COLD ADAPTATION

Biological responses to cold stress involve mechanisms of heat production and conservation. These adaptive mechanisms to cold stress are more complex than those of heat adaptation. Successful responses to cold stress require the integration of cardiovascular and circulatory systems and, most important, the activation of the metabolic process.

Environmental factors play important role in human response to cold stress. The most important are wind velocity, humidity and duration of exposure to cold. Few researchers assumed that a low temperature, usually around 0°c, with high humidity results in greater cold sensation than with low humidity.

The degree of cold stress can be classified as -

Acute cold stress : refers to severe cold stress for short period of time.

Chronic cold stress : moderate cold stress experienced for prolonged periods of time, either seasonally or throughout the year.

GENERAL RESPONSES TO COLD STRESS

The most important mechanism for response to cold stress is conservation of heat and increase in heat production.

conservation of heat ↓ through VASOCONSTRICTION, alternated with Vasodilation

increase in heat production ↓ through ~~SHIVERING~~ SHIVERING

VASOCONSTRICTION

On exposure to cold stress, the cold receptors in the skin of an individual with minimal clothing are activated to initiate the reflexes involved in conserving heat. This is accomplished through a constriction of the subcutaneous blood vessels (vasoconstriction), which limits the flow of warm blood from the core to the shell (skin).

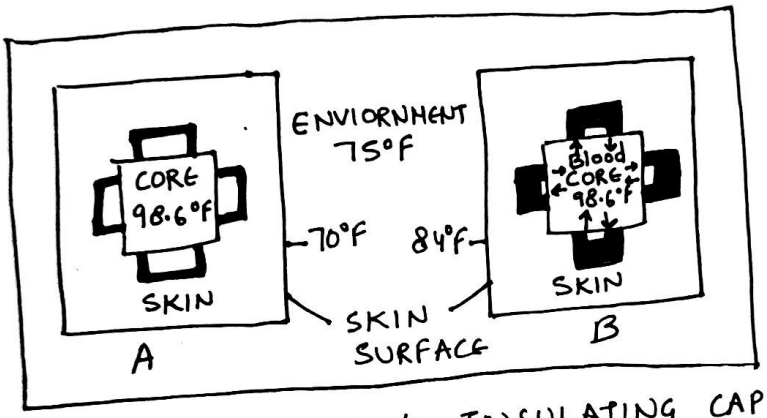
Lower blood flow ⟶ decreases in skin temperature

↓

which reduces the temperature gradient between the skin surface and the environment ⟶ Reduction in the rate of heat loss occur.

↓

As a result of VASOCONSTRICTION, heat conductivity of the blood reduced.



RELATIONSHIP OF SKIN'S INSULATING CAPACITY TO ITS BLOOD FLOW

A→ skin acts as a good insulator, i.e., with minimal blood flow temperature of skin surface approaches that of external enviornment.

B→ the increased blood flow carries heat to body surface, i.e., reduces insulating capacity of skin, and surface temperature becomes intermediate between that of core and external enviornment.

METABOLIC RATE AND SHIVERING

When the vasoregulatory mechanism of heat conservation are not sufficient to counteract heat loss, an individual adjusts by increasing the rate of heat production.

For an unclothed man an increase in heat production usually occurs when the ambient temperature falls below 25°C.

- The most rapid and efficient way to increase heat production is by voluntary exercise, such as running, which may increase the metabolic rate. Such kind of activities cannot be maintained for prolonged periods.

In the absence of voluntary exercise, shivering of the skeletal muscle is the main source of increased heat production.

- The major function of shivering is to increase the rate of heat production.
- Shivering provides improved protection of core heat by enlarging the thermogenesis of muscle mass.

Through this mechanism the temperature of muscle is raised to approach that of the core, thus eliminating the temperature gradient heat loss.

- Shivering also increases the metabolic rate two to three times to the basal value. This increase in heat production is progressive throughout the cold stress.

Along with shivering, subcutaneous blood vessels dilate (vasodilation) to keep the skin warm and prevent tissue injury from FROST BITE. Thus, adjustment to cold stress is an interplay between mechanisms to conserve heat and mechanism to produce and dissipate heat.

INDIVIDUAL FACTORS AND TOLERANCE TO COLD

1) SURFACE AREA: Tolerance to cold stress is affected by the size and shape of the individual. As per unit of body weight, the heat required to maintain a constant internal body temperature will be greater in a small individual rather than large individual. This is because surface area exposed to the environment, all other factors being constant, is greater per unit of body weight if the total body is smaller. In a cold environment, all factors being constant, a small individual would be expected to produce relatively more heat than a large individual to maintain HOMEOSTASIS.

2) INSULATION OF FAT: The most important factors affecting heat loss is the degree of artifical or natural insulation.

Subcutaneous fat represents the most important form of natural insulation among human.

The subcutaneous fat layer is not very well vascularized, the thermal conductivity of fat is much less than that of muscle. Due to this

Greater the fat layer → Lower the skin temperature → smaller the gradient between the body's surface temperature and that of the environment.

↓

Greater the fat layer → Lower the total heat loss.

3) PHYSICAL FITNESS: Physical training include
- → increased vascularization
- → increased size of the striated & cardiac muscles
- → increased maximum aerobic capacity

Degree of physical fitness would affect
- → degree of tolerance
- → rate of acclimatization to cold stress

Fit individual would be able to attain a higher heat production than those with low fitness.

4) AGE: When peripheral responses of hand measured, thermoregulatory responses are better in young adulthood than among old age. It was observed that during immersion in 10°C water (with normal room temperature) cold-induced vasodilation of the fingers was more frequent and the "hunting waves" more rapid during shorter periods in adult participant than in the older participant over 70 years.

These differences are probably caused by the effects of aging -
- decreased vascularization
- decreased peripheral blood flow
- diminished heat conductivity