaxed. Meditation can help you to refresh and recharge your body and enables you to build up a greater control over your thoughts, worries and anxieties.

Yoga is an important method of improving your body and mind. Regular practice of yoga relieves muscle tension, lowers blood pressure and decreases cholesterol levels. It is an excellent stress relieving practice. You can practice yoga when and wherever you get time.

Have a good social network

Sitting alone with your problems will never help solve your problems. It will always increase stress in your life. On the other hand when you talk to other people it not only takes your mind off your problems but also helps you to find solutions. Having a good social network of family and friends is always good. Good friends may not always have solutions to all your problems but they can definitely keep you away from your problems. A good communication especially between life partners and family members is very essential for healthy relationship because poor communication or communication gap is a major reason for conflicts in families.

Always be positive

It is your attitude which determines the level of stress in your life. It is not an event but in fact it the way you interpret it that causes the stress. A positive attitude is the best way to reduce stress. There is always something good in every bad situation. The important thing is our ability to find it out and make this a part of our life. If you have this ability you will never feel stressed. Laughter has been shown to cut levels of the stress hormones cortisol and adrenaline and boost levels of the serotonin (happy hormone) and release pain relieving endorphins. It also relaxes muscles, lowers blood pressure and boosts the immune system. Laughter is a simple way of releasing stress.

Conclusion

We are exposed to many types of stressors such as physical, environmental, physiological and psychological. These stressors cause different types of stress responses in the body including psychological responses, physiological responses and behavioural responses. If such stress exists for a long duration it causes many types of health problems affecting most of the body systems. Though it is not possible to

avoid stress totally from our lives but it can be managed by making little changes in our attitude and life style.

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