UNIT 4 POTENTIAL ENVIRONMENTAL STRESSES

Contents

Learning Objectives

At the end of this unit, you will be able to:

- understand about the potential environmental stressors that affects human being;
- comprehend how human being by the process of their in-built biological mechanism or by adopting some cultural practices make an effort to minimise the effect of stress on their body; and
- know that the responses of human to these potential stressors are not the same and there is variation in the response levels that exist in human population.

4.1 INTRODUCTION

Human population inhabits almost all the parts of the world. Take for example the Arctic dwellers like, Eskimos. These people are the original inhabitants of the arctic regions. They have developed certain common adaptive features for their survival in that environment. But, let us think of an individual or a group of individuals who have migrated to the Arctic region from the tropical or temperate region, what may happen to them? Since these tropical people do not have the adaptive features like the Arctic dwellers, can they survive? The answer is yes. This demonstrates the plasticity of human phenotypes in their capacity to adjust to a wide range of environmental stress.

Human being has the capacity to endure various environmental stresses. Stressors are conditions that threaten to disturb normal biological function or homeostasis. Heat, cold, hypoxia, disease and malnutrition are some of the potential environmental stressors that disturb homeostasis or increase the strain on human being. The coping strategy of human beings with these environmental stressors may be biological and/or cultural. Every individual with its own set of biological potentiality tries to reduce strain or enhance the endurance of strain tolerance- a

phenomenon defined as A*cclimatisation*. Although physiological and epidemiological responses of individuals to a particular environment are representative of a species, yet the concept that all population within a species would respond in the same way was challenged. But remember that A*daptation* and A*cclimatisation* cannot be used synonymously. Adaptation is a genetically fixed condition of a species or subspecies or of a specific group of organism, which favours survival in a particular environment. In other words, adaptation is something which has genetic endowment and the characters are transmitted generation after generation. On the other hand acclimatisation is a temporary biological response to environmental stress, and the response is withdrawn once the stress is removed.

4.2 POTENTIAL ENVIRONMENTAL STRESSORS

4.2.1 Heat and Cold Stress

Our body is divided into two parts (a) the core: inside which all the vital organs are present and work and (b) the periphery or shell (or the extremities, like hands and feet). The main heat reserve and production cite (because of metabolic activities) of our body is the core. The core body temperature is 98.6° F (37° C). But, this core body temperature varies between an acceptable range- 85°F or 29.4°C and 105°F or 40.6°C. However, the rise and fall of core body temperature beyond this acceptable limit disturb the balance or homeostasis of the body. If the core body temperature falls below 85°F or 29.4°C, an individual suffers from hypothermia; and if it goes beyond 105°F or 40.6°C an individual suffers from hyperthermia. The heat produced in the core is transmitted throughout the body. On the other hand, the temperature of the periphery or shell is strongly influenced by the environment and is not regulated within narrow limits like in the core.

Heat transfer in the body Although heat is produced inside the body, it is lost only through the tissues which are in contact with the external environment (mostly through skin). Within the body, heat is transported by two means- *conduction* through tissues and *convection* through blood. Heat flow by conduction is proportional to the thermal conductivity of the tissues (like muscle and adipose tissues), the change of temperature with distance in the direction of heat flow and the area through which the heat flows. Heat flow by convection depends on the rate of blood flow and the temperature difference between the tissue and the blood supplying the tissue. Here, blood capillaries have a major role to play. The blood capillaries have thin walls and together they form capillary bed across a large surface area in various tissues. The heat is exchanged through the thin walls of the capillaries between the tissues and blood.

When is the homeostasis of our body disturbed? During an endogenous heat stress (or cold stress), when the ambient temperature remains below the skin temperature, this heat flux may be enhanced by convective heat exchange between circulatory blood and adjacent tissues with the circulatory blood carrying the warmth from the central core to the peripheral tissues. During periods of exogenous heat stress (or heat stress), when ambient temperature surpasses skin temperature, the rate of sweating and the ability to move heat from the core to the skin's surface to facilitate evaporative heat loss. Both heat and cold stress disturb the homeostasis of the body.

Cold stress

Homo Sapiens is a species and thus its tolerance to cold stress is low. If you carefully follow the record, you will observe that in India, the number of death that takes place during cold season is higher than the hot season. A lesser extreme condition that may develop out of cold stress is numbness and loss of mental alertness.

When the ambient temperature falls much below the normal, the skin looses heat (because of the development of thermal gradient). Under this condition, our body tries to put a check to this heat loss by restricting the flow of blood to the skin. This physiological response of the body to cold is called *Vasoconstriction*. In this process the lumen of the blood vessels becomes narrow because of contraction of muscular walls of the blood vessels, in response to the fall of ambient temperature. The decrease in size of the lumen of the blood vessels reduces the flow of the blood to the skin and hence, heat loss from the body is reduced. However, prolonged absence of blood flow to the skin may affect energy and oxygen supply to the tissues and may contribute to the etiology of cold injury and in extreme situation may lead to frost bite. Here, another physiological response to that is cold, 'Cold induced vasodilation' (CIVD) modulates the effect of vasoconstriction. The response is termed as '*hunting reaction'* or *'Lewis wave'*. Let me give an example. If we put our finger tips in cold water we get a chilling sensation for some time and later numbness develops that region because of vasoconstriction. After some time, we regain sense in the fingers because of the effect of CIVD. This suggests that a periodic oscillation of skin temperature follows the initial decline in skin temperature during prolonged cold exposure. But, the time interval of this periodic switching over from vasoconstriction to vasodilation varies widely. For example, people who are habitual to this situation (workers of ice factory or cold water fisher men) experience a less time interval as compared to those who are not exposed to this situation regularly.

Activity

Take some ice cubes in a container and dip your fingers in it. Initially you will feel a chilling sensation; this chilling sensation will subside after sometime and your fingers will become numb. Gradually, you will regain sense in your fingers.

Shivering thermogenesis is another way by which human population responds to cold stress. Shivering is an involuntary pattern of repetitive, rhythmic muscle contractions. This is often referred as a 'Quasiexercising' state, since the muscles contract but do no external work. Shivering increases whole body oxygen uptake (V_{O2}) and thereby increasing the cardiac output. Since shivering is a muscular activity, metabolic activity increases and thereby more energy produced.

The tolerance level to cold depends on various factors- individual's familiarity with cold exposure, age, physical fitness, type of body armour, intensity of wind speed and duration of exposure. A lean individual, having a larger surface area to body mass is more likely to suffer from cold stress since heat loss from the body surface will be of higher degree. Young adult will be more tolerant to cold because of their ability to generate adequate heat through physical activity. Again, adult women, generally having shorter extremities and greater body weight compared to men are more tolerant to cold stress. Greater body mass to body surface area

means more heat production and greater average subcutaneous fat deposition and thereby heat is restored. Wind speed expedites the heat loss from the body and thereby reduces the heat tolerance.

Behavioural responses, such as taking shelter from the cold and wearing adequate protective clothing, can greatly reduce the physiological strain of cold exposure and obviate the need for nutritional interventions.

Heat stress

Similarly, during heat stress, i.e. when the external or ambient temperature becomes higher than the peripheral or skin temperature, the heat load on the individual rises. Extreme heat stress may lead to fatal heat stroke. In response to this stress, the lumen of the blood vessel becomes wider in order to allow more blood to flow through it (cardiac output increases) and thus more heat is released from the core to the environment via the shell or periphery. This physiological response is called *Vasodilation*. Since vasodilation increases the pressure of the blood down the vessels, cardiovascular strain also increases.

If the heat load still remains high, sweating through eccrine glands begins which releases further heat from the body. Evaporation of 1 liter of sweat takes away 580 kcal of heat and humans can sweat up to 4 liters an hour at the extreme. But the rate of sweating depends on the number of sweat glands that are active. Studies show that people who live in high heat load regions have more number of active sweat glands than their counter parts in cold regions. However, sweating doesn't remain as an effective cooling mechanism if the water vapour content in the atmosphere is high.

The response to heat stress is not uniform. For example, if a person who is a native dweller of cold climatic region visits Delhi during summer, the discomfort level of that individual will be high. The person will sweat profusely, experience cardiovascular strain (because of high level of vasodilatation) and may decide to stay inside the room and take rest. Contrary to this, an individual who is a habitual dweller of Delhi, will not face this discomfort level in a similar situation. Again, all the people who are habitual dwellers of Delhi, will not respond similarly because of their differential plasticity levels. Moreover, an individual who gets the first exposure of heat load in the day will find a high level of discomfort level but, will gradually feel stable as time passes.

Activity

If you start for your office from your home on a day in the hot summer season, for the first 5-10 minutes you will sweat profusely, experience tremendous heat load and cardiovascular strain. However, after some time this discomforts will go, sweating rate will be reduced and cardiovascular strain minimised.

The morphological factors impacting on thermal regulation in humans vary substantially across the population. The impact of these morphological factors becomes more pronounced when one examines the divergent subsets within a population. Individuals differing in body size and composition appear to respond differentially to variations in both ambient and core temperatures. Weight of an individual has a significantly positive relationship with sweat loss. The size of the skin surface also contributes positively towards effective cooling. If an

individual has a larger skin surface compared to mass, then the tolerance level of that individual will be high. A large skin surface means a wider surface area through which heat is released by the process of vasodilation and sweating.

Apart from biological responses, people also adopt certain behavioural adjustment and cultural practices to cope with heat stress. These include their clothing types, structure of houses, building materials used to construct houses, time of activity and food habits.

4.2.2 High Altitude Stress

High altitude environment is signified by decrease in air pressure, decrease in water vapour pressure and increase in radiant energy penetration. Out of these three, decrease in air pressure is crucial for human population. Now let us try to understand with an example how the air pressure decreases with the increase in altitude. Pile up books one above the other. Place your palm below the topmost book and observe the pressure you are experiencing. Similarly place your palm below the last book from the top and experience the pressure. I am sure that the pressures will not be the same; the pressure in the latter case will be higher. Similarly, air in the atmosphere appears to be like layers. Thus, at the sea level the pressure of the air will be the highest and will gradually decrease as you move above the sea level (towards higher altitude). The decrease in air pressure at high altitude also signifies a decrease in oxygen pressure, since oxygen is a component in the air. Breathing is a mechanical process. In this process we voluntarily (subconsciously) develop a low pressure inside the chest cavity by expanding the chest. In the way a pressure gradient develops between the atmosphere (high pressure) and the chest cavity (low pressure) and air gushes inside the lung. Now, if the air pressure in the atmosphere remains low, less amount of air can enter inside the lung and thereby a less intake of oxygen. This phenomenon is called *Hypoxia*. We all know that the red blood corpuscles (RBC) of our body contain haemoglobin, which binds the oxygen that enters with the air inside the lung. At sea level, the oxygen content of the inhaled air is high and haemoglobin becomes 97% saturated with oxygen. But, with increase in altitude level (around 4000m above the sea level), the oxygen pressure decreases and so also the saturation level of the haemoglobin decreases.

An individual freshly exposed to high altitude will experience a low level of oxygen intake, and will response to this stress by increasing the breathing and heart beat rates in order to maintain comfortable supply of oxygen to the body. This condition leads to certain health problems to the new comers of high altitude like, fatigue, nausea, increase in breathing and heart beat rates, difficulty in sleep, a reduction in aerobic capacity. It has been found that their aerobic capacity is lost by 20-30 per cent compared to their capacity at sea level. However, aerobic capacity is restored once they return to their native place (low altitude). The natives of high altitude probably manage to cope with this stress by increasing the count of their RBC, which in turn increases the oxygen saturation level of haemoglobin. But, their work capacity is not improved if they (native high altitude dwellers) go down to low altitude.

4.2.3 Nutritional Stress

Nutritional stress occurs when people fail to fulfill their nutritional requirement. This may be caused by (i) non availability of particular nutrient(s) in an ecological setup and (ii) unbalanced energy flow.

i) The study of diet and nutrition has been a central component of much research in human biology because it represents a critical interface between biology, culture and the environment. It has been argued that the increasing ability of our species to control and utilise energy was the key to understanding cultural development over the history and prehistory of cultural change. Patterns of nutritional and metabolic variation among human populations provide additional insight into the influence of environmental and cultural factors on evolution of nutrition in our species. It was commonly thought that our early ancestors were heavily dependent on meat diet. The variety in stone tool types and the depiction made by prehistoric human being in the form of cave art can be cited as supportive evidence behind this perception. In evolutionary framework, if one goes with this perception, then it becomes difficult to exemplify why the structure of digestive system of modern human signifies the requirement of some other nutrient for our body. A comparative analysis of dietary practices between two contemporary human groups, the Inuits (who are solely hunters) and Kung San (who are hunters and gatherers) will help you to understand this thesis. Inuit diet is largely dependent on meat or other animal body parts (like liver), since their habitat (arctic region) is not conducive for faunal resource. On the other hand, the! Kung San group lives in the jungles of South Africa, with plant and animal dietary resources in abundance. Their dietary practice is more dependent on diversified plant products, rather than meat. It has been observed that the Inuits probably have a lower life expectancy and face more problems related to mastication compared to their South African counterpart because of excessive dependence on meat diet.

We all know that carbohydrate, protein and fat are the major sources of nutrients in our body. Apart from these, vitamins and mineral salts also act as nutrients for our body. Carbohydrate is the principal source of energy for our body. Although fat produces more energy than carbohydrate, yet it is less consumed by the people compared to carbohydrate because of difficulty in digestion. However, there are regions in the earth, like the a Arctic, where people consume animal fat more than carbohydrate for energy because of the easy availability of the former. Again, if we look at some Polynesian communities, we will see that fat is the major source of energy and it is derived from coconut. This demonstrates that people derive their nutrients for their body from the available sources in that ecology. Protein is an important nutrient and is essential for formation of all amino acids present in our body. Human population, being omnivorous, derives this nutrient both from animal and/or plant products. But, there are people who do not consume animal products because of cultural proscriptions or dislike. Thus, these people are totally dependent on plants to obtain protein. It has been found that plants cannot supply variety of amino acids, like the animal products. An inappropriate intake of these three nutrients causes certain disorders among the human population. *Kwashiorkor* and *marasmus* are two advanced forms of protein-calorie malnutrition. They are not two different diseases with different dietary aetiology but two facets of the same disease. It is suggested that marasmus, characterised by severe growth retardation but remarkably well-preserved metabolic processes, represents a state of good adaptation to the stress of protein-calorie malnutrition. The response of the adrenal cortex may be crucial for this adaptation, a normal

increase in plasma-cortisol helping in adequate mobilisation of muscle protein and in maintenance of metabolic integrity. The failure of the adrenal cortex to respond adequately may represent the crucial step in breakdown of adaptation, resulting in the characteristic biochemical and clinical picture of kwashiorkor. The representation of this nutritional disorder comes from the countries like India, Africa, South East Asia, Caribbean and Mexico. The common symptoms of this disorder are: changes in skin pigmentation, decreased muscle mass, fatigue, large belly that sticks out and swelling.

Let me give some examples of other nutritional stress experienced by the people of the world. (a) Water is a nutrient which acts as a medium of transport and regulates the concentration of urine. In hot humid climate, water is used up in the form of sweating as a mechanism of releasing body heat. Again, in desert areas shortage of water in the environment leads to fewer intakes. In both the situation, insufficient retention of water in the body increases the chance of calculi (kidney stone formation). (b) Our body has a high level of salinity and this is critical for many physiological functions. People living in hot and humid climate lose a good amount of salt from their body in the form of sweat. This loss of salt is supplemented through selective dietary practices (plant and animal products). Human beings probably have developed this practice in course of evolution, owing to their origin in tropical regions of the world; may be by increased dependency on meat diet, which is a good source of salt. (c) There are peoples in this world (highland South Americans and Mesoamerican Indians) who lack calcium in their diets. They supplement this deficiency by using burnt limestone as spice in child's food; the adults mix this burnt limestone with coca leaves and chew. The staple food of Mesoamerican Indians is maize. These people prepare maize by soaking it in lime water. This enhances their calcium content of the body. (d) There are communities who consume leafy vegetables, meat and iron rich organs of animals (heart and spleen) to supplement iron deficiency. Use of iron cooking pots, as practiced in rural India and some parts of Africa helps to remove iron deficiency in the body. Again, over dependence of diet on meat and other blood rich organs (as found among the Inuits) or continuous use of iron cooking pots might lead to liver problems. (e) The importance of vitamins as a nutrient and its supplementation through specific diets was understood during the first half of the twentieth century. For example, people who take polished rice are likely to be affected with thiamin deficiency as the rice husk contains thiamin. Raw fish contains antithiamine compound called thiamase. Thus, the practice of consuming raw fish (as practiced by coastal Japanese people) may lead to thiamine deficiency. However, cooking of fish put an end to the action of antithiamine substance and improves thiamine absorption.

ii) The energy requirement of our body varies with body size, levels of physical activity and age. The minimum energy required by an individual when totally inactive and in thermally neutral condition is called basal or resting metabolism. Basal metabolism varies with other factors held constant according to body size. Living in extreme climatic conditions generates energy requirements. For example, living in hot climate leads to additional requirement of energy, since high amount of heat loss takes place through sweating and physical activity. Body size is another factor which varies with energy requirements. A large body size requires greater energy. Some

countries have their own energy requirement recommendations, specific to body size. We perform various physical activities in our daily life. Some of these activity types may be categorized as 'heavy', 'medium' and 'light'. Again, the duration of these activities also differ. For example, the energy requirement of a person who is tailor by profession and the one who works as an agricultural labour will not be the same. It has been found that a fit young adult of 70 kg weight can spend four times more energy than its basal metabolism for a period of 8 hours; but, the result for aged people and children will be different from this estimate.

4.2.4 Infectious Disease

Infectious diseases are also called as communicable disease and are spread from one individual to another through some *pathogens*. Pathogens are organisms that cause infectious disease like, malaria, diarrhoea, AIDS, tuberculosis and chicken pox. Pathogens may be micro (bacteria, protozoa, and virus) or macro (helminthes) in nature. The time period between infection and development of symptoms is called *incubation period* and it varies with the infection type of the pathogen. The length of time between infection and the ability to infect somebody else is called *latent period.*

Infectious diseases are a major cause of human mortality especially for the tropical countries. In fact, the tropical environment is conducive for the growth and survival of pathogens. The reasons are as follows: tropical region has a hot and humid climate; it offers tremendous floral and faunal biodiversity and has high human population density. Human beings are essentially warmth loving, and if you look at the evolutionary discourse, you will find their distribution mostly in the tropical regions, rather than in the temperate. The two most populous continents of the world that come under this region are Asia and Africa. High population density of these two regions leads to the spatial expansion of human settlement and thereby more exploitation of natural resources. For example, large scale denudation of forest took place at the cost of secured food supply and expansion of human base started with the introduction of agriculture in the society. This affected the biodiversity of this region. The pathogens that used to survive on the nutrients of plants and animals are quickly shifting their hosts and finding human as substitute. In this way many diseases which were once believed to have affected non-humans are now becoming human specific. The unicellular pathogens, with their simple cell structure, ability to modify their genotypes and multiply fast are quickly adapting in the body of the new host (human). In the process, human beings are becoming victims to emerging diseases (resulting from new mutations) and are causing more severe stress, compared to the existing ones. With the development of technology, people from the old world started moving to the new world, i.e. North and South America and the Pacific islands. In this way, the aborigines of the new world became victims to some new types of infectious diseases (like small pox, measles and influenza) that are typical of the old world. One may find this to be one of the reasons of dwindling number of aborigines from the new world.

There are two kinds of immune responses to infectious diseases- antibody mediated and cell mediated. Antibodies are proteins (also called immunoglobulin) that appear in serum following exposure to antigen (foreign substance). Repeated exposure to the same antigen elevates the immune response or the level of that

antigen-specific antibody. The second kind of immune response is cell-mediated. If a foreign body enters a cell, the infected cell is destroyed by special killer cells like, lymphocyte and neutrophil through cell mediated immunity. However, human immune system exhibits a complex set of responses to infectious agents that varies with differential biological plasticity. As a result, some of us are more susceptible to certain infections than others. Again, within human population, stress caused by a particular infectious disease is not uniform. Communities that get frequently exposed to a disease or have a historical episode of exposure to a disease are likely to develop an immune system in their body. This immunological adaptation causes less stress to its members than the ones who are newly exposed. Travellers are recommended to protect from illnesses present in other parts of the world and to prevent the importation of infectious diseases across international borders. Which vaccinations you need depends on a number of factors including your destination, whether you will be spending time in rural areas, the season of the year you are traveling, your age, health status, and previous immunisations. For example, there are some recommended vaccines for travel to India. One such is anti-malarial vaccine. The Indians do not administer this vaccine, since the disease is endemic.

An interacting complex between disease, vectors and its hosts should work together for their co-evolution. For example, a disease can be considered as fit (fit in the sense of the survival of the pathogen in the population), when (a) causes less disturbance for host and vector, (b) survives on multiple host and (c) gets adequate replacement of hosts. Pathogenic organisms use various strategies, called modes of transmission, to spread from one host to another. The wide variety of pathogens, vectors and transmission modes involved and the creative intelligence of humans have all contributed to the incredible diversity of strategies humans and other pathogens have evolved in order to survive. Modes of transmission can broadly be divided into two types- direct and indirect. The transmission of causal organisms for measles, influenza, HIV and so on takes place directly from the body of an infected person to another by various means like, sexual or simple body contact, through respiratory and fecal-oral transmission. In case of diseases like malaria, plague and dengue fever, the causal organisms are transmitted via intermediate hosts. Diseases like cholera, hepatitis B and hook worm spread through any medium, may be soil/water/food. If you take a close look at the different modes of transmission of these diseases, you will find that human behaviour and activities like, high population density, unhygienic sanitation and toilet practices, food habit, migration, agricultural practices and construction of dams for irrigation and other purposes are significantly responsible for the growth of pathogens and vectors and transmission of diseases. Let me present few examples. (1) The causal organism(s) of diseases like, measles, mumps and influenza, are found in the droplet of moisture released from the body of an infected person. Thus, the chance of rapid spread of this disease is high among the dwellers of slum and squatter and some areas of old cities, owing to their close living situation. (2) The causal organism(s) of some gastrointestinal illness (like worm infestation) are spread through fecal-oral transmission. The infectious agents get excreted in feces of affected humans and other animals. The susceptible humans come into direct contact with feces and inadvertently introduce the infectious organisms into their mouths and in turn cause illness.

4.3 SUMMARY

Let us sum-up about what we learned in this module. We started our discussion with heat and cold stress. Here we learned the various ways by which our body maintains the heat balance between core and periphery. We further learned how our body morphology is important in maintaining heat balance. *Hypoxia* is the major stress related to high altitude, and people respond differentially to this situation. Nutrition related stress is experienced by people all over the world. This type of stress may occur because of the non-availability of macro or micro nutrients in the ecology or unbalanced energy flow. It is interesting to learn how different groups cope with these various types of nutritional stress with their cultural practices. Human activities and in-activities are responsible for the spread of infectious diseases in human population. But the differential immunological response in human body makes some people more susceptible to infectious diseases than others.

Thus, we learnt about some environmental stress and how these stresses disturb homeostasis. We also learned how human population with their biological plasticity and also by adoption of some cultural practices tries to minimise these environmental stresses or increases their strain tolerance. It is also evident from this discourse that the responses of human to these potential stressors are not the same; there exist intra and inter group variations in response levels. In Anthropology, it is important to studying the variation in the response levels to different environmental stressors.

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Sample Questions

1) What is homeostasis?
2) What is hypoxia?
3) What are the ways by which human responses to cold stress?
4) How heat is transferred in our body?
5) Why tropical environment is conducive for the spread of infectious diseases?
6) When an infectious disease breaks, why the effect is not uniform in human population?
7) What do you understand by co-evolution of disease and host?