Science of Clothing Comfort
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Lecture - 10
Neurophysiological Processes in Clothing Comfort (contd…)

Hello everyone. In last class, we had discussed that there are different types of nerve endings in our skin, mainly mechanical type nerve endings and thermal nerve endings which are responsible for getting signal from our clothing. And now we will discuss the mechanical nerve endings.

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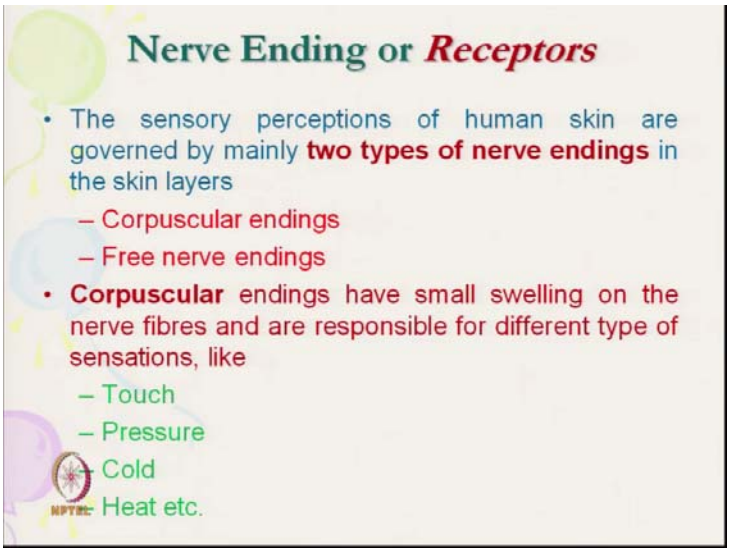

As you have mentioned that there are two types of nerve endings as far as structure is concerned, one is corpuscular nerve endings and other is free nerve endings. And the corpuscular nerve endings are responsible for specific type of sensation like touch, pressure, cold, heat.

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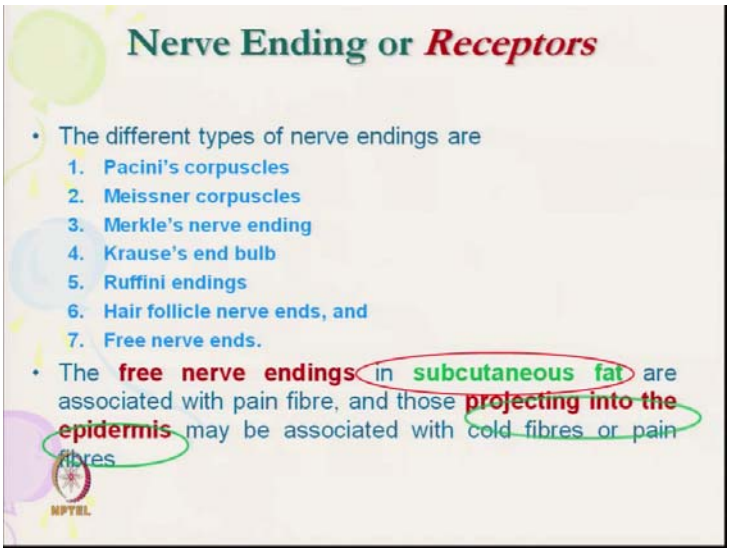

And you know that there are different types of nerve endings. So, we will discuss here mainly seven different types of nerve endings Pacini's corpuscles, Meissner's corpuscles, Merkel's nerve ending, Krause's end bulb, Ruffini ending, Hair follicle nerve ending and free nerve ends. So, these 7 mechanoreceptors are directly related with our clothing comfort. Sensation or skin gets sensation through all these nerve endings. And free nerve ending actually gets projected up to the epidermis which gets signal with the cold fibre or pain fibre. So, they are projected into the epidermis zone.

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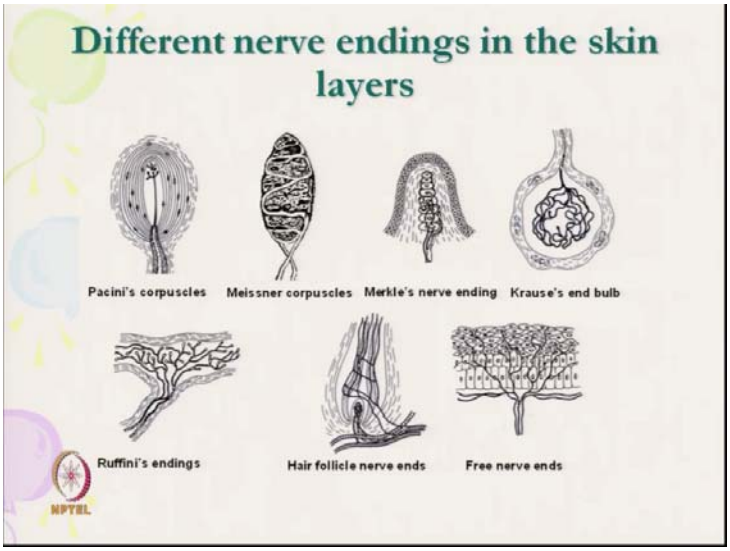

So, we will start with the Pacini's corpuscles.

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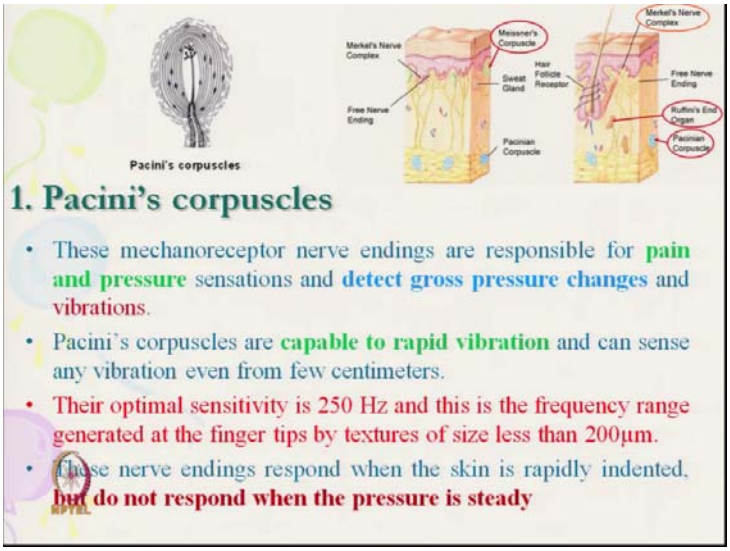

So, if you see the Pacini's corpuscles, its location is at the tip as we have already mentioned. Now, let us see what their functions are. Mechanoreceptor is responsible for pain and pressure sensation, and detects gross, pressure change and vibration. So, it senses the pressure or pressure change, and also the vibration. And Pacini's corpuscles are capable to sense rapid vibration and can sense any vibration even from few centimeter away from the skin. So, it senses two sensations, one is the pressure and also the rapid vibration.

It gets optimal signal at around 250 Hertz, and this is the frequency range generated by finger tip by texture less than 200 micron. So, it gives any sensation when our finger moves through this somewhere. So, Pacini's corpuscles comes into picture, which sense the rapid vibration. This nerve endings are responsible for response when the skin is rapidly indented, but do not respond when pressure is steady. So, it gives a rapid change in its sense with rapid change in pressure, but at steady pressure it does not give signal.

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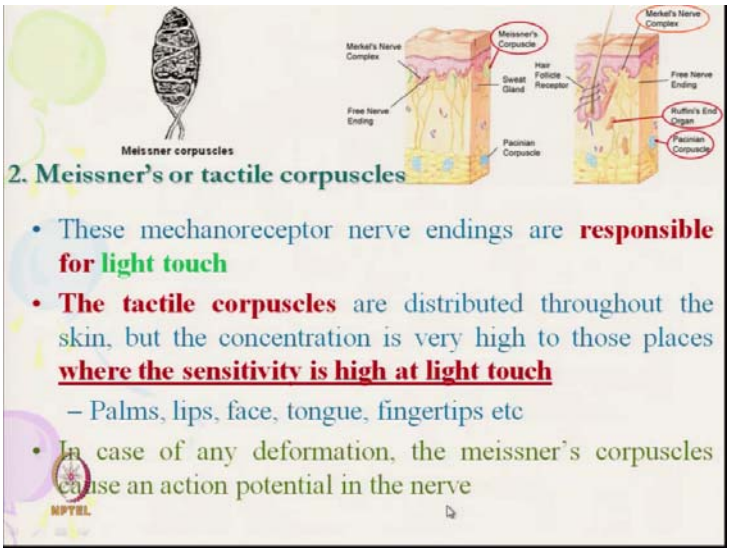

Next, Meissner's corpuscle or it is called tactile corpuscle because it gets signal of touch. So, Meissner's corpuscles as we have seen, this is the Meissner which is close to the epidermis. So, these mechanoreceptor are responsible for light touch, it is a tactile touch. And these are distributed throughout the skin, but concentration is very high in those place where sensitivity is high to touch.

Although they are very evenly distributed throughout our skin, throughout our body, but the places where the very sensible place, sensitive places, Meissner's receptor concentration is very high like palms, lips, tongue, and fingertip. These are the places where we can sense any touch with a very small, lower level of sensation.

So, the concentration, if you see of this Meissner's are very high, and where we can make out the places of our body where the sensation of light touch is less, Meissner's corpuscle are less. Or sometimes we may see that it may actually it fails. Meissner's corpuscle are not getting signal, they are not active; that means, it is not able to sense any touch. In case of any deformation, Meissner's corpuscle cause an action potential in the nerve. So, any small touch, they get any deformation in corpuscle. If we suppose this is the corpuscle here, with that touch, small touch, very light touch, it gets deformed, it gives signal, the deformation gives signal.

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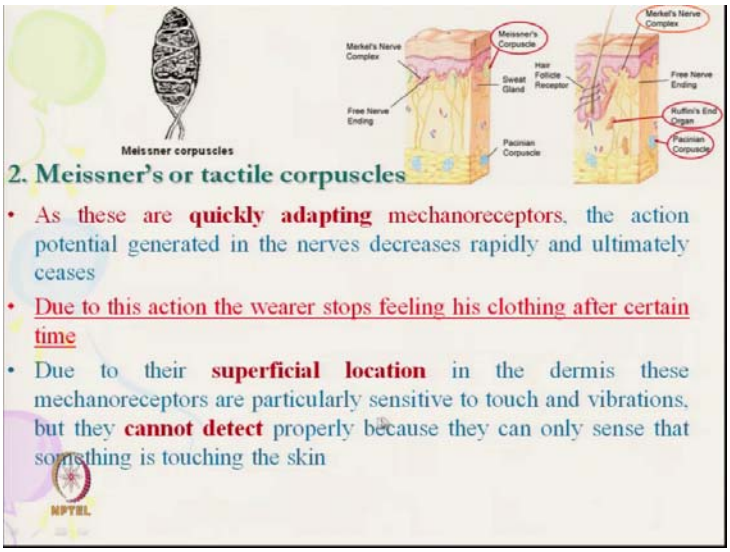

And as these are quickly adapting what does it mean? Quickly adapting; when we are touching it gets signal immediately, and then adapts quickly. Adapting means it gets, it adapts and ultimately it is generate signals immediately, but the signal fades out quickly, this is called quickly adapting. So, the action potential generated in the nerve decreases rapidly. What does it mean? Suppose a light touch is there and there is no movement, ultimately you will feel nothing is in touch with our body. Best examples is when we are wearing clothes.

When we move our body we feel that there is a cloth in our body, but suppose we are actually sitting idle quietly, no movement we sometime, may feel that the presence of clothing or we may not feel. That means, this textile sensation sensor its quickly adapting and it actually the sensation ultimately seized out; due to this action, we stop feeling the cloth after certain time, the presence of clothing we stop feeling, because its adapted immediately, but if we change our posture, it moves then again, it comes into the picture.
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Due to the superficial location in the dermis, these mechanoreceptors are particularly sensitive to touch and light vibration, low frequency. But they cannot detect properly because they can only sense that something is in touch, it cannot detect and differentiate, this particular receptor cannot differentiate. Which thing is in touch, is it due to the edge or due to something. But it can only detect that something is in touch for edge type

sensor. Edge type detects different types of sensors. This only gives the sensation, there is something is in touch with our body.

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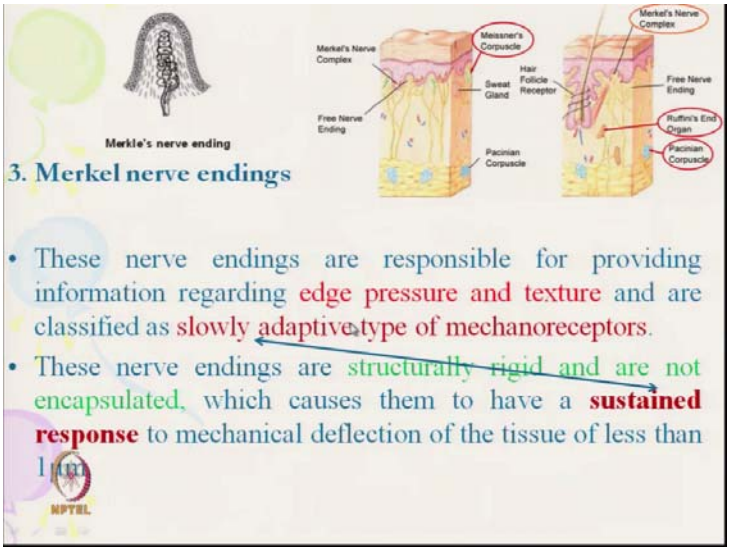

Next comes the Merkel's nerve ending, these nerve endings are responsible for providing information regarding edge pressure and texture. So, you will see that Merkel's nerve ending are also at the close to the surface. So, this type of nerve endings actually senses the edge type or textile it can differentiate, the texture. Texture, suppose we are wearing one smooth cloth or maybe some rough cloth, for that type of touch the Merkel's nerve ending will give us the sensation. And it is not the quickly adapting it is a slowly adapting, it actually can differentiate. And this type of sensor gives the actual sensation for long time, it is slowly adapting type and is called sustained response to the mechanical deflection of the tissues of less than one micron.

So, this is structurally rigid and not encapsulated, this is rigid one and it is not encapsulated like earlier. So that is slowly adapting, means it gives sustained information, sustained sensation, sustained response, but if it is quickly adapting it will quickly sense, adapt and its sensation will ease, it sensation will actually stop.

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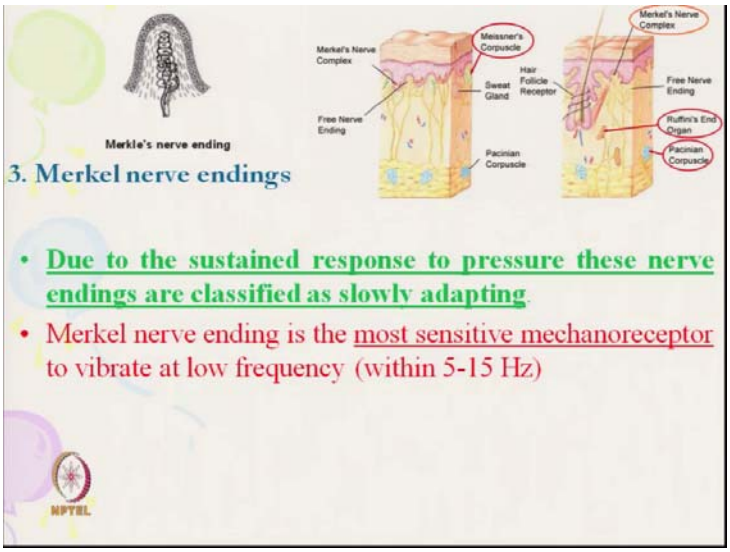

The Merkel's nerve ending is due to the sustained response to pressure, this nerve endings are classified as slowly adapting, and they are actually responsible for their most sensitive mechanoreceptor at low frequency level. Earlier one was high frequency level these are low frequency level associated with it.

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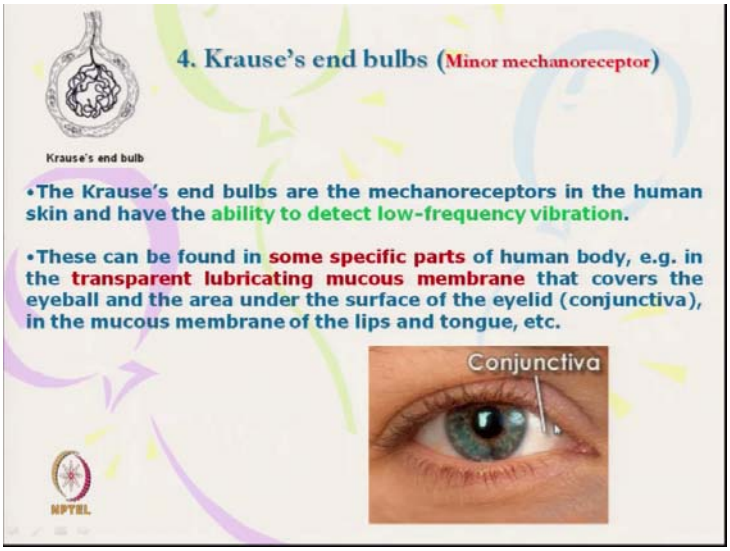

Then the Krause's end bulb which is not directly related with clothing comfort, but we must know, these are actually present in the conjunctiva of our eye. So, this mechanoreceptor of human skin have the ability to detect low frequency vibration. And

actually we can find this specific part of human like transparent lubricating mucous membrane. So, where the transparent membranes are there on those places, we get this type of sensor like your lip, tongue, and eye, these type of places we will we get these sensation.

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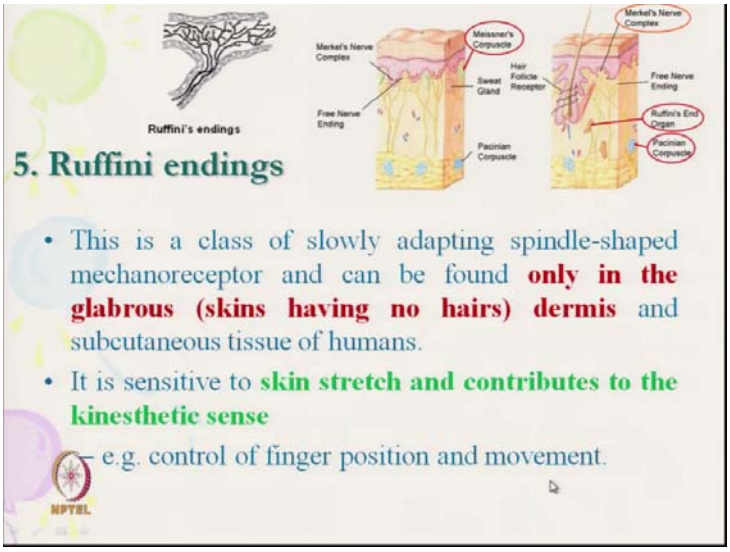

Next is the Ruffini's ending. This is the Ruffini's ending if we see the location is in the dullness. These are again slowly adapting spindle shaped mechanoreceptors only in the glabrous. These are also slowly adapting sensor in subcutaneous tissue. So, it is sensitive to skin stretch and contributes to the kinesthetic sense. Like if you move or it give some movement or we are moving this one. So, this type of Ruffini's ending gives signal of this type of sensation, it controls finger position and movement.

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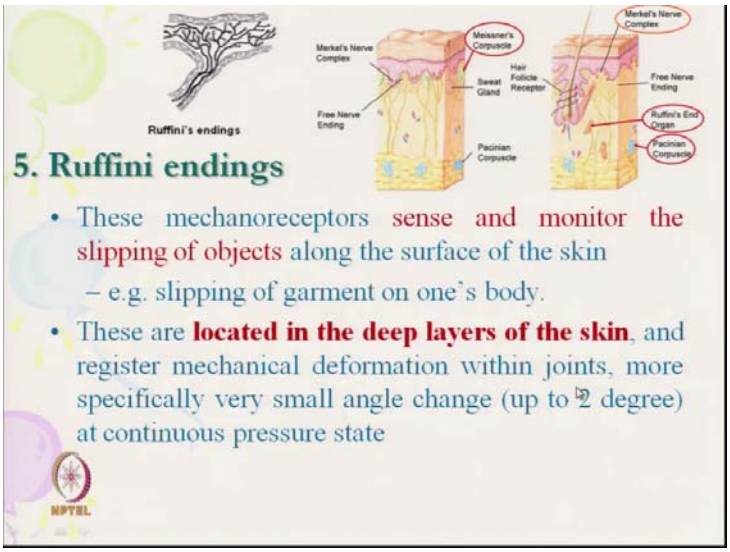

So, this mechanoreceptor sense and monitor the slipping of object. Like just moving my hand, it is a slipping of object, this type of this Ruffini's ending gives this type of sensation. Like our body cloth is moving from our body organs that is this type of sensation it gives and slipping of garments on ones' body. Ruffini's ending is responsible for sensing signal from this type of sensors, located deep in the skin in this places, and register mechanical deformation within the joint.

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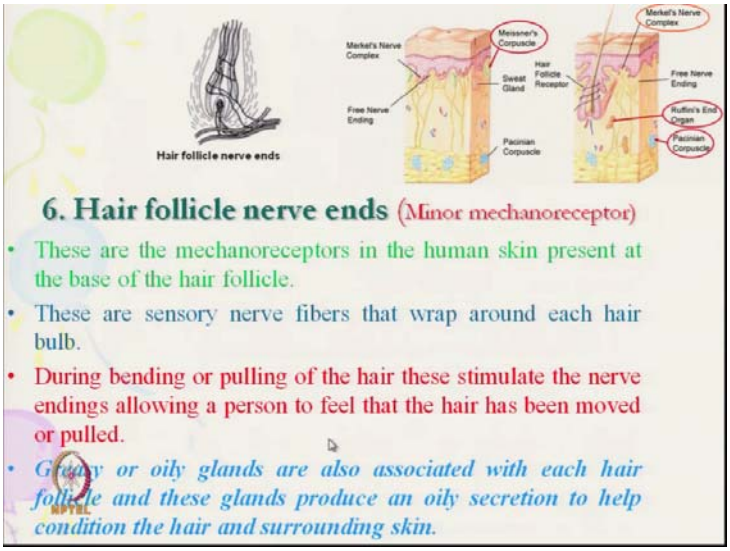

And then comes the hair follicle nerve ending, it is throughout our skin, where hairs are there. And our clothing directly interact with hairs, And even before it interacts with our skin, it is in touch with our hairs, and due to the hair movement, the hair follicle nerve endings receive the signal and gives the total sensation to the brain. These are the mechanoreceptors present at the base of the hair follicle. These are at this point at the base these are this nerve endings. For any movement of hair, it gets stressed or contracted and gets sense signal, there are sensory nerve wrapped around each hair bulb. So, this is the hair bulb and sensory nerve is wrapped around the hair bulb.

During bending or pulling of hairs, if it bends or the pulling of hairs, this nerve ending gets stimulated, and gives signal. And also grease and oils comes out they are associated with this, these are not in all domain.

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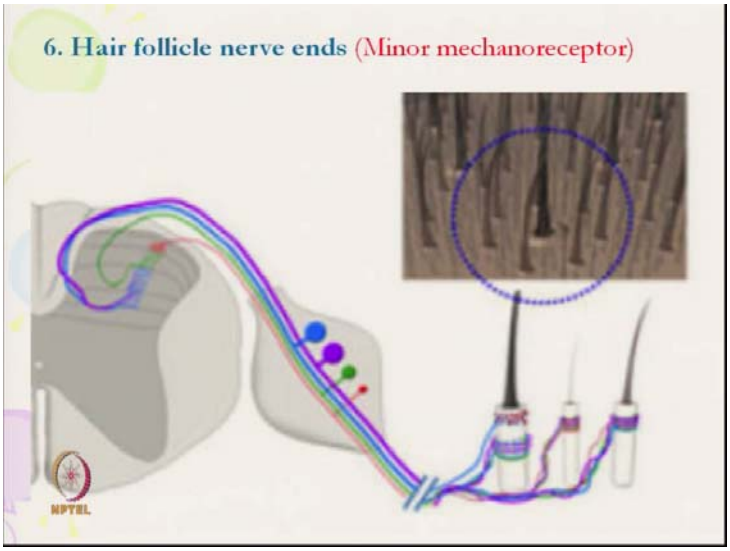

Now, try to see, this is human skin, very nice picture. And let us take one hair; this is one hair, this hair is projected above the skin. Now, if you see inside the skin, this hair and these are the nerve ending, these are the hair follicle nerve endings, they wrapped around and any movement of hair or any pulling, it gets signal and sends signal to the spinal cord and bend.

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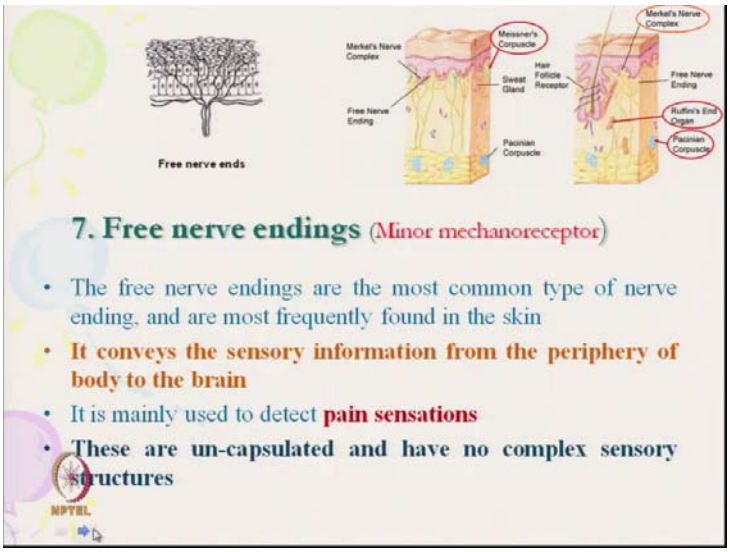

Then comes a free nerve ending which is the last type of mechanical receptors. And free nerve endings are very commonly available throughout our skin, and this free nerve endings are present at different locations. The free nerve endings are most common type of nerve endings and are most frequently found in the skin. It conveys sensory information from periphery of the body to the brain, because its location, if you see it is very close to epidermis. In the epidermis, these free nerve endings are present and any information, it senses and sends to the brain.

It mainly detects the pain type of sensation may be cold or may be mechanical pain or maybe warm. As these are free now they are not capsulated have no complex sensory structure, these are open no complex structure.

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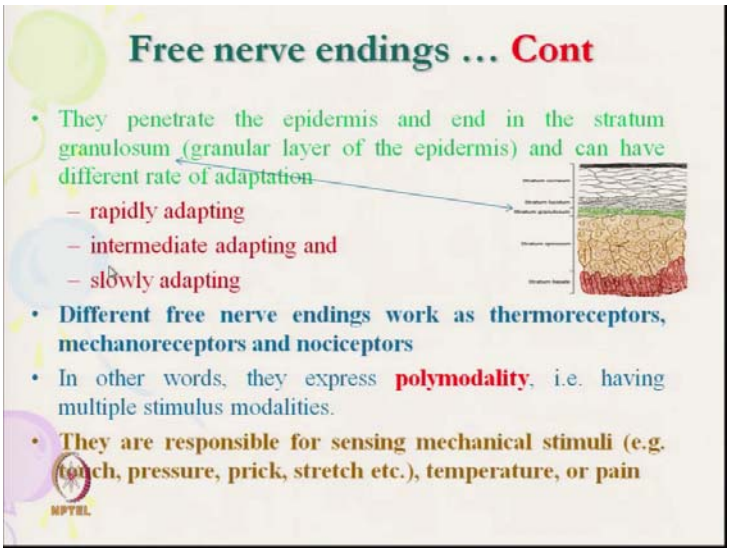

And these basically penetrate the epidermis that we have discussed and it goes up to the stratum granulosum, granular layer of the epidermis. If you see this is the epidermis, this goes up to this layer, up to this layer this is epidermis total epidermis. And this is rapidly adapting, intermediate adapting and slow adapting.

Free nerve endings are of different types and can sense the mechanical sensation, they can sense the thermal sensation, and they can sense the pain sensation.. So, a particular free nerve ending can be of polymodality, different types of sensors and they can give. They are responsible for sensing mechanical stimuli like a touch, pressure, prick, stretch, temperature, pain. So, free nerve endings are not like specific capsulated nerve ending, these actually give polymodality, multiple stimulation.

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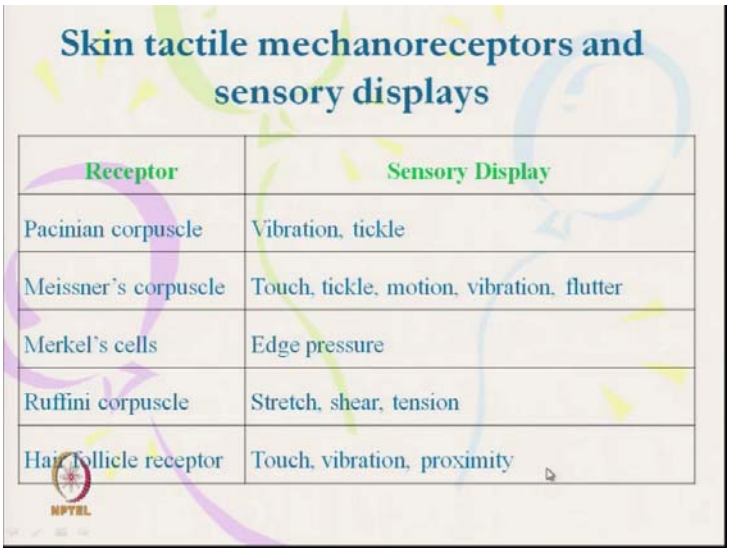

Now, we will discuss the skin tactile mechanoreceptors and sensory display. So, these are the different sensors we have discussed till now, now how this type of sensors displays the sensory stimulation with the clothing. So, you see that Pacinian corpuscle t is we have discussed in short, it is vibration and tickle, Meissner's corpuscle – touch, motion, vibration, Merkel's cells - edge pressure, Ruffini's corpuscle – stretch, shear, tension, Hair follicle – touch, vibration, and proximity also. Proximity is suppose, something is very close to my skin, and through hair it gets the signal.

Even in blowing air, hair will move, it will give signal. So, all this signals it gets, now we will discuss the mechanical sensation, which we perceived through the clothing. Due to clothing we get different types of mechanical sensations.

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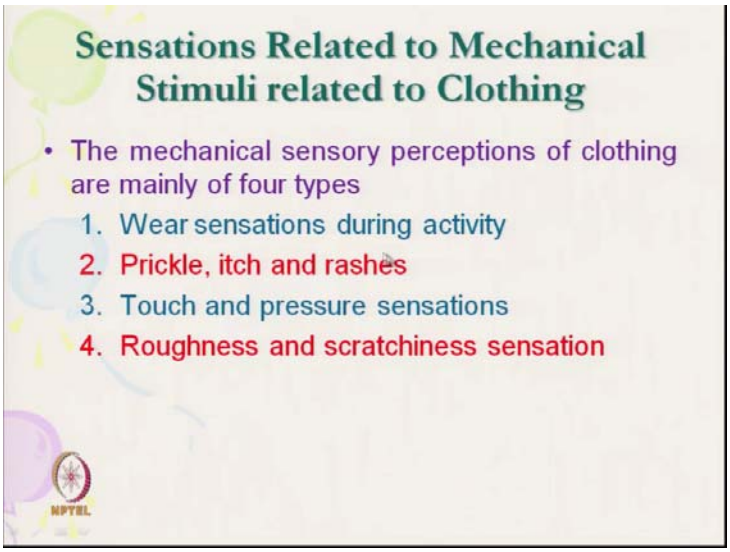

The sensations related to the mechanical stimuli when we are clothed, these are of 4 different types. We will discuss one by one, one is called Wear sensations during activity. So, after clothing, when we do activity what happens? Our cloth, it moves from the body, it starts moving. And then what happened? These clothes during movement, we get different types of sensation, it touches, it releases from the body, and it slips. So, this type of sensation we get wear sensation.

Then the clothing gives prickle sensation, itching sensation or rashes. So, this we can combine into one type of stimulation because they are related prickle, itch, rash these are related. If the skin starts prickling, one particular fabric gives prickle sensation. We will discuss in detail it also gives itch sensation if it is extreme prickle, and if it starts itching then it will also give rash. So, prickle, itch and rash they are actually interlinked to each other.

Third one is that the touch and pressure sensation; it is a soft touch, a pressure sensation. It is low pressure and high pressure; low pressure sensation means touch and high pressure sometime it may be pain type of sensation. And last one is the roughness or scratchiness, it is totally different from prickle, itch, and rashes. Roughness is related to the surface texture of clothing and prickle sensation is related with the amount of or number of hairs; steep hairs present in the surface, these things are different, we will discuss in details.

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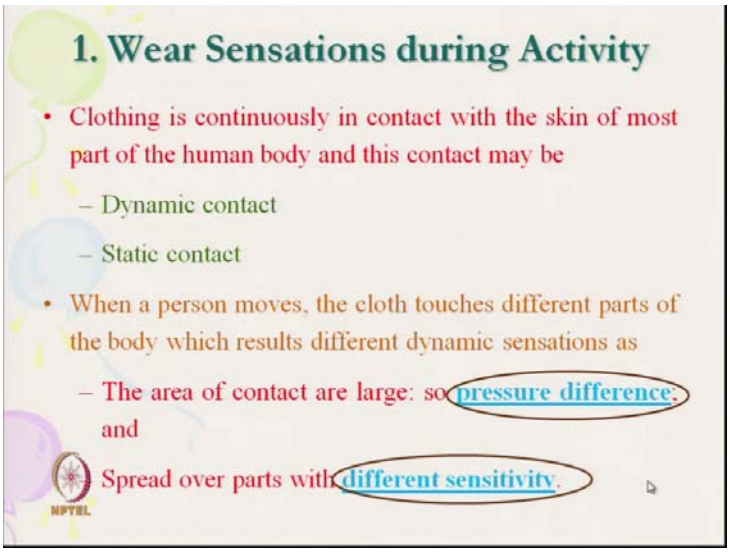

Now start with the wear type of sensation. What is wear type of sensation? The clothing is in continuous contact with the skin of most of the part of our body, this contact maybe dynamic or static. So, when you move, it starts giving dynamic sensation n,what is dynamic sensation? Means it starts slipping or it get in touch and it release touch or it gives pressure.

So, this type of sensations we get in the body and static contact means we are not moving. And when the person moves, you know there is dynamic contact, the cloth touches different parts of the body, which results different dynamic sensation. One is that at different body part, we get different sensation. So, at one part, we get higher pressure, other part we get lower pressure, and even it spreads over different part of the body with different sensation. Different sensation means different types of receptors present at different concentration, we get different sensation and this total sensation, we get it from the brain, we get ultimately total sensation; that means, we get comfort sensation.

We do not get whether it is a high pressure or low pressure or ultimately we get a combined sensation. This is dynamic condition. So, pressure due to pressure difference, due to different type of sensitivity we get overall wear sensation.

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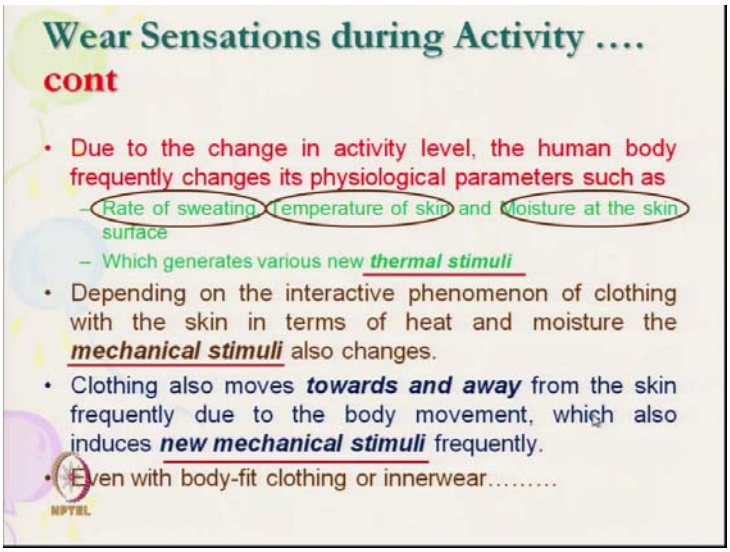

So, due to change in activity level what happened, with the different activity level of the human body, body physiological parameters change? So, suppose a particular cloth or particular garment, when a person sitting idle it gives certain sensation. Now, when he is doing activity. So, wear sensation during activity. So, his physiological parameters will change. So, what are the physiological parameters? His sweating rate will change, then temperature of the skin will change, as the temperature of the skin changes due to body physiology, its moisture in the skin will change.

So, what will happen? If all these parameters change; that means, his skin characteristics will change and interaction with the garment will automatically change. So, the person if he is not active, he will get all together different stimuli, get all different sensation than when he is active. Which activity generates different types of thermal stimuli? That means, suppose very common example, we are wearing a cotton garment, it is very comfortable because it is not sticking to the body and body is not wet.

But when a person starts sweating due to his physical activity, the physiological parameters changes. The skin gets wet, completely wet and his total interaction with the garment changes and total sensation of the garment with the body will totally change. That means, he will feel totally different, he gets totally different sensation than when he was actually dry. So, depending on the interactive phenomena of clothing with the skin

in terms of heat and moisture the mechanical stimuli also changes. If the cloth is sticking to his body, he will start getting stretch.

Clothing also move towards and away from the body; that means, a person when he is moving; due to the bellow effect, the clothing will start moving towards or away. Air pumped inside it will throw the clothing, it moves the clothing away from the body. So, this will also give different types of stimulation. So, basically this type of moving away and close in touch with the body, this is happening, this is very common phenomena when a person is wearing a loose fit garment and he gets different types of new mechanical stimuli for a same fabric it gives different stimulation.

Sometime its keeps stretching of the skin, sometime it gives a pressure, sometime it gives a light touch, these are possible for loose fit garment. But what happened with the body fit garment, tight fit garment? Tight fit garment also gives different stimulation because of the stretching of the garments; stretching of the garments gives higher and lower pressure. So, we get altogether different sensations, when our fabric, our body moves when we are in active. So, during activity we get different sensation due to body movement, due to stretching of the garment, due to change of physiological parameter, due to change of body heat.

Even a person may feel comfortable with a fabric say at lower temperature when the skin is not wet, but the same fabric may give a prickle sensation. Suppose a woolen cloth if you are wearing, it is not giving prickle sensation, but when the skin becomes wet due to activity, it will start giving prickle sensation, this phenomena, we will discuss in detail, because softening of our skin gives new mechanical stimulation.

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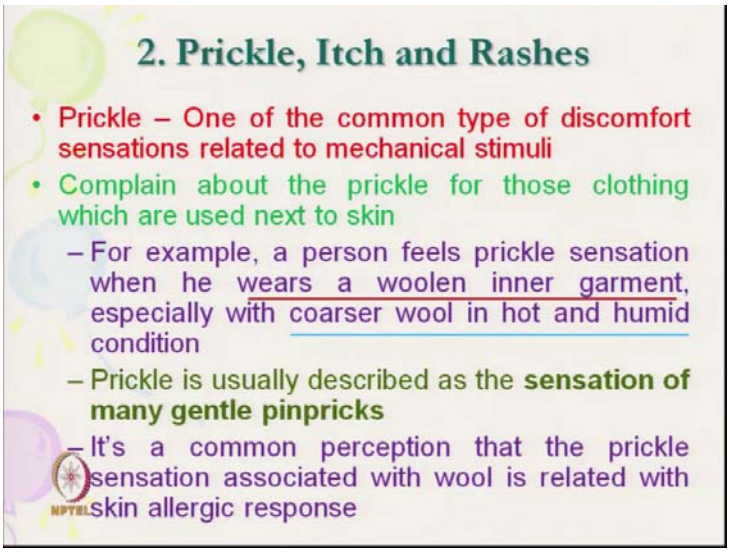

Next, we will discuss now prickle, itch and rashes, that is we have discussed earlier also. So, these prickle, itch and rashes are of similar type of sensation. These are interrelated.

So, what is prickle? Prickle is one of the most common type of discomfort sensation related with the mechanical stimuli when we wear clothing. This is the most common type of discomfort. Complaint about the prickle for those clothing which are used next to the skin. So, we get a particular clothing in touch with our body, for those clothing we get the prickle sensation. For example, a person feels prickle sensation when he wears a clothing, woolen inner garment specially made of coarse wool, and he is wearing in hot and humid climate. Definitely you will get sensation of prickle sensation, if we give all this conditions.

Like woolen inner garment, it is to wear coarser wool in hot and humid condition. These are the ideal condition for getting the prickle sensation. Now, we will try to understand why prickle, what are the factors which actually control prickle sensation. And if you understand, then you can develop fabric develop prickle free clothing, itch free clothing or rash free clothing, which will be very comfortable clothing. So, prickle is usually not a single point, it is many gentle pin pricks, it is now to pricking inside the skin, It is a sensation generated from many such prickles, pricks, its common perception that the woolen fabric gives prickle sensation due to allergy, it is not that, because some people may get allergy with woolen, but wool, coarse wool particularly in this condition with

hot and humid condition keeps prickle sensation to everyone. So, prickle sensation is nothing to do with our allergy, it has been proved.

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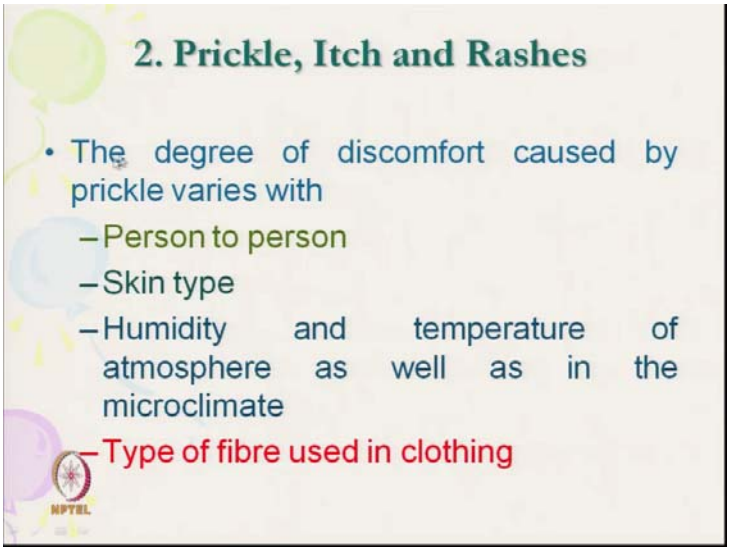

So, the degree of discomfort caused by prickle sensation, it varies with person to person. A person may feel very high prickle sensation, but someone else may not feel. But prickle sensation will be there definitely, but degree may be different. Type of skin, sensitive skin will get higher prickle sensation. Humidity and temperature of atmosphere as well as the microclimate. So, in microclimate, the temperature and humidity changes we get different types of prickle sensation, and type of fibre used in clothing. So, if we understand the interrelationship between all these factors then we can develop a cloth without prickle sensation.

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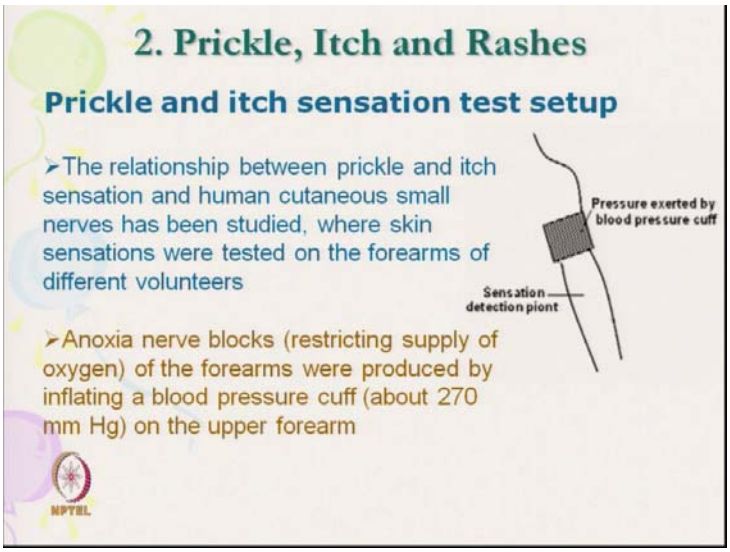

Now, let us see one experiment. Actually, it has been tried to understand the type of sensor responsible for prickle. Whether this sensor is same as the touch type sensor. So, here, what is done at this point, at the upper arm, so here forearms, relationship between prickle and itch sensation and human cutaneous small nerves has been studied, where the skin sensations were tested in the fore arms of different volunteers.

So, at this point, forearm, the sensations were detected using inflating the blood pressure cuff, at 270 millimeter Hg, at upperarm it has been inflated. So, pressure has been generated, this is done to stop the supply of oxygen. So, the skin does not get the blood. And the touch and prickle sensation has been studied using some object.

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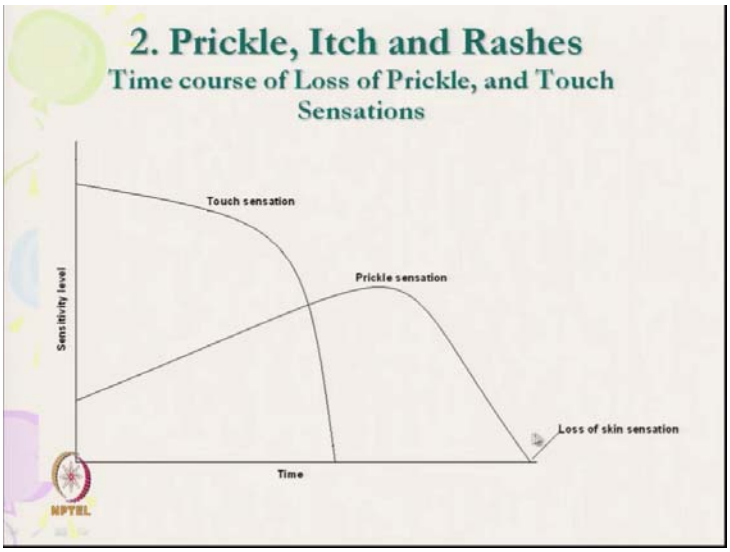

Now, what is observed here, this is the sensation The x axis gives the time and y axis give the sensitivity, sensitivity level. Two types of sensitivity level has been studied, one is touch type sensitivity, and another is prickle type sensitivity. So, what has been observed that touch sensation drops quickly and this is around say 20 minutes time, say. So, touch sensation drops quickly; that means the person stops sensation of touch after 20 minutes.

The prickle sensation increases it continues to increase; that means, touch and prickle sensations are actually two different types of sensors are responsible for sensing. That means it is proved that touch sensor are actually mechanical pain sensors. Some pain sensors, free nerve endings present on the surface of the skin, the epidermis zone. These are responsible for this type of pain sensation which gives the prickle sensation. And it goes up to maximum point then it drops and here actually skin loses its total sensor, a total complete anesthesia is there. So, that means, that pickle sensation is totally different from the touch sensation.

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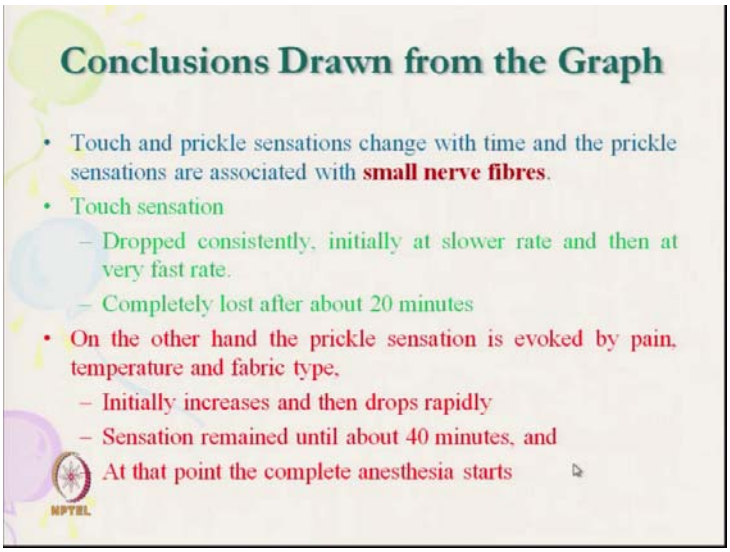

So, the conclusions drawn here; the touch and prickle sensation changes with the time. And the prickle sensation are associated with the small nerve fibers, which is the free nerve endings. And touch sensation drops continuously, consistently from the beginning initially at slower rate and then suddenly drops and completely lost after 20 minutes whereas, the prickle sensation is evoked by pain, temperature and fabric type.

So, here in the study, what they have done at different temperature, it has been studied at different types of fabrics and different levels of humidity, and this prickle sensation has been observed that initially it increases and then drops rapidly, sensation remains up to 40 minutes. So, actually prickle sensation is by some pain sensors; at that point complete anesthesia is up to that point. Just before the complete anesthesia, people start feeling the prickle sensation. Now, we will discuss different studies conducted to study the prickle characteristics of different types of fabrics.

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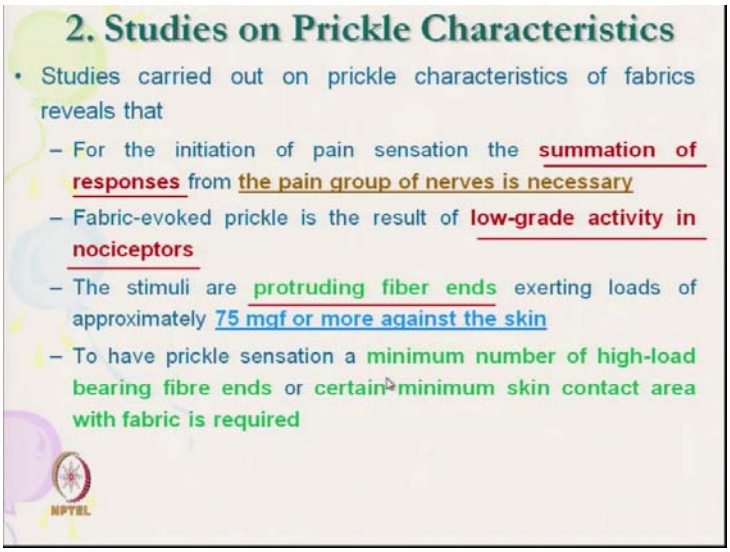

So, studies carried out on prickle characteristics of fabrics reveal. So, what are the findings of this study? For the initiation of pain sensation, the summation of response from pain group nerves are required. It is not the single prick, single point will not give us the pickle sensation, and it is a group of nerves has to give sense signal then only we will get. If one or couple of few nerves keep, it will not ultimately give prickle sensation you may get something else, but it will not give the prickle sensation. Summation of response from pain group of nerves this is very important.

Fabric evoked prickle is result of lower activity, low activity of nociceptor. What is that? Nociceptors is basically damaging when something is penetrating inside that type of pain, it is not that type of activity it is a low activity. One wool fibre, if it penetrate inside then it tries to penetrate the skin, that type of low activity will give the prickle sensation

The stimulation is produced by the actually that the amount of load, it is around 75 milligram force. So, actually the protruding fibre ends has to produce that much force, or more to the skin. So, one fibre will not give that much force. So, if we talk about the large number of fibres and if it produces this much force or more then we will start getting the prickle sensation.

If it cannot give the type of force then we will not feel. Like, this is only possible, if the fibres are stiff or if the fibre ends are less, projected hairs are less and stiffer, then only it will give that much force. Otherwise what will happen if the fibres are longer enough

and fine fibres what will happen? When it will try to give that force before it penetrates, it will bend. So, it will not be able to give the prickle sensation. The fibre end has to penetrate and has to give that much 75 at least milligram force. So, protruding fibre has to give these things and to have prickle sensation, a minimum number of high load bearing end should be there.

It is not that few fibres are giving a prickle sensation of load 75 milligram force. Suppose one particular needle is giving a force of 75 milligram force or say 100 milligram force, 1 needle gives do you feel prickle sensation. We will not feel prickle sensation. Although the amount of force is very high, it has to be more than this and also number of fibres has to be more. So, we will continue discussing on this issue; different types of studies on prickle sensation in the next talk.

Thank you.