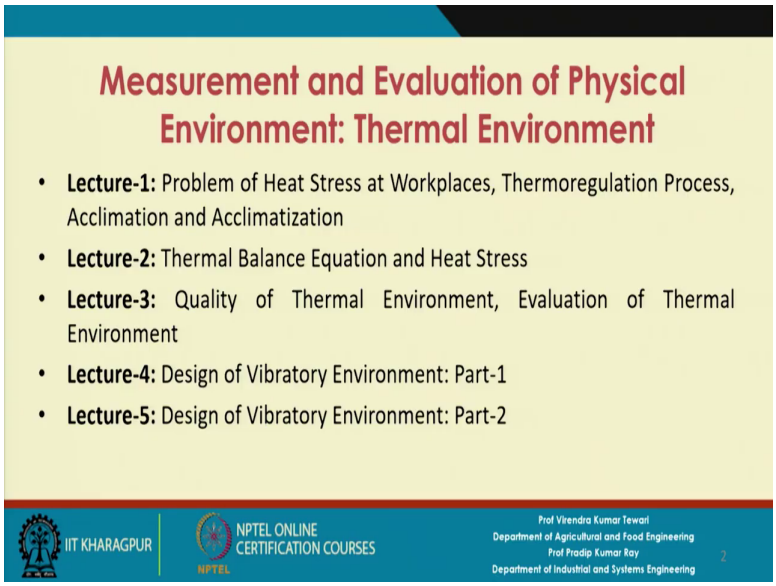
Human Factors Engineering
Prof. V K Tiwari
Prof. P K Ray
Department of Agricultural and Food Engineering
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Lecture - 36
Problem of Heat Stress at Workplaces, Thermoregulation Process, Acclimation and Acclimatization

Dear students and participants, during the 8th week we will be discussing very important topic called thermal environment and vibratory environment design. The context is measurement and evaluation of physical environment and there are four types of physical environment. First one is the visual environment and the second one is the thermal environment and the third one is vibratory environment.

During this week we will be discussing in detail the two important physical environments specifically on thermal environment.

(Refer Slide Time: 02:00)



The topic that we will be discussing this whole week are as follow:

Lecture-1: Problem of Heat Stress at Workplaces, Thermoregulation Process, Acclimation and Acclimatization

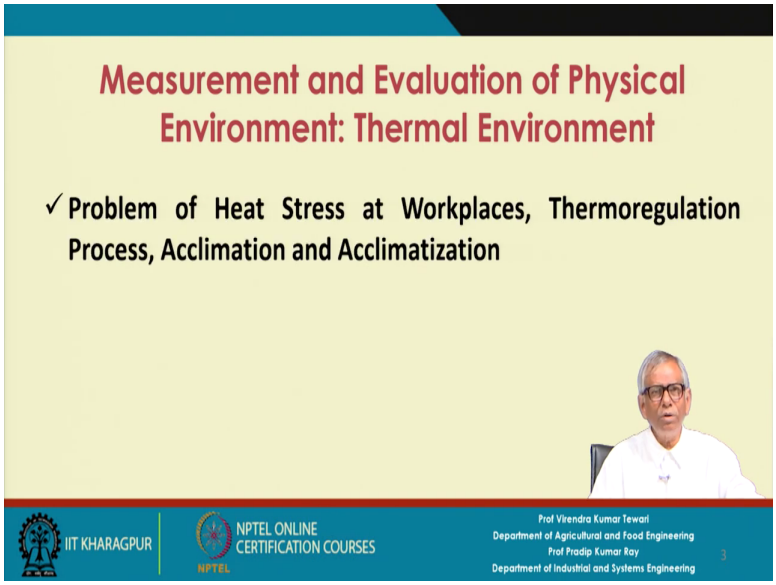
Lecture-2: Thermal Balance Equation and Heat Stress

Lecture-3: Quality of Thermal Environment, Evaluation of Thermal Environment

Lecture-4: Design of Vibratory Environment: Part-1

Lecture-5: Design of Vibratory Environment: Part-2

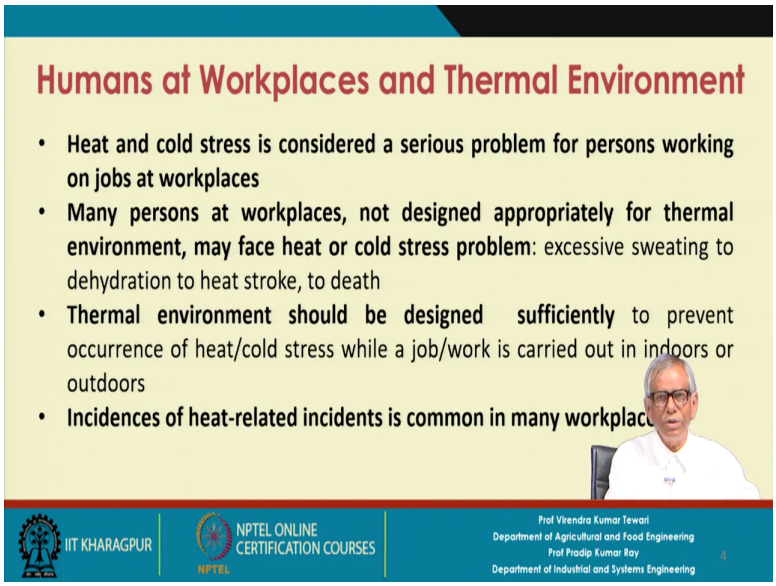
(Refer Slide Time: 03:36)



let me first discuss what are the main problems related to heat stress at work places, how the thermoregulation process of a human body is basically is related to the heat stress at a work place.

And there are two sorts of conditions in human body, one is acclimation and another one is acclimatization to a particular thermal environment. Even if in an extreme condition to what extent you can acclimatized yourself to a particular thermal environment. So, these are the important issues we are going to discuss.

(Refer Slide Time: 04:53)

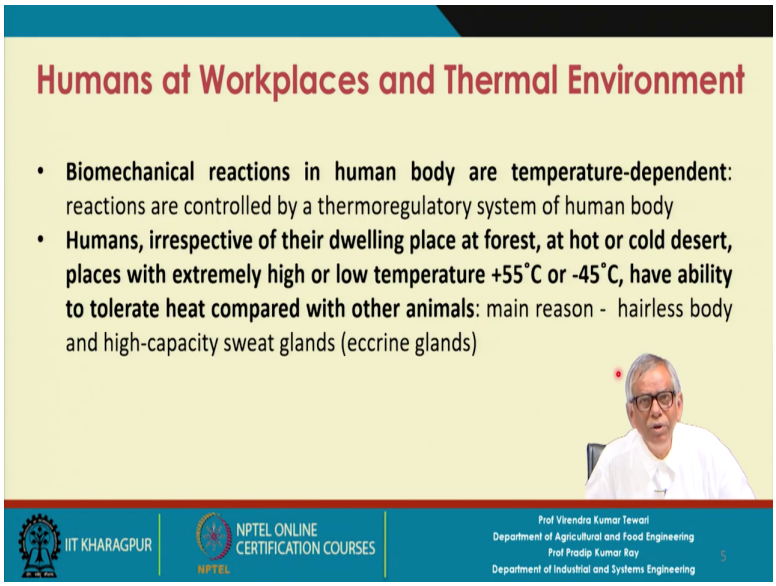


Heat and cold stress is considered a serious problem for persons working on jobs at workplaces which you cannot avoid. Different countries have different kinds of problems like in some country that ambient temperature in certain seasons could be as high as 55° Celsius whereas, some other countries the ambient temperature could be as low as -40° Celsius and for both types of countries you have a manufacturing system you have many kinds of production systems where people work. The people who are working or people at the workplaces in such conditions should feel comfortable and their health status should not deteriorate. And should be no heat stress or the cold stress because they have negative consequence.

There could be heat stroke and ultimately there could be death cases. Thermal environment should be designed sufficiently to prevent occurrence of heat/cold stress while a job/work is carried out in indoors or outdoors.

Incidences of heat-related incidents is common in many workplaces.

(Refer Slide Time: 09:24)

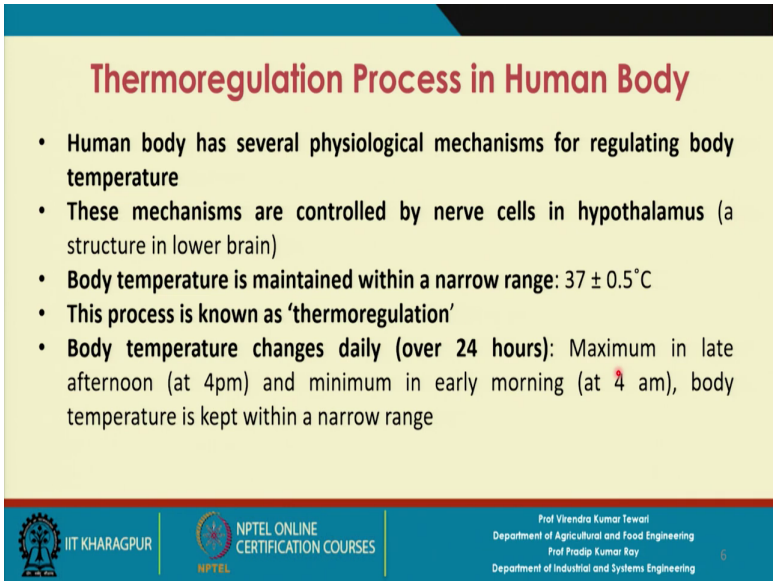


Particularly during the summer season or during the winter seasons. So, many workers, operators many persons they may fall sick. So, this is to be prevented. When we talk about designing a thermal environment for humans, we should know how human body behaves or response to a particular kind of thermal environment.

This is referred to as the biomechanical reactions in human body. Biomechanical reactions in human body are temperature-dependent: reactions are controlled by a thermoregulatory system of human body

Humans, irrespective of their dwelling place at forest, at hot or cold desert, places with extremely high or low temperature +55˚C or -45˚C, have ability to tolerate heat compared with other animals: main reason -hairless body and high-capacity sweat glands (eccrine glands).

(Refer Slide Time: 11:57)



So, we have certain advantages and disadvantages. Now human body has several physiological mechanisms for regulating body temperature and one such mechanism is thermo regulation.

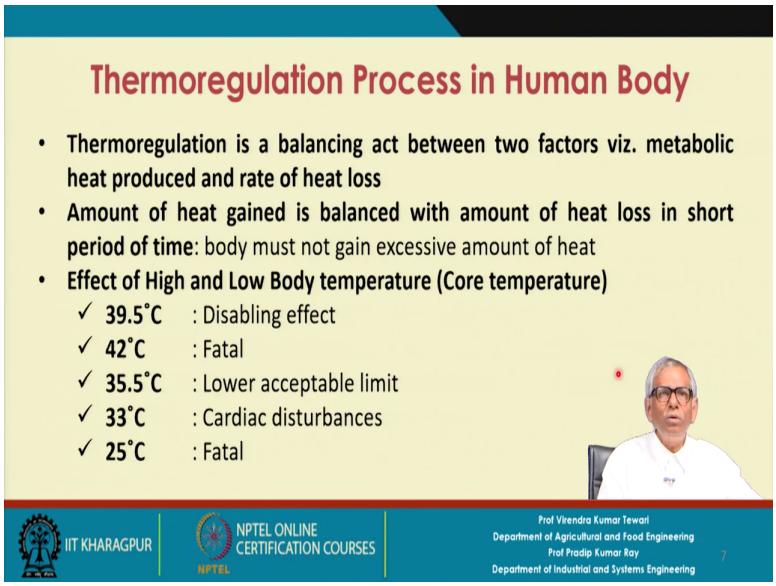
These mechanisms are controlled by nerve cells in hypothalamus (a structure in lower brain).

Body temperature is maintained within a narrow range: 37 ± 0.5˚C.

This process is known as 'thermoregulation'.

Body temperature changes daily (over 24 hours): Maximum in late afternoon (at 4pm) and minimum in early morning (at 4 am), body temperature is kept within a narrow range.

(Refer Slide Time: 15:53)



Thermoregulation is a balancing act between two factors one is the metabolic heat produced and another is the rate of heat loss just.

Amount of heat gained is balanced with amount of heat loss in short period of time: body must not gain excessive amount of heat

Effect of High and Low Body temperature (Core temperature):

39.5˚C: Disabling effect

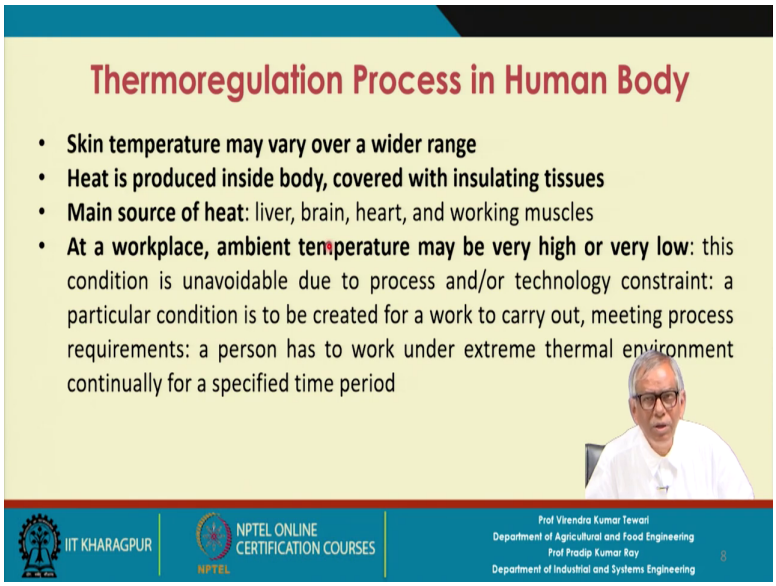
42˚C: Fatal

35.5˚C: Lower acceptable limit

33˚C: Cardiac disturbances

25˚C: Fatal

(Refer Slide Time: 19:08)

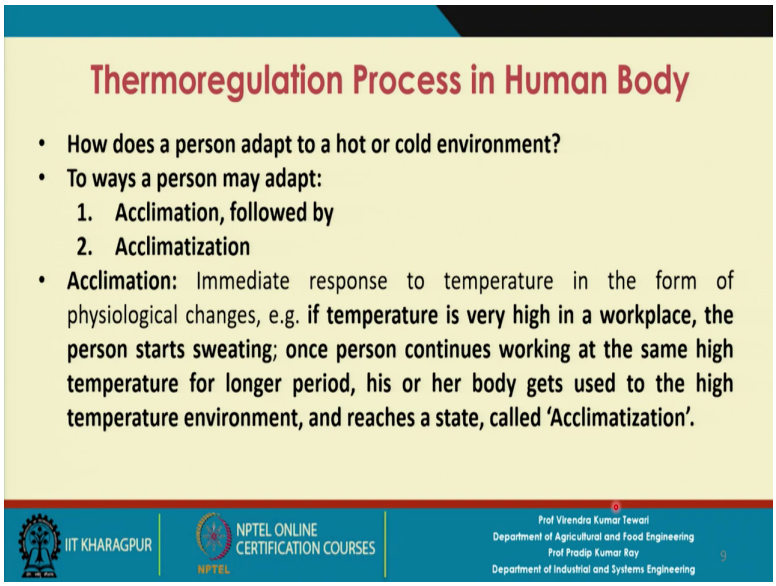


So, to what extent the workplace conditions is affecting the body temperature? So, that is to be verified. Under factories laws there are many jobs listed as dangerous operations. You may conclude that the thermal environment if it is not appropriately designed taking into consideration its effect on human body temperature then quality of thermal environment is considered very poor and not acceptable. Skin temperature may vary over a wide range. Already you might have noticed that skin temperature could be as low as 25 degrees could be as high as 42 degrees.

Heat is produced inside body covered with insulating tissues, this is the reasons of maintaining body temperature or skin temperature. Main source of heat is the liver, the brain, the heart and working muscles.

At a workplace, ambient temperature may be very high or very low: this condition is unavoidable due to process and/or technology constraint: a particular condition is to be created for a work to carry out, meeting process requirements: a person has to work under extreme thermal environment continually for a specified time period.

(Refer Slide Time: 23:40)

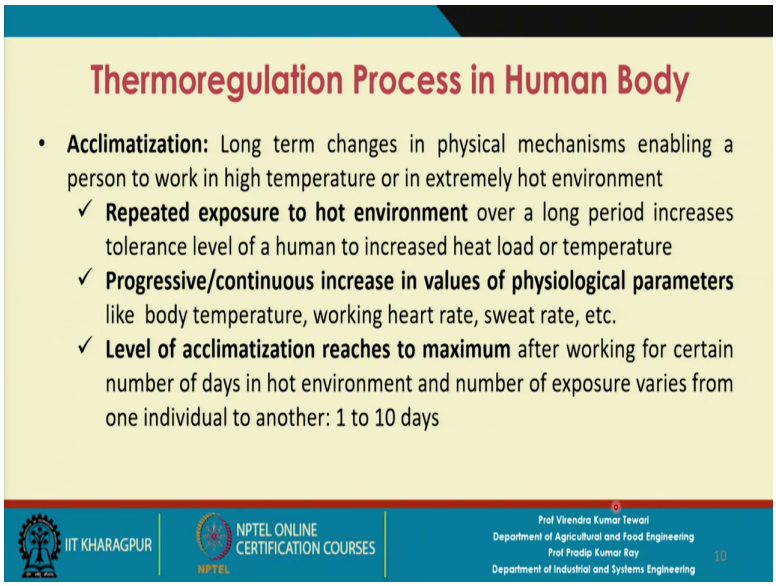


How does a person adapt to a hot or cold environment? Human body responds in Two ways a person may adopt one is acclimation (it starts responding it means human body) followed by acclimatization. And if the same condition prevails for a longer time period slowly your body becomes used to this. Body reaches a particular condition it is referred to as acclimatization.

Obviously, to get that condition you need certain time and this time may vary from say one person to another for one person the acclimatization may take just one day for another person the acclimatization may take around say 10 day time. Lot of variability is there because the individual difference with respect to a number of factors this individual difference is quite substantial.

Acclimation: Immediate response to temperature in the form of physiological changes, e.g. if temperature is very high in a workplace, the person starts sweating; once person continues working at the same high temperature for longer period, his or her body gets used to the high temperature environment, and reaches a state, called 'Acclimatization'.

(Refer Slide Time: 26:28)



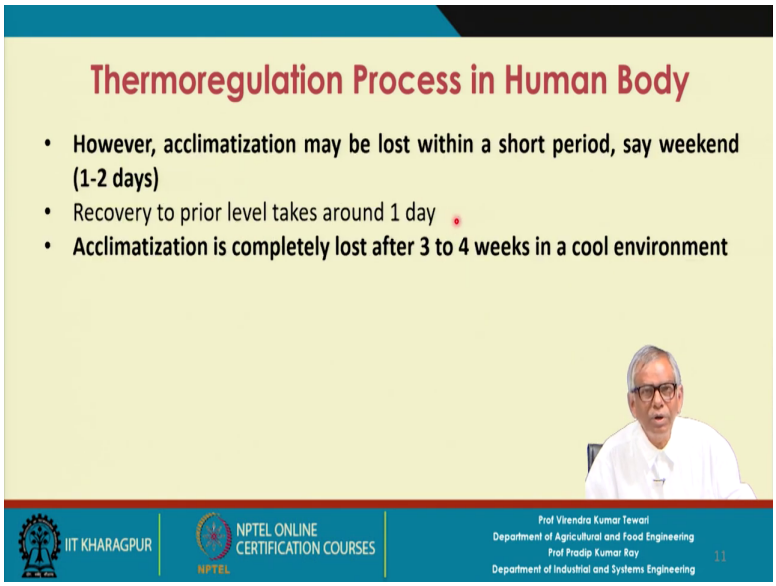
Now, you are feeling you feel totally comfortable in working in an on environment hot environment. Acclimatization is the long term changes in physical mechanisms enabling a person to work in high temperature or in extremely hot environment.

Repeated exposure to hot environment over a long period increases tolerance level of a human to increased heat load or temperature.

Progressive/continuous increase in values of physiological parameters like body temperature, working heart rate, sweat rate, etc.

Level of acclimatization reaches to maximum after working for certain number of days in hot environment and number of exposures varies from one individual to another: 1 to 10 days.

(Refer Slide Time: 27:33)



However, acclimatization may be lost within a short period say weekend one to two days because you work in an acclimatized condition in hot environment. For example, for one week from Monday to Friday and then Saturday and Sunday you do not come to the workplace and you start living in your house in an air conditioned most of the time, in a controlled environment as a control temperature obviously, the 48 hours you live in a different environment. So, in the Monday morning when you say reach your workplace and start working at given thermal environment you will feel discomfort; that means, your acclimatization condition will go away. So, that is why it is said that acclimatization may be lost within a short period.

Recovery to prior level takes around 1 day. Acclimatization is completely lost after 3 to 4 weeks in a cool environment.

(Refer Slide Time: 32:02)