Science of Clothing Comfort
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Lecture – 12
Neurophysiological Processes in Clothing Comfort (contd…)

Hello everyone. We have discussed in last classes, the different aspects of Neurophysiological Comfort related parameters. We have discussed that there are different types of receptors present in the human skin. And, these receptors get sensations from environment and clothing and, ultimately it sends signal to our brain in the first segment we have discussed the mechanical receptors.

So, different types of mechanical receptors we have discussed, we have discussed the tactile receptors, receptors for pain sensation, then we have discussed various sensations related to clothing like prickle sensation, itching sensation, skin rashes. This all we have discussed, related to mechanical reception.

Now, we will start the next type of reception which is thermal reception. There are different types of thermal receptors, we have discussed, we have mentioned earlier. Now, we will discuss in details.

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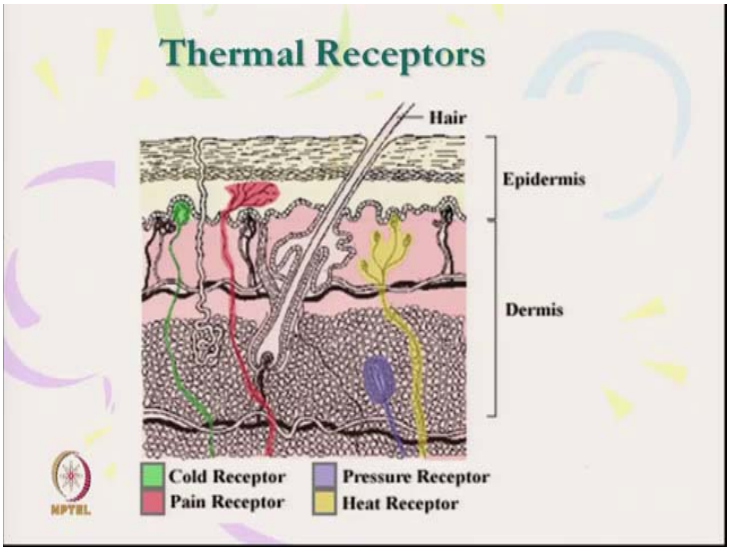

So, if you see the receptors are of basically 4 different types of thermal receptors are there. One is cold receptors, that is that sense the cold sensing it has got, then heat receptors, it sense anything warm and within this 2 receptors thermal receptors. There are 2 more receptors, which deal with the pain. Like pain due to cold extreme, cold and pain due to extreme heat. So, this all receptors, we will discuss here.

And, related activities when we wear clothing. And, we should have clear understanding about this type of receptors, how do they work to understand the thermal comfort behavior?

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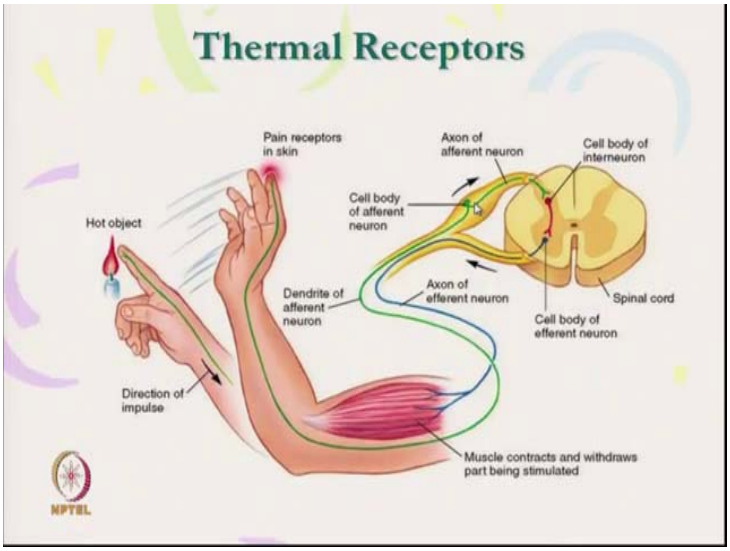

So, these are the receptors we have discussed, basically thermal receptor, suppose pain receptors, this is a say, hot spot is there hot object some flame. So, our pain receptor, if it senses there is a hot object. So, it immediately sends signal the transmission of signal that we have discussed in last class. So, it send signal to through the spinal cord and to our brain and our brain reacts, it evaluates, then it reacts.

And, ultimately it sends back the signal again to our muscle and muscle contract and our hands we can move out of the flame. So, this way it in the closed loop it works.

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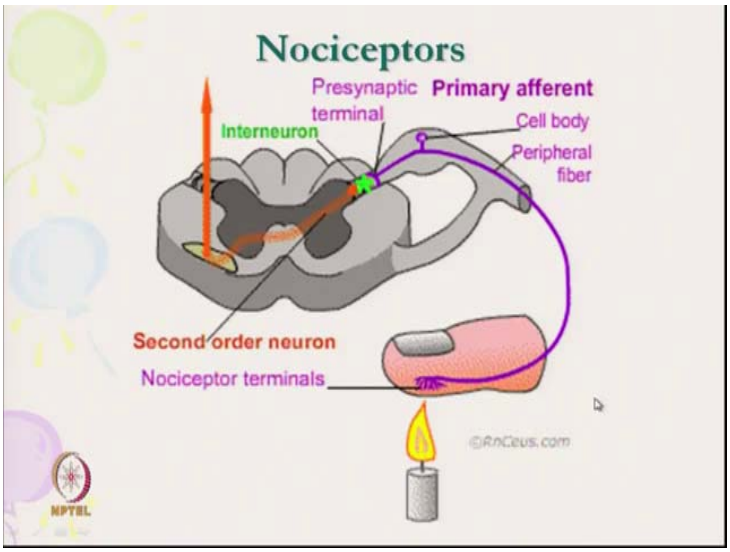

So, if we see the thermal receptor the nociceptor of hot pain (Refer Time: 04:30) it is receiving a signal. And, it sends back the signal to the brain and this way it works.

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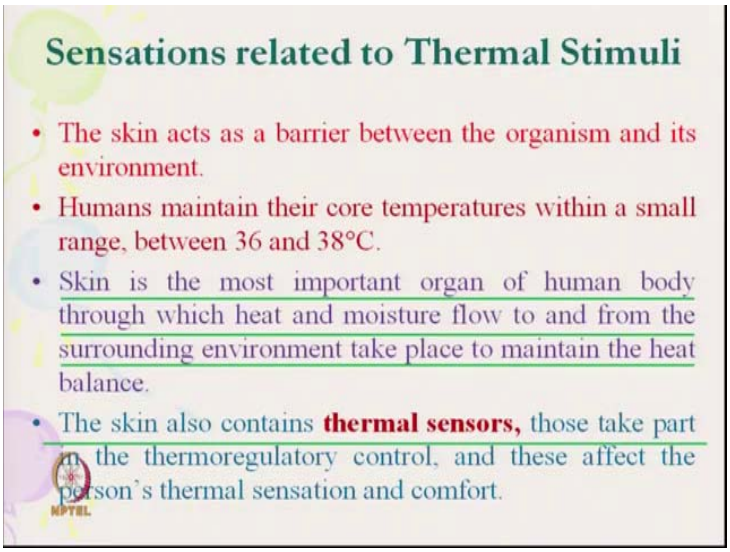

Now, sensations related to thermal stimuli is that the skin acts as a barrier between our environment and the body. It is our internal organism. And, the idea of this barrier is to maintain the core temperature within a very short range, which is 36 degree Celsius to 38 degree Celsius, that our body tries to keep maintain this temperature by physiological activities.

The skin is the most important organ of human body, through which heat and moisture flows out from the body to the environment, when it is required. And, from the surrounding it receives, if it is needed. So, that the through skin the heat and moisture flows to keep the heat balance of our body. So, in when our body gets warm. It sends it is transmits heat from inside to outside through a skin. So, to maintain the heat balance, the skin in addition to this making heat balance, it also has got thermal sensor, which actually regulates the human physiological activities.

The skin these thermal receptors take part in the thermoregulatory control. And, this affect the person's thermal sensation and related to comfort.

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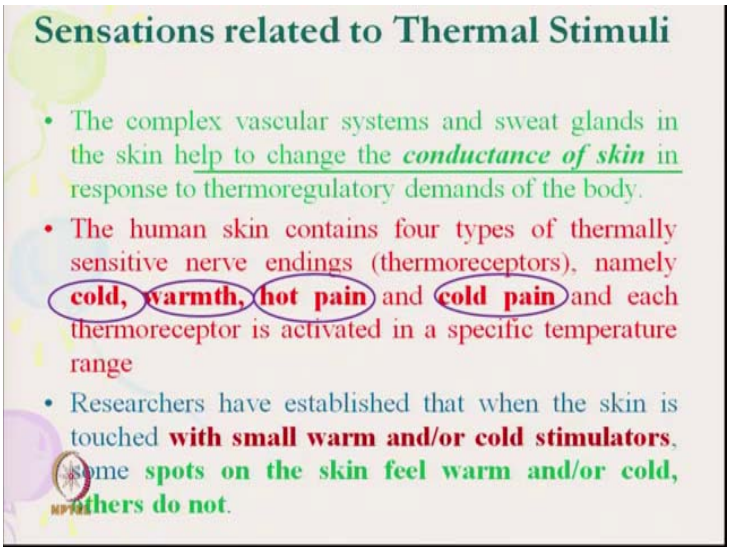

The complex vascular system and sweat gland actually in the in the skin helps in maintaining the conductance of skin in response to the thermoregulatory demand what does it mean? So, it actually the human skin actually it, when we feel warm? So, to release the heat, it starts physiological activity. So, by to a release the excess heat it releases the sweat. So, and our conductance of the skin also changes.

So, the human skin contains basically 4 different types of sensors, that is thermoreceptors and these are basically nothing, but nerve endings. So, this nerve endings; one is cold nerve ending, warmth, then hot pain and cold pain. And, each of this receptors, they have their own range of activity. Means within that particular range, they are active. Beyond that range they are not active, some other receptor thermoreceptors will act.

Now, let us see and also their presence in the body is not uniform. In our human body it is not uniform. So, it has been observed that in some places, suppose on with a small object. When, it is touched with the skin our skin it may get some places we may feel warm or some may some places we are we do not feel, which what does it mean? That is the distribution within the skin of this thermo receptors say cold receptors or warm receptors are different.

And, it is not present throughout the body uniformly. So, a small hot object suppose, if we touch. At different parts of our body, in some part we may feel warm. And, some part we may not feel warm; that means the point where warm receptors are present. There it sense it is actually it sense that signal, but the places where warm receptors are not there that it does not sense similarly in case of cold receptors.

So, within small warm and cold stimulator so, that touched with small warm and cold stimulator; suppose with the help of warm pin if we touch. So, this is actually proved.

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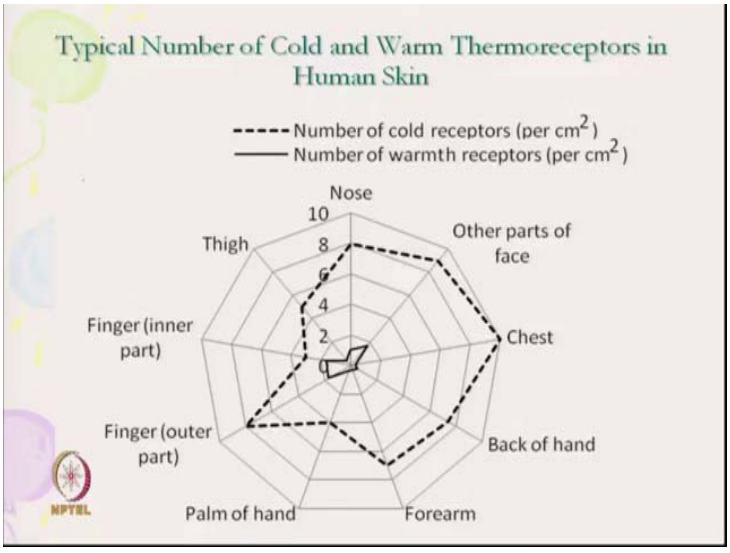

So, that means so, distribution at different places are different, let us see with this picture. So, if we see the distribution is the cold receptors number of receptors a cold receptors are much more than the warm receptor. If, we see like and maximum concentration of cold receptor is at chest, where typically it is around 10 number 10 receptors per square centimeter. And, least at the say finger, where it is maybe less than around less than 2. So, these receptors per centimeter

So, that is a type of so, less than say 4 receptor 3 receptor around 3 receptors there the what does it mean? That means, at the chest the concentration of the receptors are a very high where; that means, it is a highly sensible to the sensitive to our cold, too cold. And, that is why we feel too cold, we feel cold sensation at the chest region very first.

And this outer part of the finger also it is very high it is around 8. So, this type of data gives the total clear idea about that where do we want to keep our body warm, like one simple example we can see suppose one we when we feel very cold suppose we are not closed. So, we have feel very cold. So, if you rap one piece of cloth around our chest we suddenly feel start feeling warm.

Similarly, if we wear gloves so, that outer side of the finger with very high number of cold receptors gives the warmth. It sense cold and that is why is it gives when we wear gloves it gives the warmth ok. Similarly, if we see the other end that warmth receptor number of warmth receptor is very less very low. So, it is less than 2 if you see if you see that most of the places it is less than 2 per square centimeter. So, this distribution if you see so, it says that if we touch at particular place. There it may not be it may not be available the sensor may not be available. So, it will not sense. And so, these are the places 2 different zone we can see here, where the maximum and minimum receptors are present concentration of receptors.

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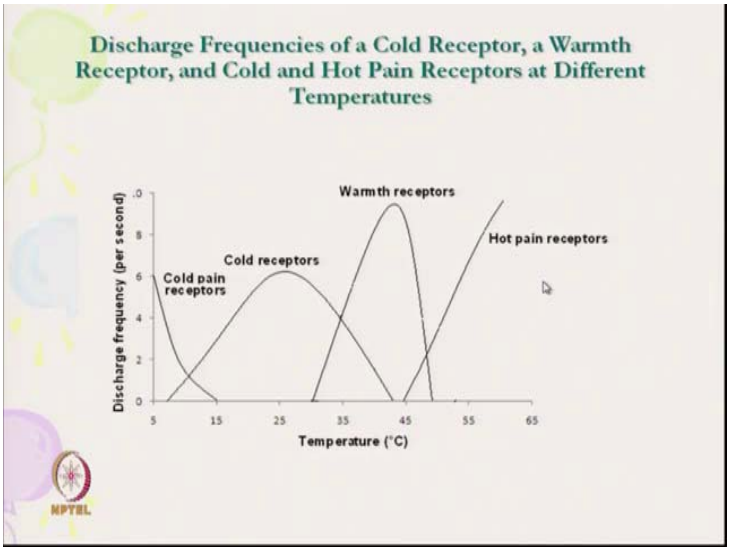

So, now if we see the discharge frequency of this receptors; cold and warmth receptors, if you see even cold pain and hot pain receptor at different temperature. So, this picture this schematic diagram, it shows that the cold receptors, it start sensing around say from 7 degree Celsius. At 7 degree Celsius it is start sensing and maximum frequency of reception that is discharge frequency is maximum is around say 25 degree Celsius.

And, with the increase further increase in temperature, it is actually reception discharge frequency reduces. This means that the cold receptor a particular cold receptors, it starts sensing whether it is a cold ok, only cold it start sensing from say 7 degree Celsius or 7-8 degree Celsius. And, it stops it is sensation; it is activity, around say 45 degree Celsius. So, that way so, this is the zone of activity.

Similarly, normal warmth receptor it starts it is activity around say 35 degree say 30 degree Celsius. And, maximum activity is around say 40-45 degree Celsius. So, at 45 degree Celsius it is maximum discharge frequency and as the temperature goes on increasing it, it is discharge frequencies sensation it drops. And, it stops sensing any further increase in temperature beyond around say 50 degree Celsius.

So, it is activity range is from say 30 to 55 degree Celsius. So, 30 to 55 are between say 30 to say 45 degree Celsius in this zone there is an overlap. So, both the warmth receptors and cold receptors they are active ok, but maximum activity of warmth receptor is at 45 degree Celsius and for cold receptors it is around say 25 degree Celsius this we have discussed.

And, suppose now what happened beyond this? So, beyond this we do not feel either warmth or cold. Like say, if the temperature starts dropping beyond say 10 degree-15 degree Celsius. So, around say from 15 degree Celsius our cold pain receptors start it is activity. So, and as we keep on reducing the temperature from 15 and below, gradually it is activity discharge frequency increases. So, what does it mean? So, at 15 degree Celsius, it starts sensing we start sensing a little bit pain like and then around say 5-7 degree Celsius, 7 degree Celsius we do not feel cold, should say at 0 degree Celsius and cold receptors they stop it is sensation. So, cold receptors does not work at below say 7 degree Celsius.

So, it stops working and then the activity is for only for cold pain receptor, that this means we can get example we sends this type of sensation. Like, when we keep

temperature keeps on reducing, we start feeling cold. Gradually we start feel say 40 degree Celsius, it is we 40 to say 35 we start feeling little bit cold, because this activity of the cold receptor increases the discharge frequency increases.

And, gradually this activity is maximum, but when it is at 5 degrees Celsius when it stopped, it has been taken over by the cold pain receptors and at 0 degree even sub 0 degree Celsius it is activity (Refer Time: 17:16). So, in that particular temperature although it is a cold receptors, cold pain receptors we do not feel normal cold we feel cold pain, cold we know it is a cold, but it is a cold pain receptors.

That means, at normal cold that normal cold receptor is different and cold pain receptor. Suppose at one example is that suppose one ice block, I am pressing against my skin. What will happen? Ice temperature is say 0 degree Celsius in 0 degree Celsius, we feel cold, but it is mixed with the pain; that means, it is normal cold receptors it stopped working. Then cold pain receptor has started work.

Similarly, in warmth receptor it is a stopped working at 50 degree Celsius. And, beyond that the hot pain receptors, that very common example suppose a boiling water we put our hand. We will not feel basically warm, we will feel warm with actually pain; that means, our pain receptors will start it is work.

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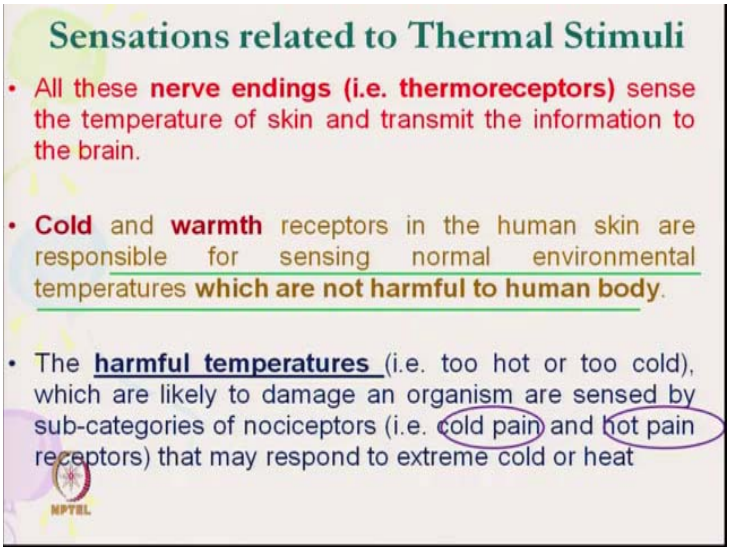

So, there are 4 different types of thermal receptors we have discussed. And now so, all as we have explained here. So, all this nerve endings this thermoreceptors sense the temperature of the skin and transmits the information like our mechanical receptors we have discussed to our brain ok. And, this cold and warmth receptors actually it is in the human skin are responsible for sensing normal environmental temperature. So, it is not harmful to our body.

So, this is a; this normal cold and warmth receptors, but the harmful temperature, which is actually can damage our body, these are sensed by cold pain receptor and hot pain receptor.

And, after sensing they accordingly our body physiology work, and our brain sends signal and they accordingly our muscle and all these closed loop system start working. So, our in normally in clothing comfort we are concerned about the normal cold and normal warmth receptor. We are not concerned about the cold pain and hot pain receptor. Although the cold pain in extreme temperature, the environmental temperature is it is beyond this normal temperature, but our clothing has to bring down this extreme hot or extreme cold to the normal cold and normal warm within the our microclimate zone. If, we cannot then we will not feel comfortable. So, and this part we have discussed in detail.

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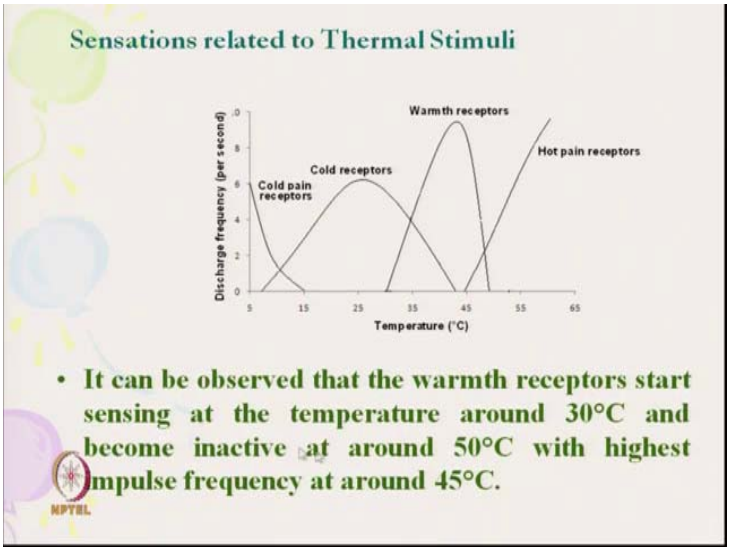

Now, it can be observed that the warmth receptor that we have discussed now, it starts sensing the temperature around 30 degree Celsius. And, it ends at 50 degree Celsius with the maximum impulse frequency is 45 degree at 45 degree Celsius.

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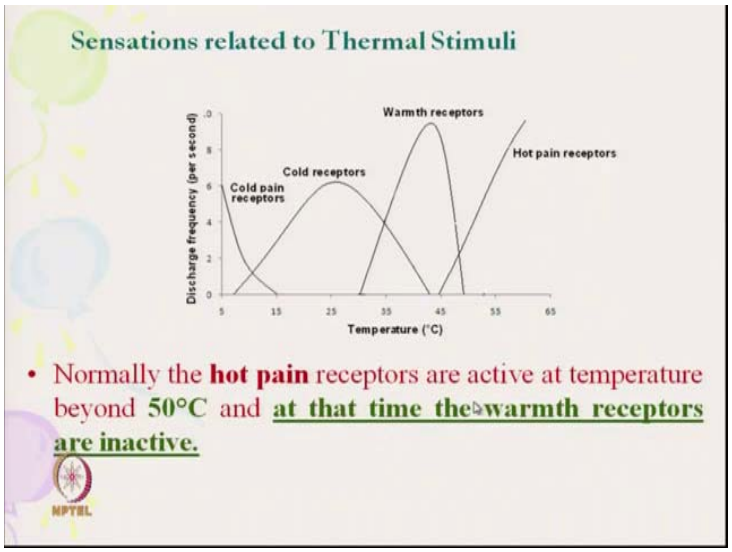

And, similarly the cold receptors if we see the and hot pain receptors, it starts it is activity beyond 50 degree Celsius ok. At the time of at that time the warmth receptor stops it is sensation.

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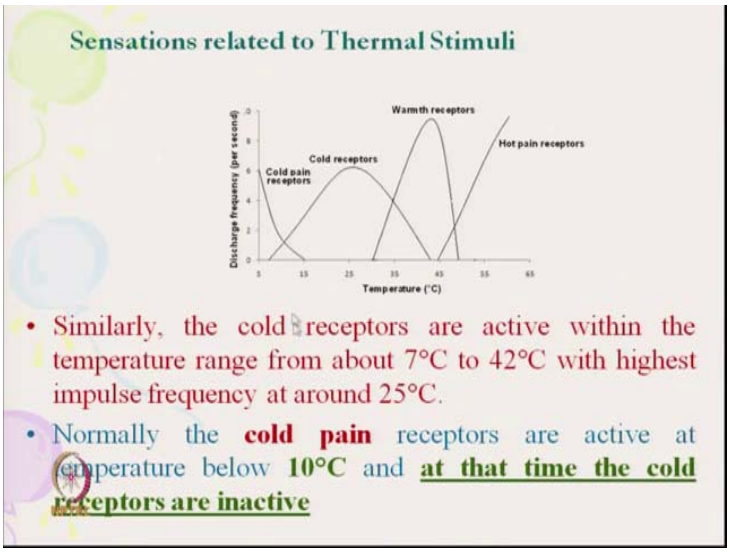

Similarly, the cold receptor if you see the cold receptor starts it is activity from 7 degree Celsius to 40 typically around 42 degree Celsius and maximum activity as at 25 degree Celsius.

Now, the cold pain receptors starts it is activity below 10 degree Celsius around 15 degree below 10 degree it is activities starts. And, at that time the cold receptors are inactive. So, at lower temperature cold receptors are inactive.

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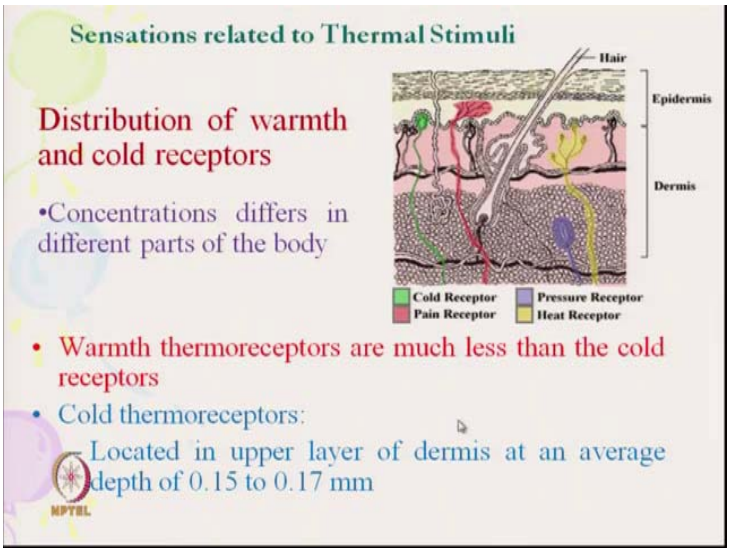

Now, if you see the location and number of sensors. So, the distribution and of warmth and cold receptors, it is a concentration of this type of receptors as we have discussed, are different at different zone of our body we have mentioned that at the chest, the number of cold receptors are more.

So, and warmth receptors are much less than the concentration of warmth receptors are much less than the cold receptors. So, that is why that we have seen that and also the location of cold receptors around say 0. 15 to 0.17 millimeter from the skin at that depth. So, if you see this is the cold receptor, it is close to the skin. This depth this depth is say around say 0.15 millimeter.

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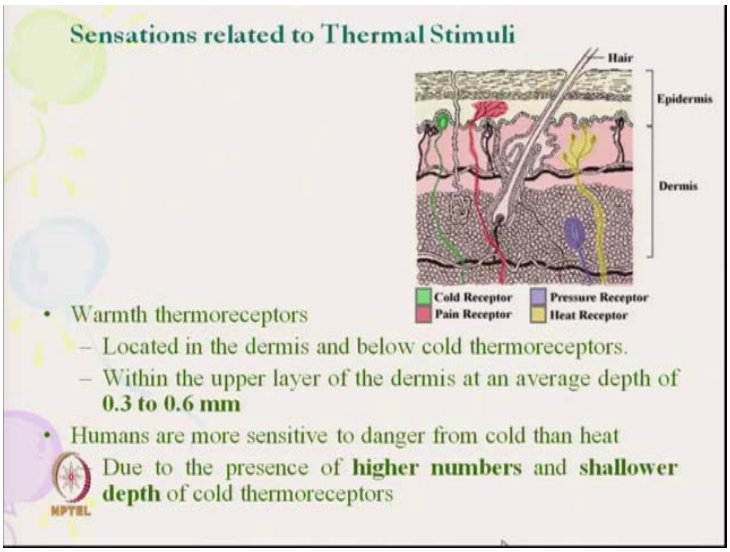

And, if we see the warmth receptor, it is depth is more than this cold receptor. Cold receptor is present at 0.15 to 0.17 millimeter whereas, the warmth receptor is actually present in the dermis and which is around say 0.3 to 0.6 millimeter average depth of the warmth receptor.

So, what does it mean? So, number of cold receptors are much higher than the number of warmth receptors and cold receptors are present at shallow depth and the depth of the warmth receptor is more than the cold receptor. So, this means that humans are more sensitive towards danger of the from the cold than the heat. So, due which is due to presence of higher number and shallower depth of cold receptor. So, we should be very careful about the cold receptor, because that we sense more we are more sensitive towards cold.

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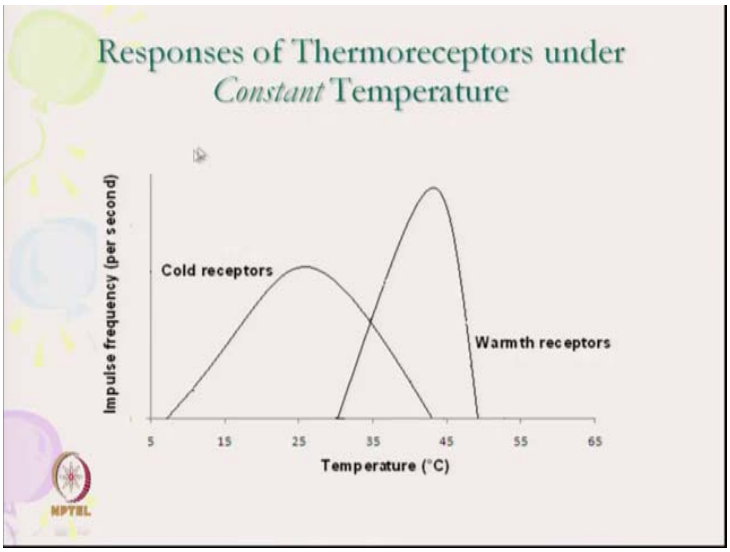

Now, so, this all these responses these picture this schematic diagram we have shown the cold receptors and warmth receptor. Now, we will not discuss the pain receptor now normal cold and pain receptor.

These are actually the activity at constant temperature. Suppose our temperature here the we are not talking about the variation in temperature; that means, if the room temperature is say or skin temperature is say 15 degree Celsius or cold receptor will act at this frequency at certain frequency. If it is 25 degree Celsius it will act as a maximum frequency like that. Even say at 45 degree Celsius cold receptor will not work our warmth receptor will work at it is maximum frequency. So, this is the curve which shows the input frequency that is impulse frequency at constant temperature.

Now, what happens when the temperature changes abruptly?

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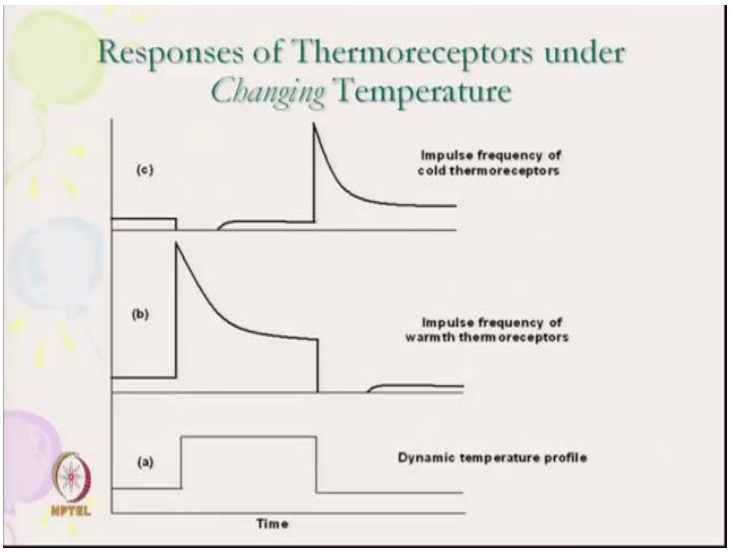

Now, let us see this curve shows the schematically the, what happened to the warmth receptor this curve is it is a b, which shows the warmth receptors activity. And, this c is the activity of cold receptor and curve this graph a shows the temperature profile. Suppose say this is the, with the time against time and here is the, it is a frequency or impulse frequency. If now temperature profiler is that for certain time, the temperature is constant ok. Now, suppose a person is at constant temperature. Suddenly he is he entered in a room of higher temperature. So, it shows the sudden change in temperature earlier we have discussed up to the constant temperature.

So, here it temperature has changed to certain temperature at hot room he has entered. And, now at that temperature he is there for certain time ok. And, after that he comes out from that room and entered in a little bit cooler room. So, so this is and remains there for some time. So, this is the temperature activity, temperature suddenly increasing temperature, remaining there for some time with higher temperature, and then he is coming out from that zone and in cold room he stay. Now, what are the activities of our cold receptor normal cold receptor? Will it active like normal constant temperature, it will act if totally differently.

Like in the warmth receptors, it shows that with the increase with the time, it has it gives a constant signal, that we have discussed it gives a particular impulse frequency. So, like we can go back to that a say for a particular say 25 degree Celsius, it is giving a

particular constant frequency, this frequency, it will not change ok. This is for constant temperature.

Now, here this is giving at particular temperature it is giving. Now so, this time this is a frequency. Now, if we suddenly change; increase the temperature. Increase the temperature of that he is going entering to another room. So, suddenly the warmth receptor will start sending the impulse frequency at very high rate. So, impulse frequency will increase suddenly sudden jump will be there due to increase in temperature.

And, it will as he is the person is there for some time at high temperature, but that gradually the impulse frequency will drop gradually. So, sudden change in temperature will have shocking effect. So, it will the sensor will suddenly increase the sensation and then gradually the sensation will be dropped. And, when the temperature is dropped, what will happen? The warmth receptor will stop it is sensation. There would not be any sensation on suddenly dropping the temperature.

Dropping the temperature suddenly it is becoming cool. It is not gradual; sudden change in so, it is impulse frequency become 0 and at that temperature, if the person remains for some time after certain time. So, it will again start sending some signal for constant whatever it was there for constant certain constant temperature or something. So, it will give that amount of signal.

So, this is giving that signal it is done because there is certain temperature. So, it is giving sudden because this temperature is whatever this temperature, it is within the within this warmth zone it is within from 30 to 50 zone; this temperature is between say 30 to 50 zone. So, that is why it is giving this for warmth receptor.

Now, if you see the increasing temperature. So, here in the, this is the curve c shows the cold receptor activity of cold receptors. So, at certain temperature it is getting this value may not be same for warm or cold receptor; that means, this receptor this temperature is within the cold reception zone; that means, say 7 to say 42 degree Celsius, for this for cold receptor this temperature is within this zone.

And, as the temperature suddenly increases, what will happen it will act just opposite? The cold receptor will suddenly stop it is activity suddenly it will drop, but after certain

time like warmth receptor, it will again start sending signal it will get, but when the temperature drops suddenly it is activity will increase suddenly like warmth receptors.

So, warmth receptors; it activate this cold and warm receptor, it activates abruptly with the change in sudden change in temperature. So, it is activity is maximum here then again it gradually lowers (Refer Time: 30:59) it is drops, it is activity and become stabilized. So, this is the activity when we actually move from a warm place to cold place or cold place to warm place. So, this sudden shock is due to this say this activity of sensor.

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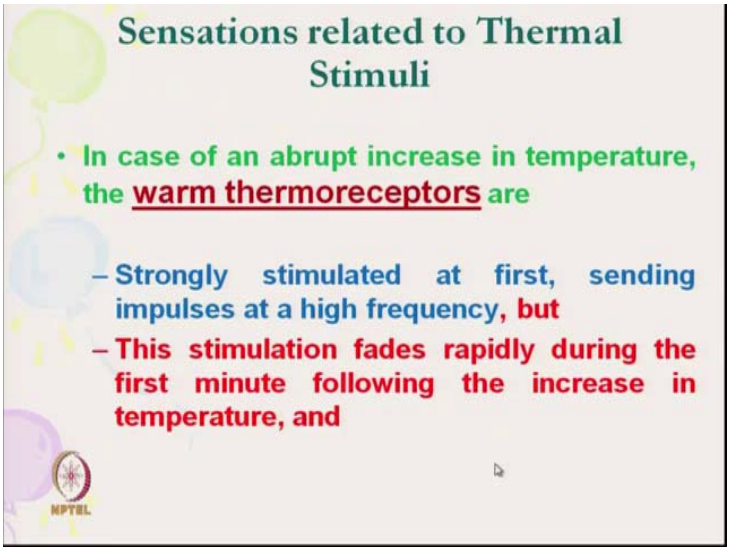

So, in case of abrupt increase in temperature the warmth receptors are strongly stimulated at the at first and sending's impulse signal at high frequency , but it gradually with it, fades rapidly during the first minute followed by increase in temperature. So, as it is it gradually it fades out. So, after increasing and then gradually the activity fades out. Then progressively more and more slowly until it reaches steady state that we have discussed.

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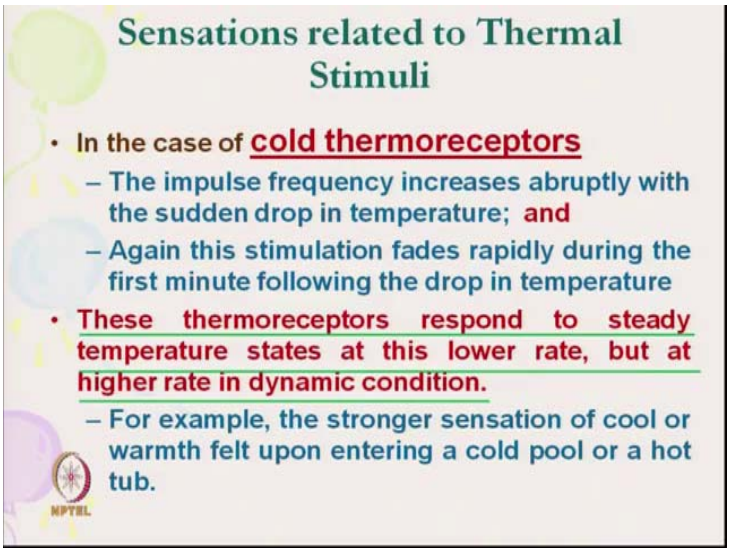

Similarly, in case of cold receptors the impulse frequency increases abruptly when sudden drop in temperature. And, similarly it again this stimulation fades rapidly during first minute and following the drop of the temperature.

So, after just dropping the temperature, during first minute it immediately it shoots up, then gradually it is drops. These thermoreceptors respond to a steady temperature state at this lower rate, but at higher rate in the dynamic rate. So, this at lower rate it sense. So, this picture this graph shows at steady temperature, this is the activity, this is the sensation, but at changing temperature it is activity is very high it impulse frequency is very high.

Very common example is that a strong sensation of cool or warmth felt upon entering a cold pool or hot tub. Suddenly, we jump into a cold pool or we are entering into cold pool with a cold waters, initially we will be shocked our because our sensation impulse sensation is very high, but after remaining for certain time there that type of sensation would not be there it gradually drops it. (Refer Time: 33:46).

So, this is true for hot tub also. So, that is why our clothing has to take part to actually avoid the shock cold shock , or hot suppose from cold room or someone is entering from normal room to cold room . He has to wear a clothing so, that to avoid this type of shock. And opposite is true suppose someone is entering from normal temperature to the very extreme hot temperature. So, this type of shock we may encounter ok.

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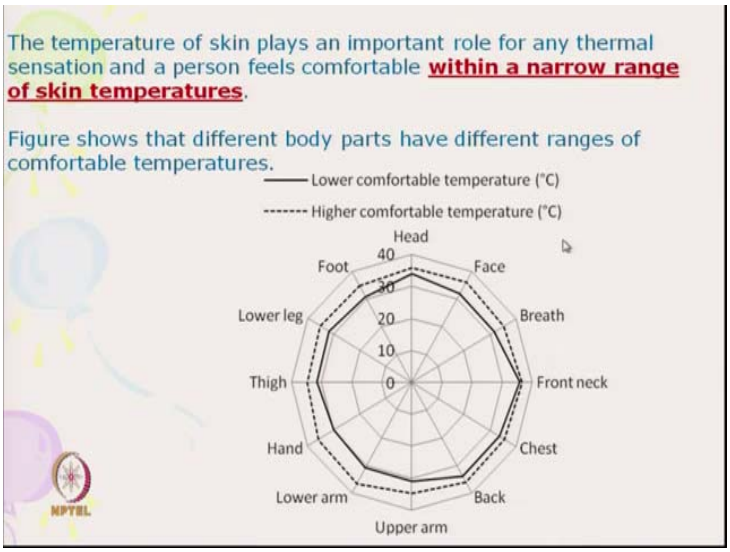

So, the temperature of the skin plays an important role for any thermal sensation and a person feels comfortable within a narrow temperature of skin. So, our temperature zone is very narrow. Now, you can see this is the temperature zone comfort temperature zone at different body parts at and at different body parts this range is little bit different.

So, within this narrow zone suppose in hand, we feel the zone the comfort zone is between this and this that is between, you can say it is a 35 to 30 degree Celsius within that zone. Similarly, in a front neck it is very close ok. Say around say 35. So, we can see the temperature zone is 30 to 40. So, that 30 to 35 is the comfortable zone so, at different parts of the body. So, lower temperature is at solid line and high temperature zone by the dotted line. So, within that zone at and different body part gets different comfortable range.

Now, what about the humidity stimuli? We have seen the mechanical stimuli, which sense the mechanical sensation like touch pressure, we have seen the thermal stimuli thermal sensors, which actually sense the different types of sensation related to whether it is a hot, whether it is cold, whether it is constant temperature, whether it is changing temperature, but we have to see whether there is any humidity stimulation sensor.

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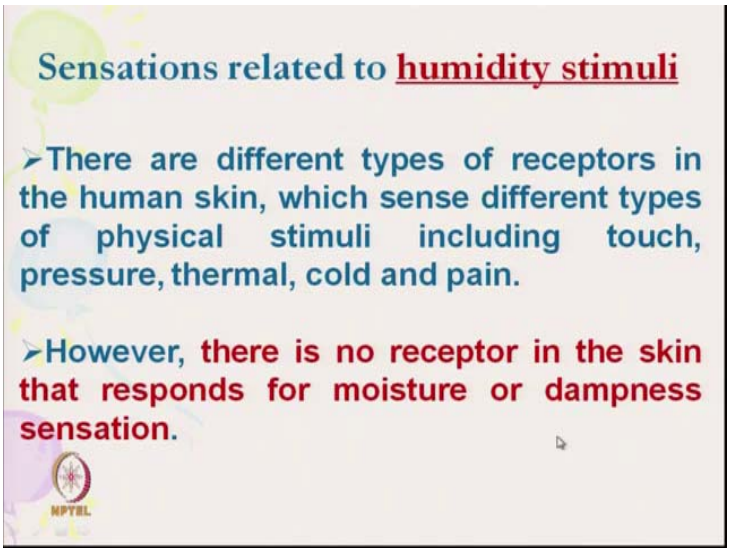

So, there are different types of receptors in the human body, which sense different types of physical stimuli. Like including touch, pressure, thermal, cold pain, but there is no receptor present which sense the presence of moisture or dampness sensation.

So, but we may think that we can sense the presence of our moisture or presence of sweat or presence of dampness, but these are not due to the presence of humidity stimuli or moisture stimuli. Moisture stimulation is not there. These are actually this we get with the help of either mechanical stimuli, mechanical receptor or with the help of thermal receptors, but there is no such moisture receptors present. Like suppose we are we have started sweating, sweat we have started sweating, but we may not sense the sweat we may sense warmth or cool, but suppose our forehead sometime we feel our at the forehead or some places it is a sweat we may not feel.

But, when the sweat starts dripping due to it is amount, it is starts dripping, due to dripping it moves through our skin. And, that is sensed by our mechanical receptors indirectly then we can feel, it is a sensing, suppose we are pouring water ok. During water pouring, what we sense? We do not sense the presence of water. We sense indirectly; that means, it is due to it is pressure, due to it is flow characteristics, or due to it is temperature difference. If sweat is there at our body the on the skin, when sweat starts evaporating; that means, our body gets our skin gets cooler sensation. So, thermoreceptor indirectly is sensing the presence of sweat.

Now, so, what we have seen that we have mechanical receptors, to sense mechanical activities, mechanical stimuli, we have thermal receptors, which sense the thermal different thermal simulation. And, there is no humidity receptors and humidity reception we get indirectly with the help of mechanical receptor and thermal receptor. Now, in this segment we will discuss the, that how to measure this sensory perception? So, we have various techniques to measure the sensory perception, we have seen that the receptors are there different receptors are there which receive signal, now to how to measure?

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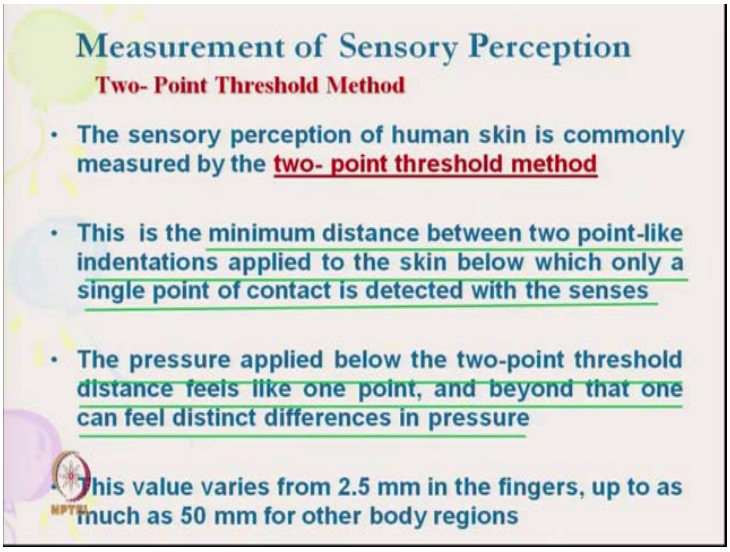

So, first measurement technique is it is called two-point threshold technique. So, 2 point threshold technique means there is 2 indentations is there. So, the sensory perception of human skin is commonly measured by two-point threshold method, the what is two-point method, this is the minimum distance between two-point like indentations applied to the skin below which only one single point of contact is detected with the sense. That means that at different parts of the body had got it is sensation. So, two it is contacted with two pointed object at different distance so that the sense of detection that distance can change.

So, the minimum distance between two-point like a; that means, if we keep on changing suppose at a certain distance, it is kept now if we keep on reducing the distance of a distance of this objects the points. At certain point we will start our body will start sensing exhibits a single point, that point is called minimum distance between two-point

(Refer Time: 41:07) any. So, that that is the one measure of the sensory perception of the body ok. It will our skin will sense as a single point the pressure applied below the two-point threshold that is two-point threshold point ok. The distance feel like a one point ok. So, this two-point this is called the two-point threshold distance.

So, if we apply pressure below that distance, then our skin send signal as it is a single point. So, this is actually method is known as two-point threshold method. So, and beyond that a person can you can feel that there is a 2 distinct points are there for the values it is vary from different parts. So, at finger it is very close it is around between 2 around 2.5 millimeters. And it goes as 50 millimeter at say 5 centimeter at different other zone. So, if we see this is the technique.

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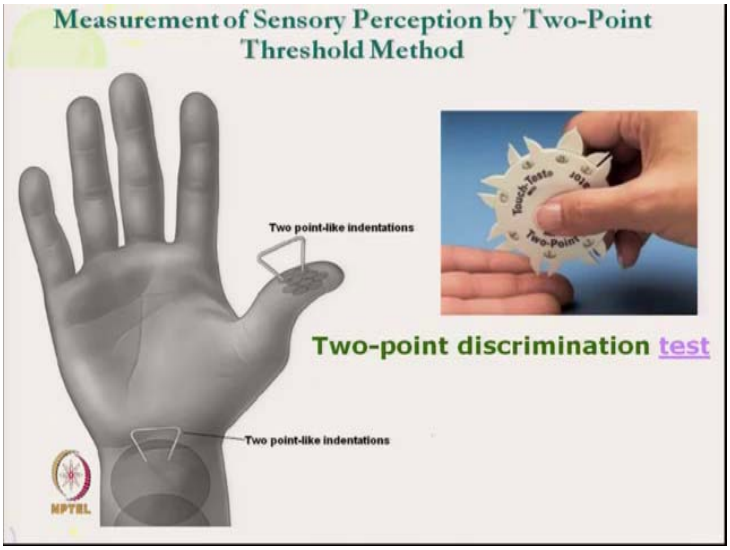

So, this 2 indentations are there two-points it is touching the two-point. And, if the person says I cannot distinguish. The, it whether it is a 2 points or single point that is the, that you can increase little bit distance and gradually. And, that the point where he starts sensing, it is a there are 2 separate sensation, which is known as two-point threshold distance.

And, it depends on the sensors sensitivity. If body sensitivity is poor, it is not sensing, it is mechanoreceptors are not working or receptors are not working, that type of test one can do here.

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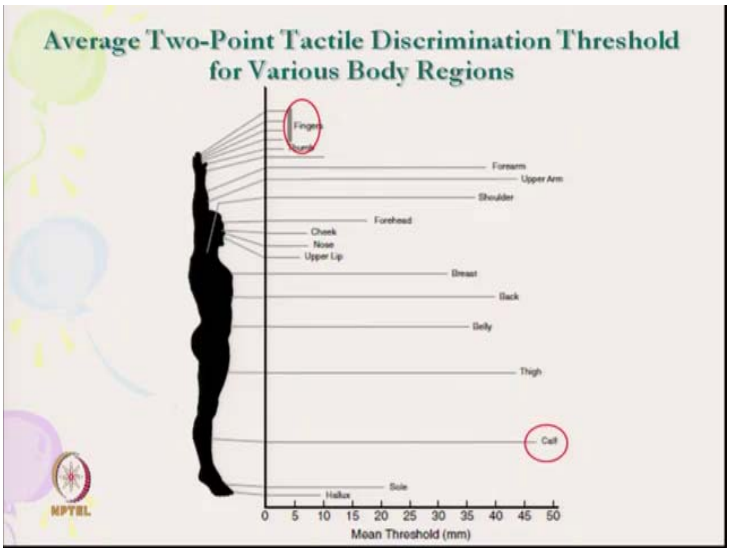

And, this picture shows that different zone different parts of the body, what is the two-point threshold distance? So, at finger it is minimum. So, around say 2.5 this is zone it is a 2.5 zone ok. And, then it gradually increases, it is a very common sensor (Refer Time: 43:31), we normally sense the texture of fabric by finger. Not, by thigh or something; that means, there it is sensation is not there.

See you just see thigh it is a very higher calf it is around say 50-55; So, within 40 bit below that we cannot sense that why there is a particular texture on there is a two points are there it gets rough signal. And, that is why and, but by the finger we can sense whether there is within maybe within say 2.5 millimeter at that distance, we can sense that there are 2 different objects are there. So, that that actually indirectly we can correlate with our comfort or body sensation can correlate with this is the lowest zone and here at the calf it is a highest.

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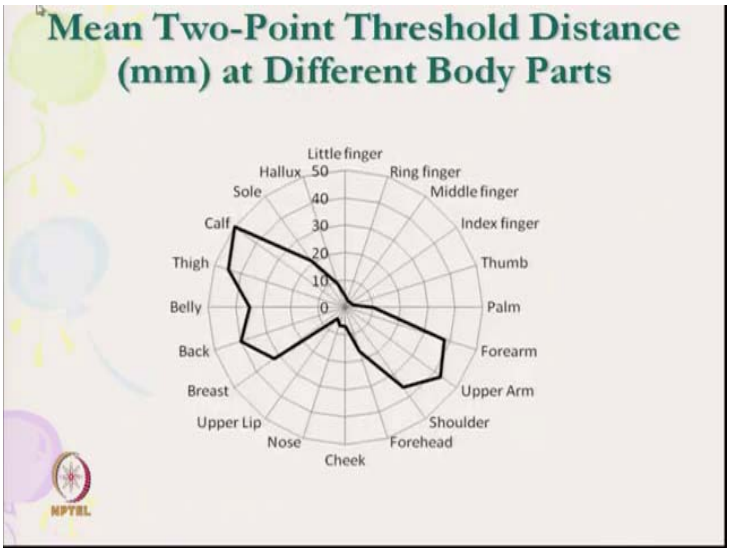

And, this is the mean two-point threshold distance, that the same data it is shown in different picture. So, we can get idea about that at the calf it is maximum.

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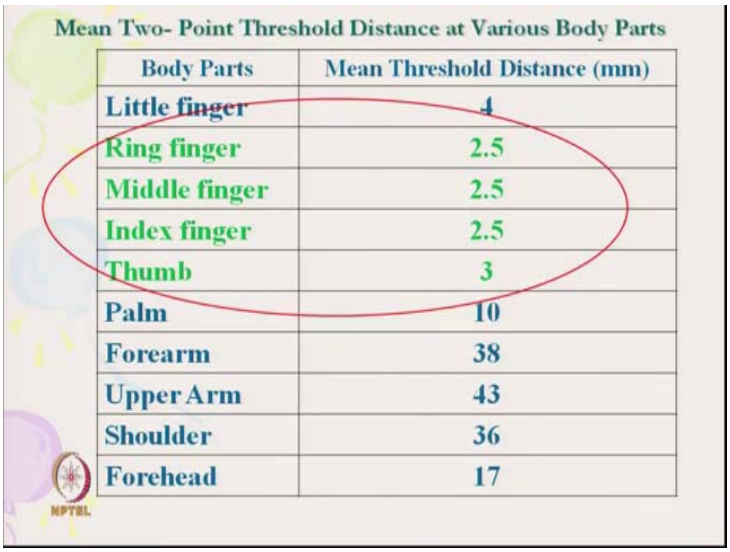

So, we can see the data here it is a 2.5 millimeter and thumb it is there, and we can see this is the minimum zone that is the most sensitive zone. So, we can texture or anything we can test with this help.

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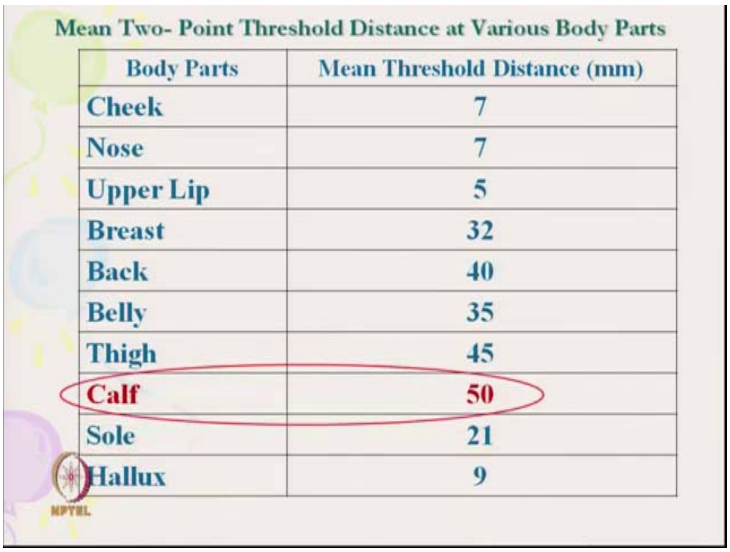

And the calf and this zone it is a very high.

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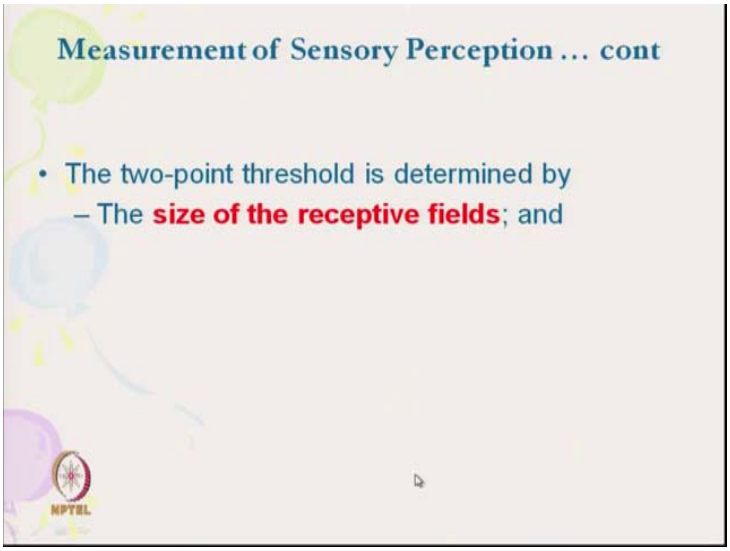

Now, we will this two-point sensor scale (Refer Time: 45:14) by thus this we will next class next class we will continue with this measurement technique, by two-point threshold and different other techniques we will discuss.

Thank you for the time.