Science of Clothing Comfort
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Lecture – 13
Neurophysiological Processes in Clothing Comfort (contd…)

So hello everyone so, we will continue with the topic measurement of sensory perception.

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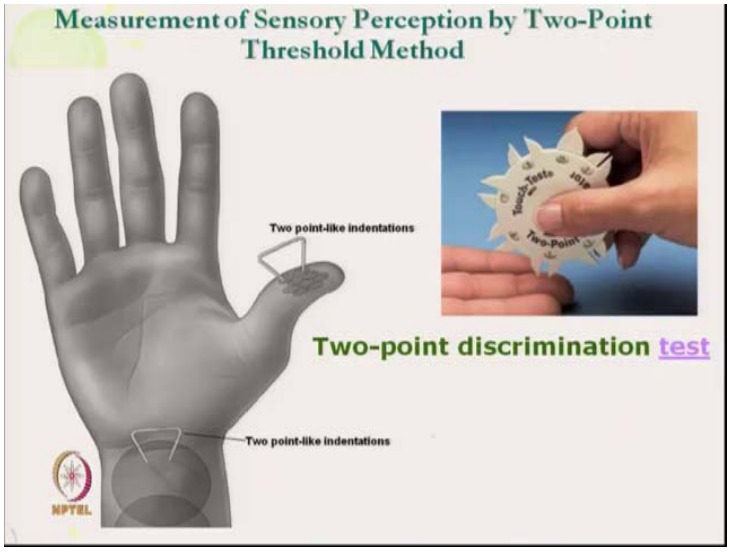

So, as we have mentioned that two point discrimination test where we try to measure the threshold distance, where a person can discriminate the two different points of contact.

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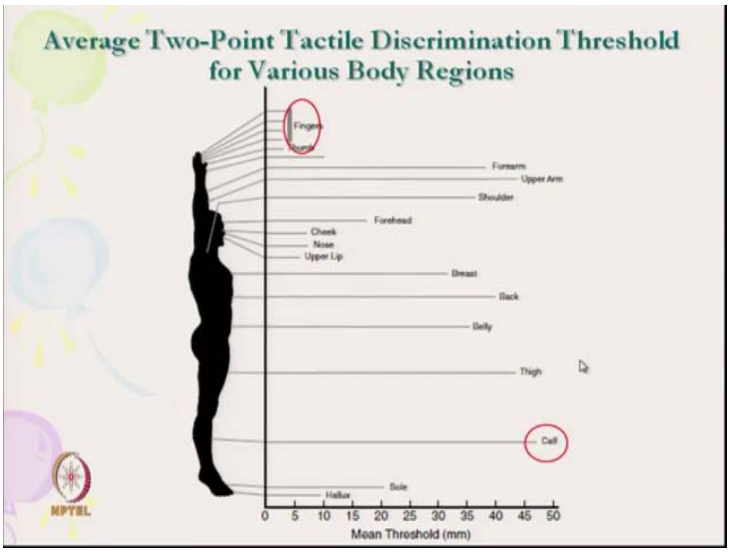

So, as we have mentioned at the finger it is a very low, it is around 2.5 millimeter. And, at the calf or high region, it is a very high. So, this is the lowest zone, highest zone, and this has the data curves taken from the same data.

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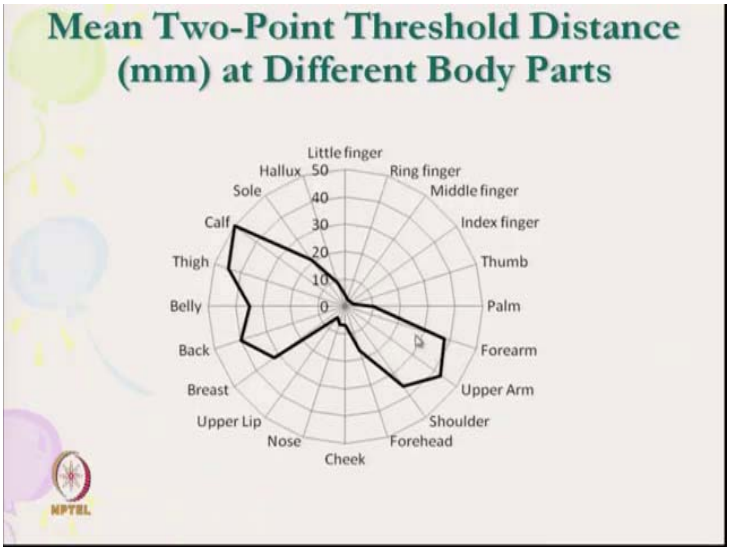

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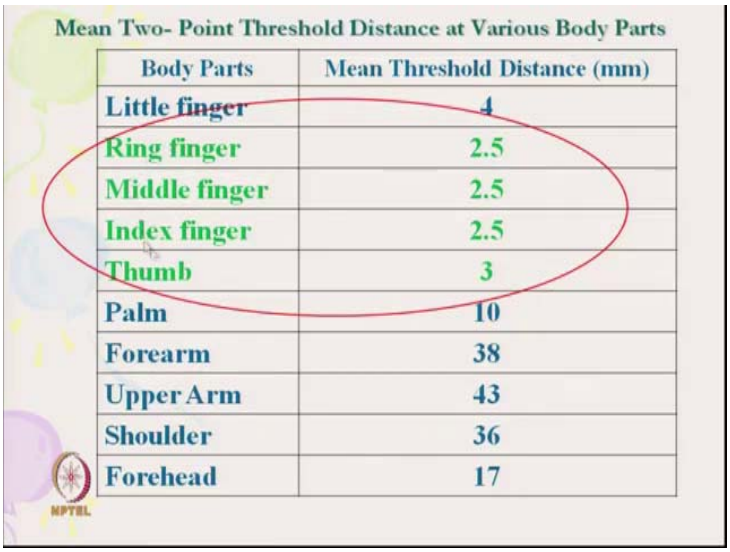

Now, if you see the in tabular form. So, these green color that finger zone and so, it is very low.

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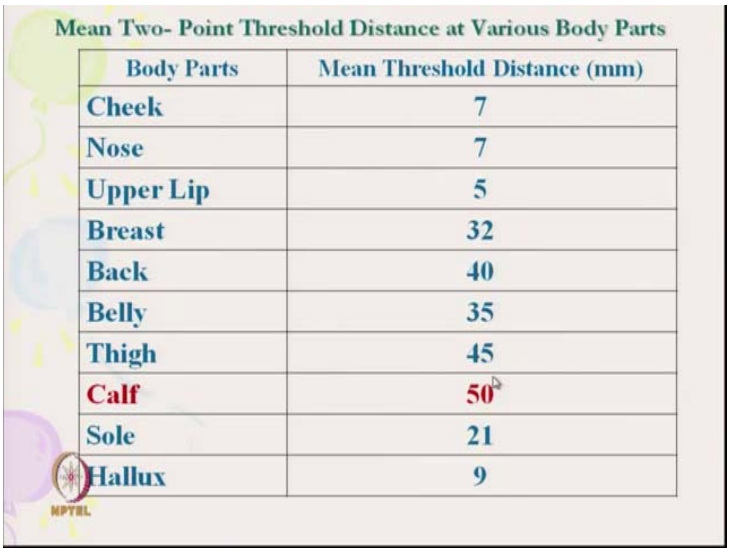

And, calf it is so, the finger the sensitivity is very high.

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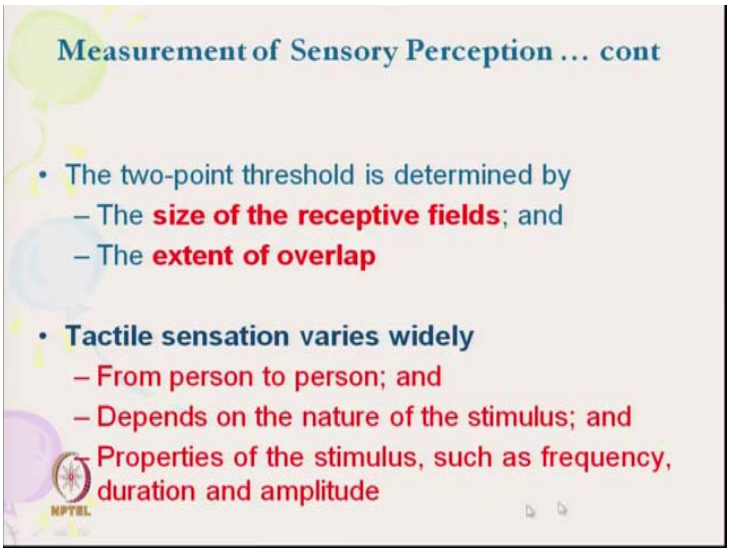

So, and two point threshold is discriminated by the size of receptive field. So, that if size of receptive field is more; that means, it will give a higher distance. And, extent of overlap, if overlap is more; that means, it will give it will not be able to give the proper sensation. So, it will not be able to discriminate so, that that is how the extent of overlapping.

And, tactile sensation it that is this the touch sensation, it varies with the person to person. Different person will have different level of sensation and two point threshold distance. And depends of the nature of the stimuli, if it is touch then he may not be able to detect, but if the pressure it becomes pressure, if it is or it if it becomes pain or if it is warm or cold so, depending on the nature of stimulation. So, it can detect this value changes that is two point threshold distance changes person to person and with the nature of stimulus.

And, properties of a stimulus, such as frequency, duration and amplitude; so, if it is say frequency is high, the stimulus it is a vibrating stimulus if the stimulus frequency is changing. So, that also affect the value this. So, for a particular type of stimulus this and for a particular person for it will give certain value. Even, as we have seen it changes at different places.

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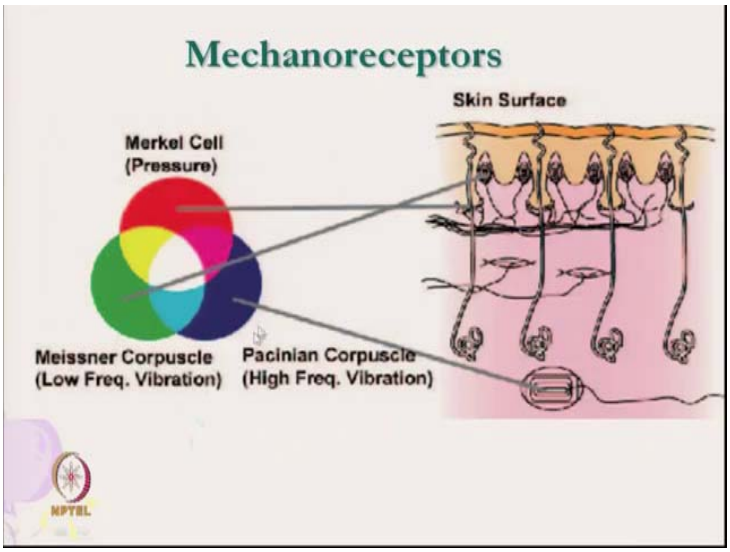

Like type of overlap, this we have seen this picture earlier also. So, if the overlap is very high; that means, sensation will be totally different.

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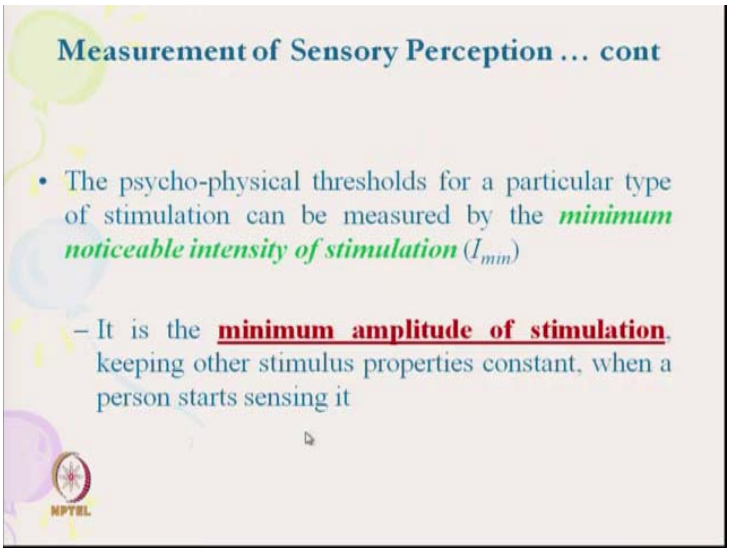

Psychophysiological physical thresholds for a particular type of stimulation can be measured by minimum noticeable intensity of stimulus that we have discussed in psychophysics ok. Here also that the total range here, it is not only the stimulus intensity of (Refer Time: 04:06) here itself the, what is the range of that stimulus?

So, that stimulus that is the minimum noticeable intensive suppose it is touch. So, it is a suddenly it is a just we can sense start sensing. So, which is called intensity I min. So, it is the minimum amplitude of stimulus, keeping other stimulus properties constant, when a person starts sensing it. So, minimum amplitude is there it is there.

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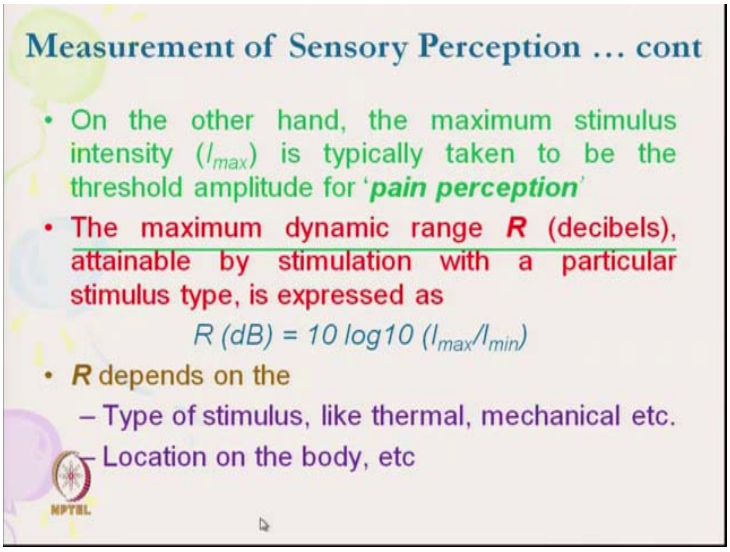

And, on the other end, when the person starts sensing as pain the same stimulus; so, on the maximum stimulus intensity I max is a typically that can be the threshold amplitude for pain receptors. So, just noticeable touch and then up to the pain receptors that total range. So, it is related with the maximum dynamic range in decibel we can express in terms of R is log 10 I max by I min; this ratio it is the it is called the range of stimulus.

This is also a measure of sensory perception. For a particular sensation for a particular sensation a person, what is the minimum and maximum sensation limit? That can be expressed in terms of R dynamic range. So, suppose something is so, after at what point is I have started sensing and up to which point I am able to bear that. So, that range is expressed in terms of R that is called dynamic range.

And, R depends on the type of stimulus like thermal, mechanical. So, at certain temperature, I start feeling cold, but up to what temperature I will be. So, this is important, this is very important for designing a comfortable clothing.

Similarly mechanical receptors are also location of the body; at which location it is there depending on the type of number of sensor.

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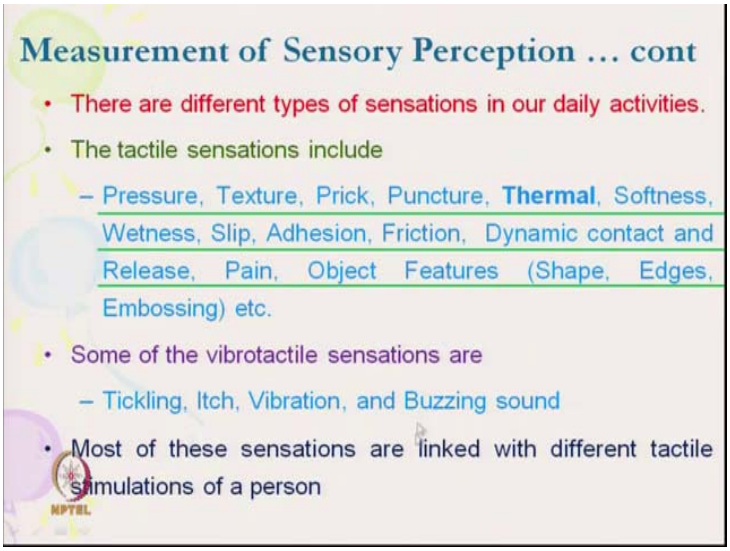

Are so, this at location we depends and there are different types of sensation in our daily activities. So, the tactile sensation, which includes the pressure, texture, prick, puncture, thermal, softness, wetness, slip, Adhesion, friction, dynamic contact and release. So, dynamic contact all this things are directly or indirectly related to clothing pain. So, and shape of the object edge, whether it is embossing or text surface texture.

So, these are the tactile responses some of the sensory perceptions are actually vibrotactile sensation due to the vibration direct or indirect vibration, like tickling, itching, buzzing sound. So, these are the sensation we received or body different types of vibration. And, most of this sensations are linked with different tactile stimulation of body. So, these are the tactile sensation and vibrotactile they are related.

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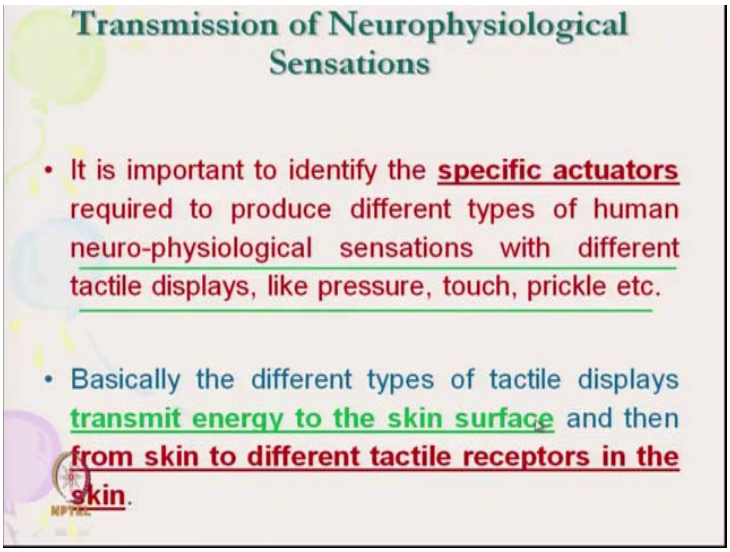

Now, we will discuss that how this neurophysiological sensation get transmitted? So, we have discussed that it is important to identify the specific actuators required to produce different types of human neurological sensation, which results with the different tactile display like pressure, touch, and prickle. So, first we have to get this sensation, basically the different types of tactile display transmits the energy to the skin surface. So, maybe it is a vibration, maybe tickling or maybe something maybe touch or so, they actually sent energy to the skin.

First this, all this stimulation, we have discussed earlier. So, this all send energy to the skin. And, then from the skin it goes to different sensors; if it is warm sensor, if it is vibration, if it is high pressure. So; that means, first it is the stimulation is there, then it is basically like different types of pressure touch prickle, then it is sends signal energy to the skin from the skin surface thus energy transmits to the tactile receptors different receptors of it.

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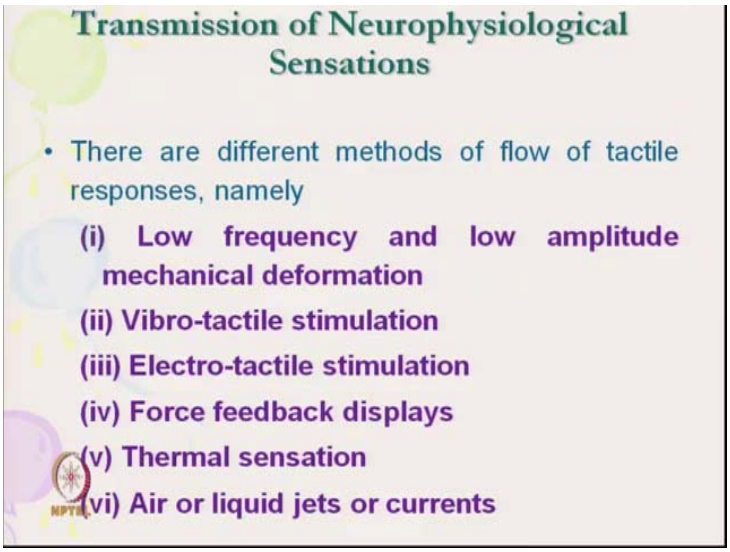

And then from that receptors there are it gets transmitted to the brain and through the spinal cord. So, there are different methods to flow the tactile responses. So, tactile receptor get signal ok, this the low frequency, low amplitude, mechanical deformation. So, how this mechanical stimulation gives the signal to the receptors is the way, it is one is the low frequency, low amplitude mechanical deformation.

So, if it touches. So, it may deform the skin as well as the receptors as we have discussed, then Vibro-tactile stimulation through the vibration. It gets stimulated, Electro-tactile stimulation, through electric current it gets stimulated, forced feedback display. So, it is like it is some kinesthetic (Refer Time: 10:51) if it is moving. So, that type of display it is there thermal sensation with the heat it is flowing. So, that type of sensation it gets.

So, all these ways the sensation gets transmitted. And, another way is that through air or liquid jet out liquid current; so, through air so, air is blowing so, that sensation we can get. So, when air is blowing as we have discussed that through hair follicle nerve ending, we get sensation. These are the 6 different ways we get the tactile flow of tactile sensation to our body. Now, one by one we will discuss. The low frequency and low amplitude mechanical deformation.

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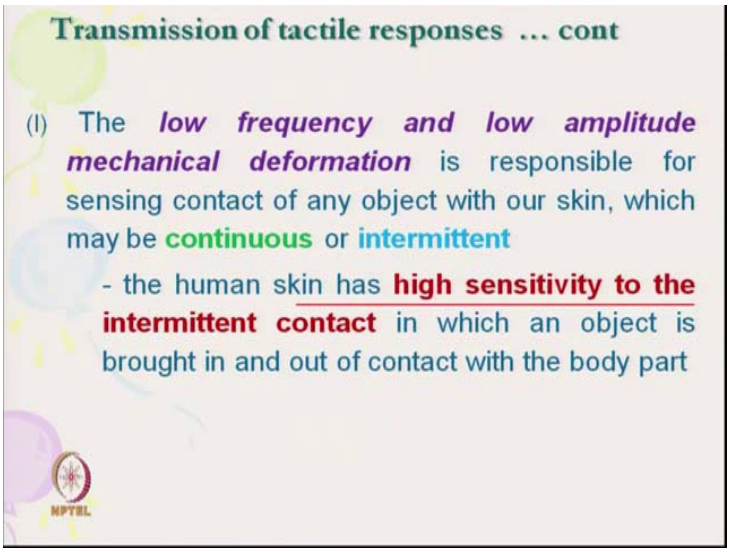

What is that? The low frequency low amplitude mechanical deformation is responsible for sensation of contact of any object without skin, which may be continuous or intermediate. So, that with the help of this so, when human skin has high in sensitivity with the intermittent contact. In which an object is brought in and out of contact of the body. So, if it is touching continuously or it is releasing, it starts that sensation is very active in our skin. Whereas, if an object is constantly in touch the sensitivity, may not be that high.

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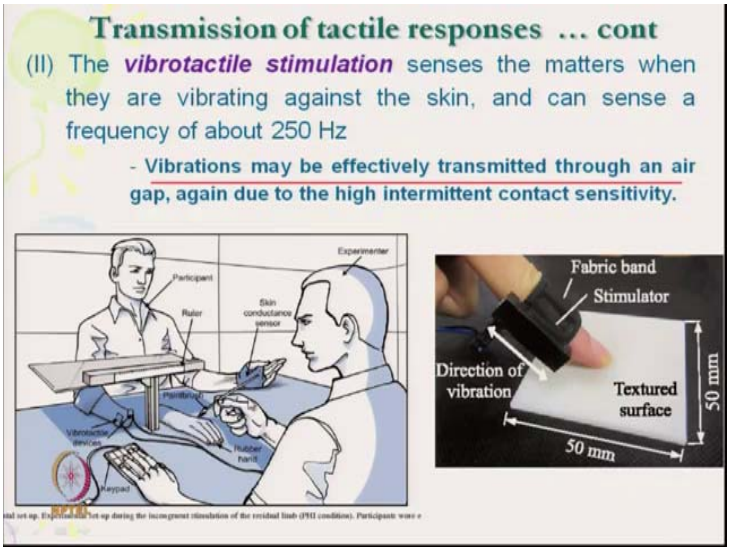

Vibrotactile sensation it sense the matter when they are vibrating nature against the skin, this can sense frequency, send a sense of frequency is about say 250 hertz. So, that type of sensors are present we have discussed earlier. So, this 250 hertz so, are at that high frequency our body gets sense sensation it gets transmitted. So, vibration may be effectively transmitted through air gap, and again due to high intermittent contact of sensitivity.

So, through air gap suppose some vibration something is vibrating, through air gap it gets sense signal or something is continuously touch we have we have actually touched at very high frequency something is vibrating at high frequency, that sensation we can get ok. And, our sensors get signal, it is getting transmitted. So, vibrotactile sensation is these are the different techniques available to actually sent signal, tactile signal, in our body ok. So, something is vibrating if it is touching, then we can get signal. This is an examiner, this is a participant, here some vibrating object is in is touching and he is trying to get the signal.

And, this is another this here is a textured surface. And, if someone is moving the finger and then there will be a vibration. So, due to the textured surface, there will be certain direction of vibration and this is the stimulator. We can get that signal. So, there will be vibration stimulator and our skin gets some vibrating signal and it gets transmitted.

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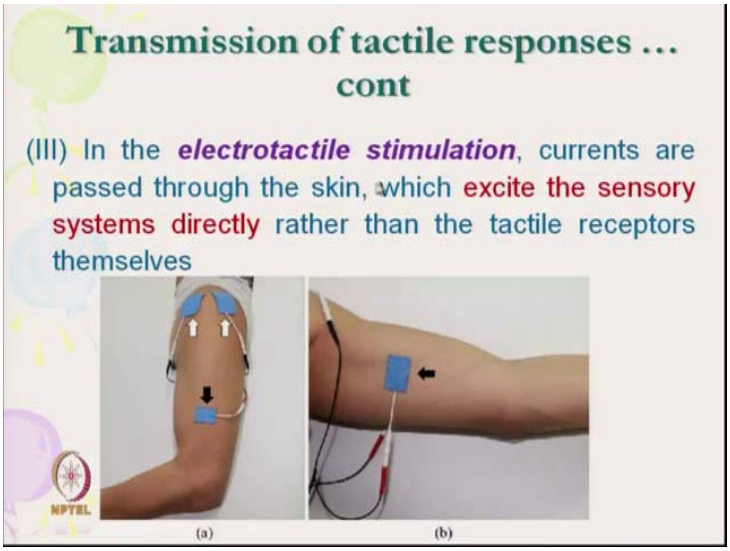

Similarly, the electrotactile sensation, the electrotactile stimulation is when a current is passed through a skin. We get certain signal shock, which excites the sensory system directly rather than the tactile. So, it directly it sent signal to the sensory system, we get some shock. This is called electro tactile stimulation and by this, we can test whether our sensations are working or not.

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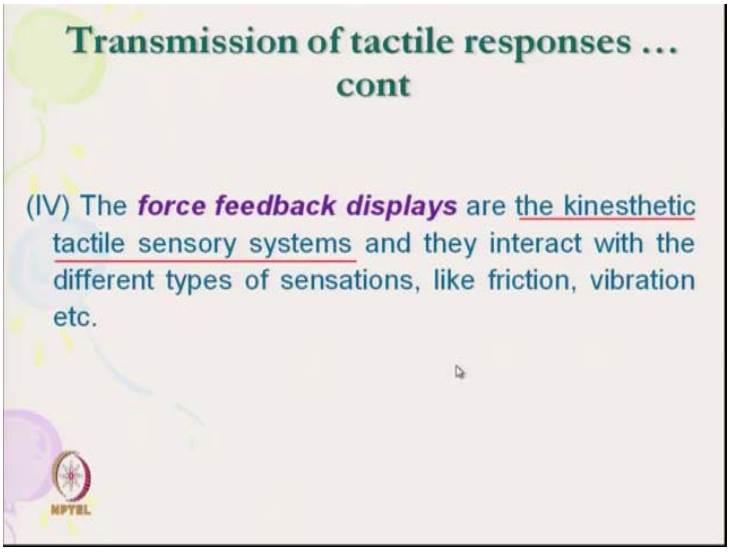

And forced feedback display as we have it is a kinesthetic type sensory system. And, they interact with the different types of sensor like friction, vibration. So, when something is moving, whatever sensation, we get it is called forced feedback display. Like when we move our cloth start slipping from (Refer Time: 15:45), it gets some movement a relative movement. So, that gives this type of feedback system display, it is kinesthetic tactile sensory system, like friction, vibration.

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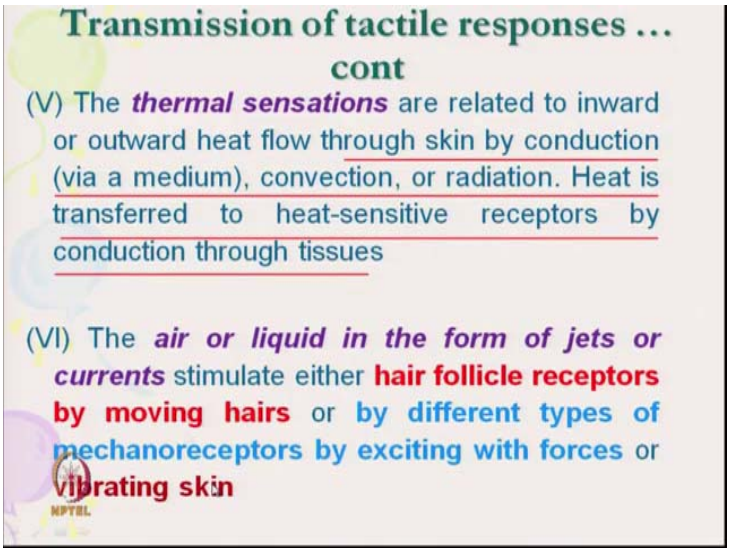

And thermal sensation related with the inward and outward flow of heat from our body; through by the conduction of the skin or convection or radiation. Heat is transmitted to the heat-sensitive receptors by conduction through tissues. So, another way of the transfer of heat is our skin receives heat from the environment through conduction, convection and radiation. And, then this heat is transmitted to the skin to the receptor by conduction through the tissue. And, then thermal receptor that they sense the signal, and that ultimately this up sensation, it is sent to the brain. Refer Time: 17:13).

Next is air or liquid. In the form of jets or current, stimulates either hair follicle receptors by moving the hair or by different type of mechanoreceptors by exciting with the force or vibrating skin. So, this is very important, suppose air is moving slowly, if it is able to distort our hair; that means, our hair follicle receptor will sense. The movement of air and it gives a signal, suppose there is no hair.

So, still we get feeling of that type of or movement or air is moving or air jet is there. So, if air jet is projected against our skin; that means, it will give some pressure sensation. So, our mechanoreceptors will be activated, by the force or vibrator, it starts vibrating the skin. So, these are the ways we get the tactile sensation responses which are getting transmitted in our body.

Now, we will discuss that, the physiological requirement of our body. That is thermoregulation, the thermal temperature regulation, how to actually control the

temperature our body, controls the temperature by physiology. And accordingly we can select our clothing to keep our body comfortable. So, in this segment, we will discuss the temperature regulation. So, metabolic heat and body temperature it is a known.

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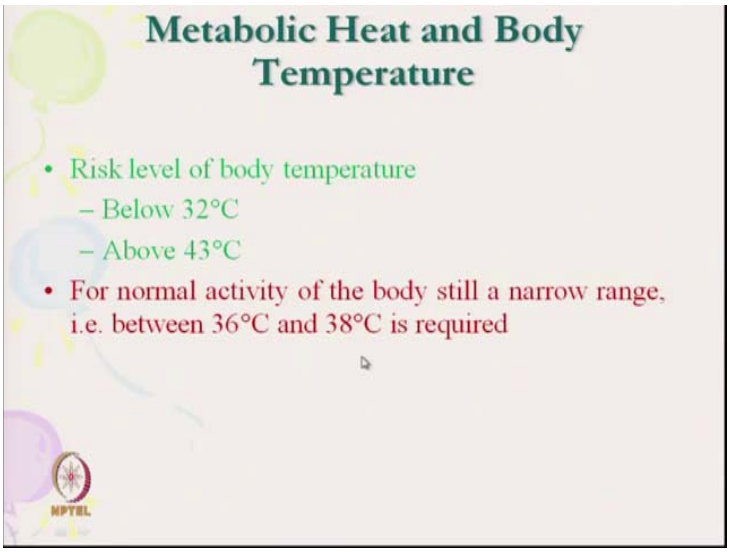

So, the risk is that if it goes beyond plus minus 5 degree Celsius, then our body will be at risk like normal body temperature is 37 degrees Celsius. If, it goes below 32 degree Celsius, hypothermia and hyperthermia will be there if it is going above 43 degree Celsius.

So, this is the temperature, it is within this range we can survive, but ideally the temperature should be around say 37 degree 36 to 38 that range. It is a comfortable range. So, 36 for normal activity the body requires narrow range. So, 36 to 38 degree Celsius is the normal range. So, beyond that range we will not be able to survive.

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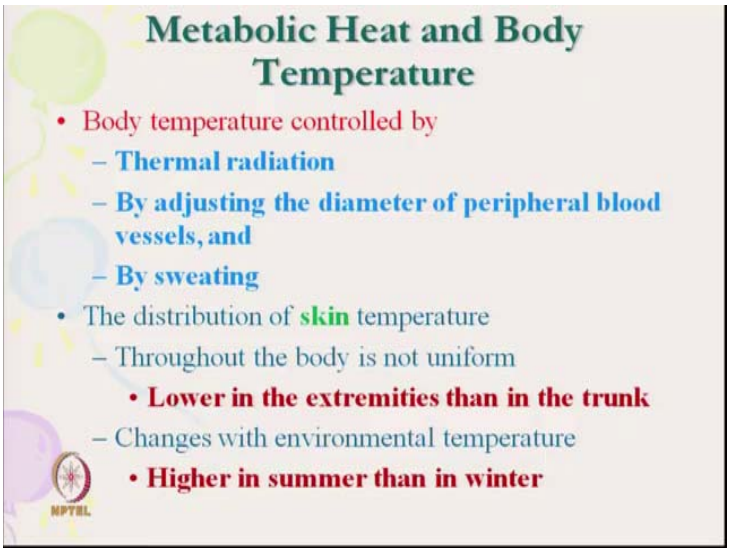

So, how to control the body temperature physiologically. So, body temperature is controlled by thermal regulation. So, our internal physiology, it actually controls the body temperature automatically, but our clothing's function is to help, it assist in case if it is required, if it is required then our clothing can assist to keep the body temperature constant under control. And, the thermal that is the body temperature, it is actually that thermo physiological activities or physiological activities are there. So, that way it can control.

So, it is by thermal radiation. So, our body can release the heat by radiation, by adjusting the diameter of peripheral blood vessel that we will discuss, like vasoconstriction or vasodilation. So, by changing the diameter of the blood vessel, it controls the flow rate of blood. Accordingly our body temperature is controlled by sweating. So, when our body gets heated up.

So, our physiological activity automatically it starts working and our sweat glands get activated. And, we start sweating by sweating, we release body heat, but our clothing's function is to actually manage this sweat. If our clothing does not actually absorb the sweat, then our body temperature cannot be controlled, our body temperature will keep on increasing. And, one is body temperature controlled and next is the distribution of skin temperature.

So, skin temperature, our body temperature as we have seen the core temperature is within 36 to 38 degrees Celsius. Typically it should be around 37 degree Celsius.

But, what happened to the skin temperature? Skin temperature is not constant; at different parts of the body, at different environmental temperature it varies it is changes. So, throughout the body, it is not uniform. And, lower in the extremities means from say or that stomach from this part. So, at the extreme point like if the finger. At the extreme point it gets at it reduces the temperature reduces. And, at the trunk zone the body temperature is almost it is a higher knowledge.

And, it changes with the environmental temperature. So, as the environmental temperature increases, the skin temperature also changes, higher average temperature of skin is higher at summer than winter. So, in winter, our skin temperature is lower than the summer average temperature, but our body core temperature is always constant. It is irrespective of winter or summer, body core temperature remains same.

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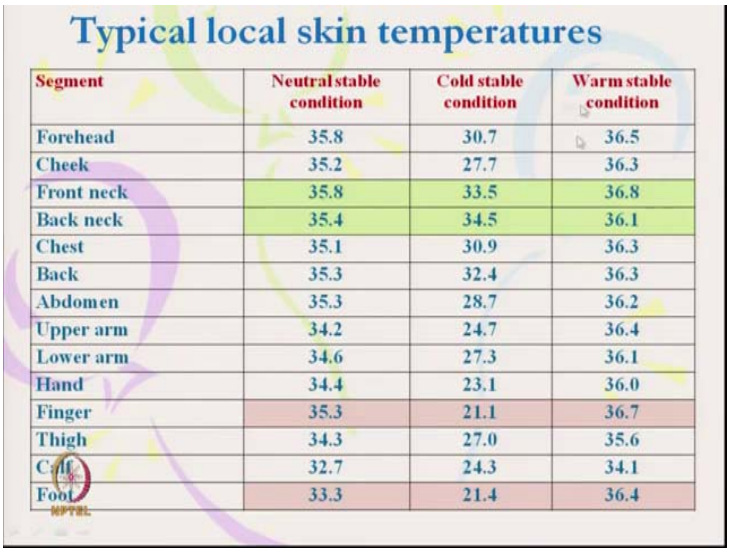

Now, let us see these are the temperature distribution of our body different of the skin at different condition. Like neutral condition, at neutral condition it is maybe around say 35 36 degree Celsius, (Refer Time: 24:51) neutral condition it is at say 34-35 degree Celsius forehead and all. So, is we see at normal temperature, neutral stable condition the temperature range of temperature is not that high? It is a maximum at say around 35.8 in

forehead. And, we can say it is a 32.7 in that calf zone. So, that is the temperature differences there.

But, if we see in the cold stable condition; so, we will see that minimum is at the finger or foot at the extremity, it is actually as slow as say 21 degree Celsius, that and at the front neck or back neck it is 34 degree Celsius. So, at that zone it gives higher temperature abdomen it is a so, at different portions, this is actually this temperatures for unclothed person, this is the temperature distribution.

Similarly, if we see at the summer the temperature in high so, warm stable condition this is the front and back neck, it is around 36-37 degree Celsius, but the finger you can see when it was in the cold, it was 21 degree Celsius, but in warm condition it is very high. So, that is the temperature and here we will see in warm condition, the temperature distribution is almost uniform throughout the body.

So, warm condition so, we can see in normal condition it the there are certain range of temperature. So, around say 3 to 4 degree Celsius, but in cold condition the ranges become around 15 degree Celsius. So, that is the range change, but in warm condition. So, due to the why is it so, because at warm condition due to our physiological automatic physiological control of the human body temperature. So, this due to this activity it is almost same. So, due to secretion of our sweat and different activities that we will discuss, that it maintains the skin temperature almost constant.

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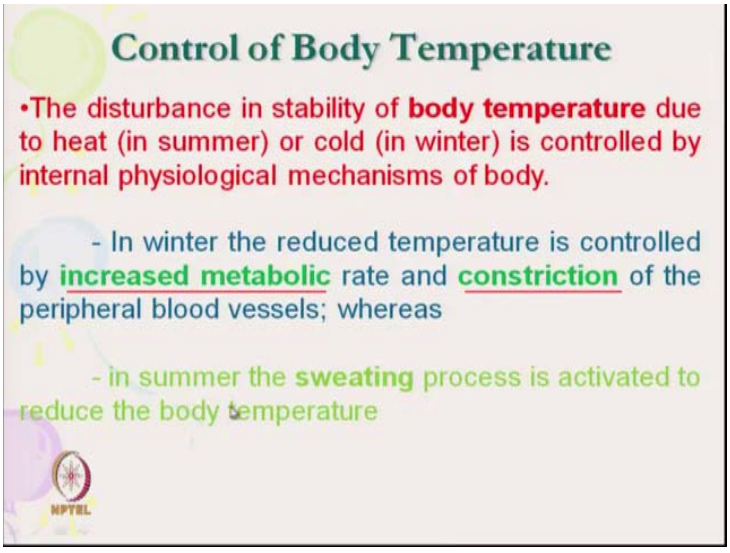

So, how to control the body temperature? The disturbance in stability of body temperature due to extreme heat in summer or cold in winter is controlled by internal physiological mechanism of the body. So, body internal physiology maintains the body temperature. So, this although the skin temperatures are different, but body temperature is controlled. So, how is it controlled? So, in winter, the reduced temperature is controlled by increased metabolic rate. So, in winter, our metabolic rate is high. So, automatically it is metabolic rate high (Refer Time: 28:29) so, that it increases the generation of body heat to maintain the body temperature. So, in winter, we start releasing the body heat.

So, to maintain that automatic the physiology, physiologically increases the metabolic heat rate and constriction of the peripheral blood vessel; that means, the diameter of the blood vessel reduces, which actually help in reduction in blood flow. So, blood flow has got other important aspects, but along with that, it also helps in maintaining the body temperature by changing the rate of flow. This part we will discuss. So, increase metabolic heat rate and constriction of peripheral blood vessel.

Whereas in summer, it actually just opposite thing happens so, where the metabolic rate in summer is reduced lower. And, in place of constriction, it is dilation takes place. So, in summer, another activity takes place, which is sweating. By sweating our body tries to release the heat immediately with the water with the sweat. The sweating process is activated to reduce the body temperature. So, if body temperature goes up so, immediately our body actually releases the sweat and such so, that it gets cool down. So, it releases the sweat, but if the sweat starts evaporating, then the cooling effect will be enhanced.

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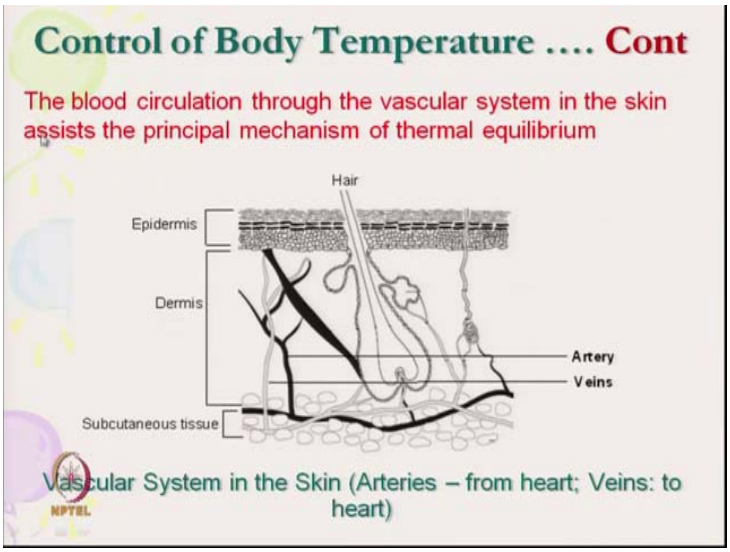

Now, we can see these are the blood circulation system. Through the vascular system in the scheme assist the peripheral principal mechanism of thermal regulation. So, this blood circulation, it actually controls the body temperature.

So, blood circulation has got it is important function of actually sending the nutrients to different parts of the body. Along with that whatever the blood vessels are there in skin, due to the transmission of blood, it actually controls the body temperature. Like from the artery and vein. So, from like through the artery actually, it goes from heart actually it goes to a throughout the body. What happened constriction if takes place? So, it will actually give the slow movement of heat.

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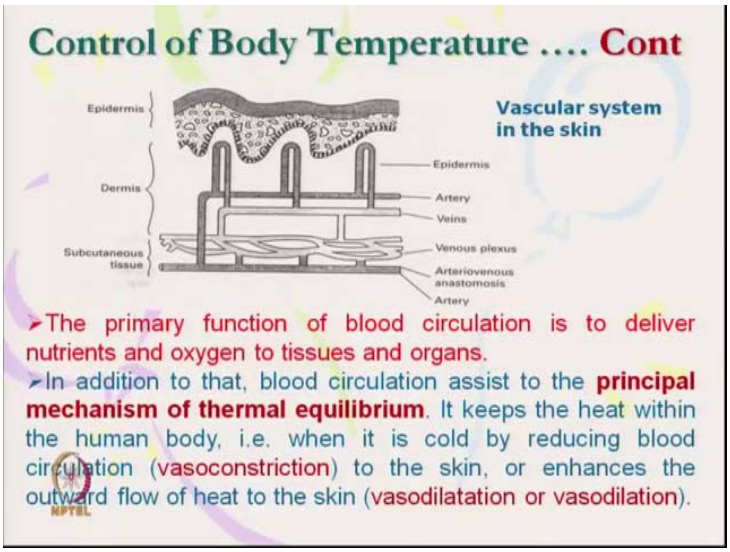

So, primary function of blood circulation is to deliver nutrients and oxygen to the tissues. So, that is the primary function, we have nothing to do with that, but to maintain the body temperature, to in addition to this that blood circulation assist the principle mechanism of thermal equilibrium.

So, our body core temperature has to be kept constant. So, it actually kept within the normal temperature when. So, it keeps the heat within the human body; that means, it does not allow the heat to flow out. How does it do? It is actually by constriction of the blood vessel. So, if it is constricted; that means, the blood flow will be reduced and so, the heat will not reach up to the skin that rate it will remain within our body. So, our body will remain warm. This phenomena is known as vasoconstriction.

But, in summer, we need to release our body heat. So, we need our body heat to flow out and that is done by it is outer flow, which is done by the vasodilation. So, it gets dilated. And, then it flows out, the rate of blood flow increases. So, our body gets cool down. So, due to the control of blood flow, we can maintain our body heat. I will discuss other physiological phenomena, but all this phenomena that this mechanism works within a certain limit, but if it exceeds then our body will be on the threat. So, then our body temperature may increases above the safe range, safe zone, safe temperature, and it may drop down. So, that these are the physiological phenomena by which our body temperature gets controlled.

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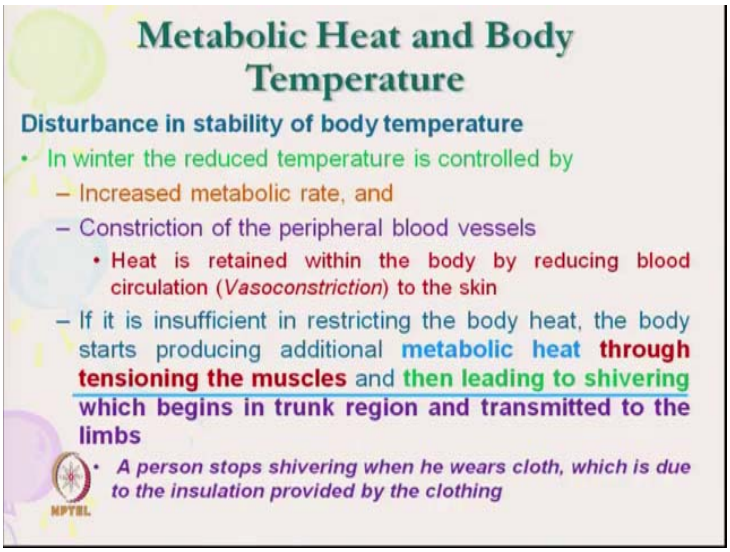

Disturbance in stability of body temperature like in winter, the reduced temperature is controlled by increase in the metabolic heat. So, metabolic rate is increased. So, body generates extra heat. Constriction of peripheral blood vessels so, we try to retain the body heat. So, heat is retained within the body by reducing the blood circulation as we have discussed to the skin. So, the skin does not get the blood at that rate and so, heat is retained there. And, if this system; total vasoconstriction and metabolic rate, that is we have discussed if these are insufficient to retain the body heat, then what happens? Then the body starts another mechanism.

This is by tensioning the muscle, it is starts tensioning the muscle and then leading it to vibrate, then people will because our it is tensioning, the you will see, that our the hairs at the skin, we will get with get erected. So, that is the by tensioning those and then we will start shivering. So, by shivering it is by muscle. So, body tries to get extra heat mechanical heat, mechanical energy. So, that extra heat is provided by the shivering. To get the extra energy, extra heat and it starts at the trunk region. And, then gradually spread over the other (Refer Time: 36:39). So, these are the mechanisms we get.

Now, these are the physiological mechanism, but if we start so, if metabolic increasing metabolic rate fails, then constriction, if a constriction fails to retain the body heat, then shivering starts. Now, shivering is not enough to maintain the body heat. Suppose body heat starts still it is dropping then what happens? So, if we start shivering, then what we

do normally? If a person starts shivering, if we rap a cloth around to him, if a wrap a cloth, then we will immediately stop shivering, because it provides insulation. The cloth is providing the insulation that is the extra layer, it actually stops the flow of heat from the body. And, you will stop feeling comfortable, what does it show?

Our body physiology has it is own action. Body physiology due to our body own body physiology, we get automatically we get to control the body temperature. In case of cold as we discussed by increasing metabolic rate, by vasoconstriction, by shivering we can control, but if it fails, if it reaches, it is extreme point then by using proper clothing, we can make oneself comfortable. So, the activity of this clothing, which we must understand and rate of change, rate of shivering when a person will start shivering and rate of constriction depends on the temperature. So, that accordingly, we can design our clothing to make oneself comfortable.

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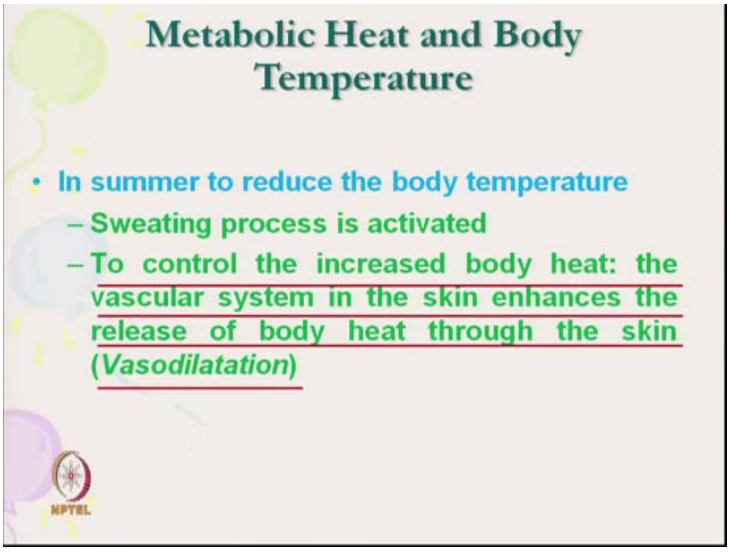

On the other hand in summer, the opposite phenomena happens; the body physiology, opposite thing is happening what is that, it starts sweating process? So, sweating through extra sweating, when we release the extra sweat? So, immediately by that we want to reduce the heat. And, in winter, we have seen to retain the body heat, the vasoconstriction was required that means the flow of blood to is reduced. So, that the body heat does not get transmitted from inside through the skin.

But, here in summer, we need to enhance the release of body heat. Vascular system, heat we release the heat by the dilation of the blood vessel, this is called vasodilation. So, sweating process is activated and then vasodilation starts. So, to control the increase of body heat, the vascular system in the skin, enhance the release of body heat through the skin by vasodilation.

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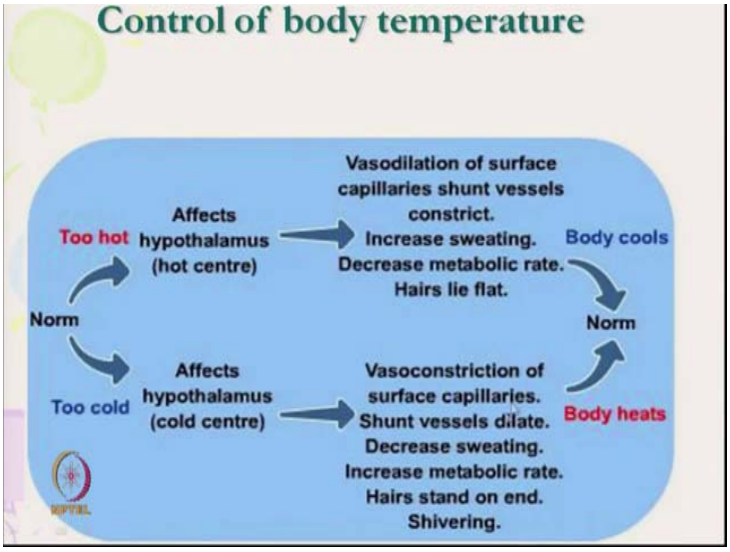

And, this diagram shows the detailed activity of our body physiology to control the body temperature. So, this is the normal condition. Normal condition, we tried to maintain our body. It is a normal condition that body always tries to keep the body temperature normal, but if the temperature is too hot, it affects the hypothalamus, Hypothalamus there are 2 types of centre.

So, hot centre and another is cold centre. This actually is present in our brain human brain which sense the hot and cold. So, if it is too hot then our brain senses, it is too hot then it starts the physiological activities. So, this physiological due to the physiological activity, then all this activities will start. So, first the sensor will sense. And, ultimately it will send the signal to the brain, will get activated and it will start the physiological activities.

So, this hypothalamus; the hot centre, in extreme hot temperature. It will give signal to the physiological activity, it will actually it will activate this physiological performance, then that is the vasodilatation of the surface of capillary shuts and shuts the vessel

constrict, that is vessel constriction will shut. And vasodilatation will shut and this part so, how to control the body temperature?

So, we will start we will discuss in the next class.

Thank you.