Science of Clothing Comfort
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Lecture - 11
Neurophysiological Processes in Clothing Comfort (contd…)

Hello everyone, we will continue with the Prickle Characteristics of Clothing.

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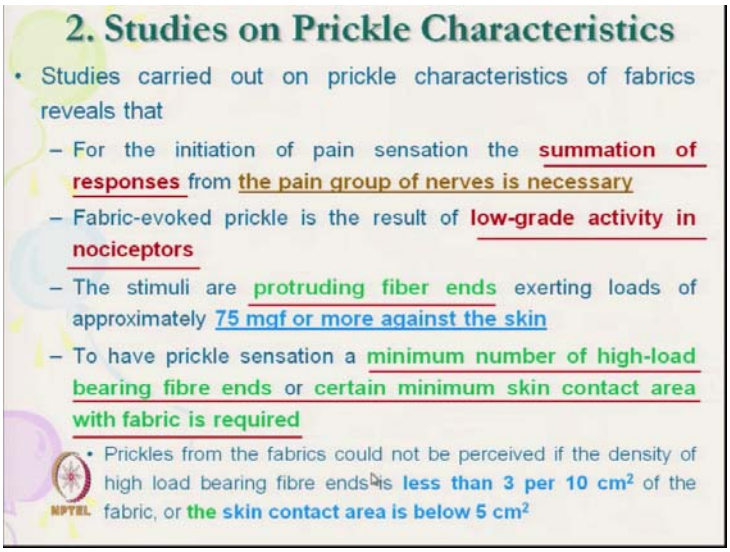

So, we are discussing different aspects of clothing prickle sensations. There are different factors which affect the prickle sensations. As, we have mentioned that that the prickle sensation is not the single prick point. Since, it is a summation of number of prick sensation of pain group of nerves, which is necessary to have prickle sensation.

So, and fabric evoked prickle sensation is a low grade activity of nociceptor. It is not the very high damaging activity; it is a low grade activity. And, also this says actually it is a stimulation should be total force should be around more than 75 milligram force, all together and by the protruding fibres.

So, and to have the prickle sensation minimum, number of high load bearing fibre end should be there, there are minimum number of fibres concentration should be there. And minimum area of contact should be there. Suppose with a small patches small patch I am some very harsh fibre is in touch, we will not have the prickle sensation, there has to be a

minimum area (Refer Time: 02:11) and also certain number of minimum number of fibres. Suppose fibre very high load bearing fibres are with very less are in number are pricking, we will not prick sensor, but we will get something else some other sensation, but definitely we will not get prick sensation.

So, to have prickle sensation, we need minimum number of high load bearing fibre ends are required. So, that is, what is that? So, it should be less than 3 per 10 centimeter square, if it is there ok. So, then the prickliness of fibre could not be sensed. So, minimum there has to be more than 3 fibres per 10 square centimeter, that many number of fibre should be it may be more than that, but if there are 1 or 2 fibre it has been observed that we will not get prickle (Refer Time: 03:16). Even if there are it is harsh fibre it is, but we will not prickle sensation.

And, also the minimum contact area of the skin has to be 5 centimeter square, 5 centimeter below 5 centimeter square we will not have prickle. So, even a particular, we can see that particular patch with the say prickled fibre surface, if small say one centimeter patch we are putting somewhere, we will not get prickle sensation.

So, there has to be minimum certain value. If it is more than that we will get start getting prickle sensation. So, 2 main conditions are there one is the there are 3 conditions the fibre has to have minimum load bearing, then number of fibre should be there per unit area. And, also the minimum contact area, then only we will get prickle sensation ok. This is the minimum requirement. And these are that.

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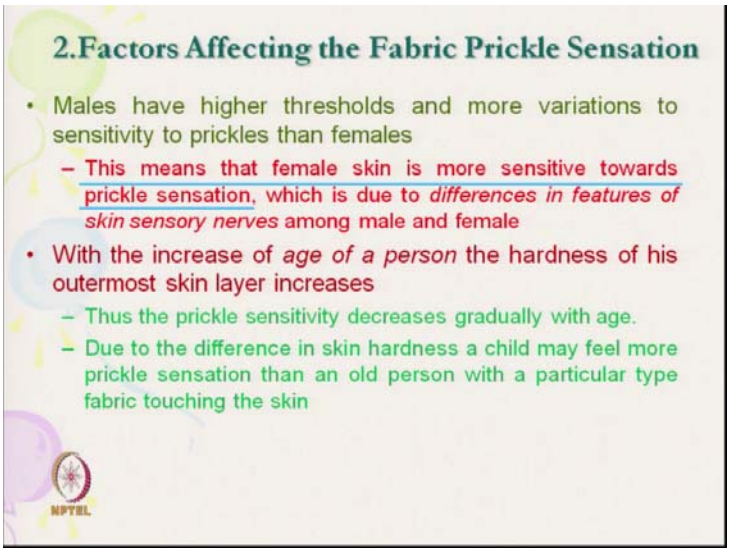

And then it has been observed that male has got less prickle sensation than female. Because, it is a male has got higher threshold, higher threshold of sensation more variation to the sensitive of the prickles than it is a female.

This means that female skins are more sensitive toward the towards the prickle sensation ok. And, this is related to the feature of the skin. It has also been observed with the increase in age, people feels less and less prickles. The skin actually it is outermost skin get harder and harder, hardness of the skin increases. So, the prickle sensation gets reduced, which means the sensation sensitivity decreases with the age.

So, due to this that the child feel higher prickliness than an aged person. While touching with the same type of fabric. So, that we have to be very careful while designing the children's clothing. This type of clothing, we have to avoid for children.

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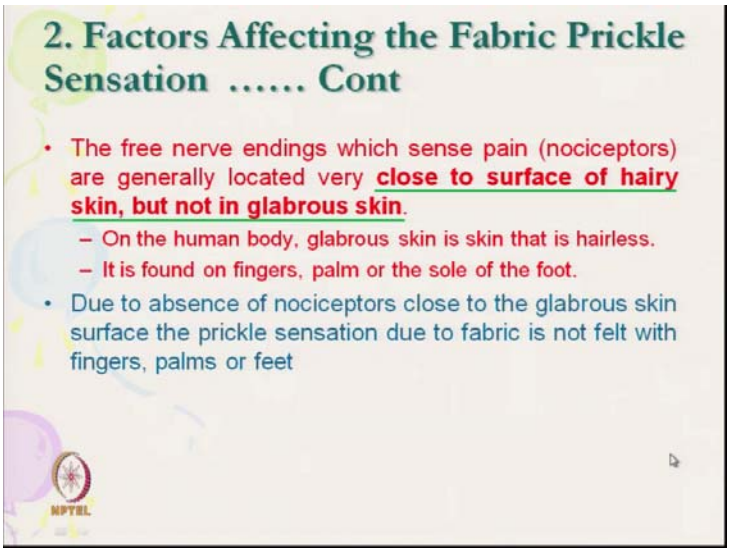

And, then the free nerve endings which sense the pain are generally located very close to surface (Refer Time: 05:57). This type of prickle pain, we sense they are very close to the sensation where the hairs are there hairy skin (Refer Time: 06:07), but this type of prickle sensation that type of sensors mechanical sensors are absent in glabrous skin; that means, where the without hairs like palm, feet and all this.

So, this type of sensors are absent in a glabrous skin, which means it is hairless, it is found in palm or sole of the foot; that means, we do not feel any prickle sensation in palm. Same fabric if we touch. Even all other conditions of density of hairs or number, amount of area of contact area or every all the senses and all the parameters are there, still we do not feel prickle sensation in the palm, because of the absence of this type of sensors.

We normally feel this type of sensation with hairs or skin portion where hairs are there. So, feet, finger, palm. So, this type of prickle sensation, we do not feel.

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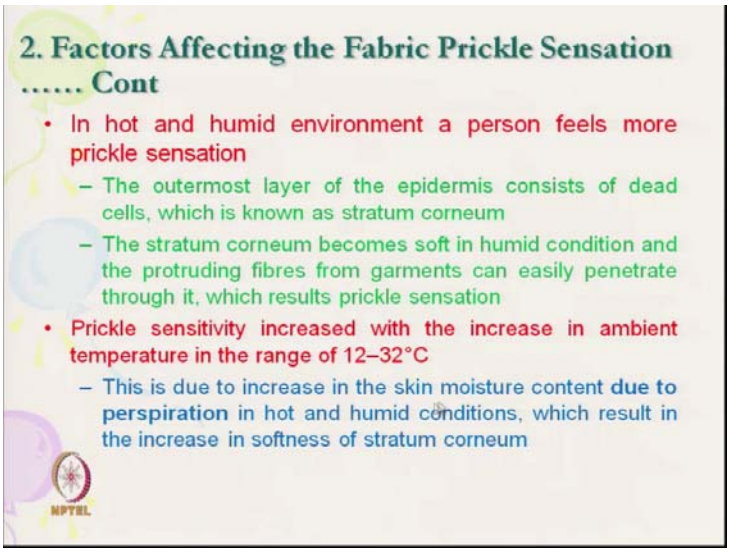

It has also been observed that in hot and humid environment, we feel prickle sensation. Same fabric is not giving prickle sensation in cold climate, but we get feel prickle feeling at the hot and humid climate, why? Because in hot and humid climate our outermost skin, that is the epidermis which is of a dead cell gets soften it gets which is called known as stratum corneum, it gets wet at humid high humidity or sweating. And, then it gets soften and the hairs can easily penetrate through that high load bearing fibre ends can easily penetrate through this and through this portion and gives prickle sensation by exciting this type of nerve endings.

So; that means, the prickle sensation is more in humid hot and humid condition. And prickliness sensitivity, it increases with the temperature particularly from say 10 to 12 degree Celsius 30 to 32 degree Celsius. So, this sensitivity increases with the increase in ambient temperature in, why? Because as the temperature increases due to our body physiology, our body starts releasing the sweat, and this the skin gets wet and our sensitivity increases.

Increase in skin moisture content due to perspiration. So, as in skin moisture content increases and so, again we have discussed it is a gets soften and we get this type of sensation. Now, one specific study which is conducted with different type of fabric just to know the difference in prickle sensation, and using the rating scale. The rating scale

we have discussed in earlier where we have discussed in psychological aspects this is by rating scale the prickle sensation has been studied.

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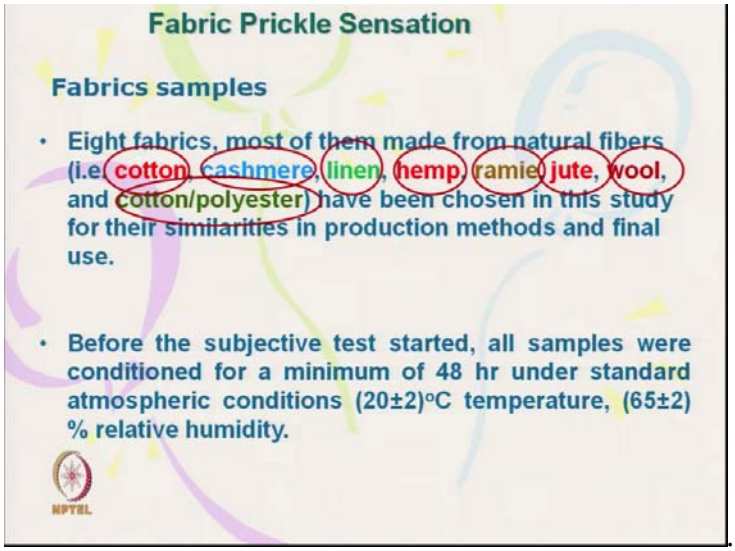

So, 8 different fibres have been selected, with wide range of surface characteristics or wide range of their bending characteristics, wide range of diameters.

So, these are the cotton, cashmere, linen, hemp, ramie, jute, wool, and cotton polyester most of them the all the fibers are natural fibre in nature except cotton polyester blend. So, this natural fibres selected and same similar fabric were prepared, with the similar yarn count similar weave pattern, similar mass, everything remains same. So, the similar production method has been adapted. So, this fabrics have been produced.

And then subjective tests were carried out and this fabrics after preparation they have been conditioned, conditioned for 48 hours with the temperature of 20 plus minus 2 degree Celsius and relative humidity of 65 plus minus 2 percent relative humidity. So, with this condition these fabrics were kept so, to for conditioning. So, that they are they do not have any other impact of environment so, same condition.

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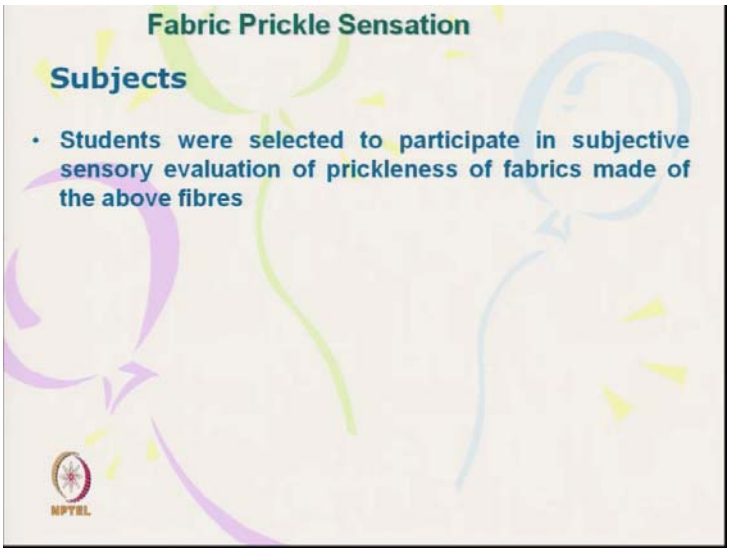

Now, the subjects are taken different students were taken. And, they are selected to participate in the sensory evaluation, they have been trained as we have already discussed, for how to evaluate this sensation. This rating scale how to get this rating scale they have been trained.

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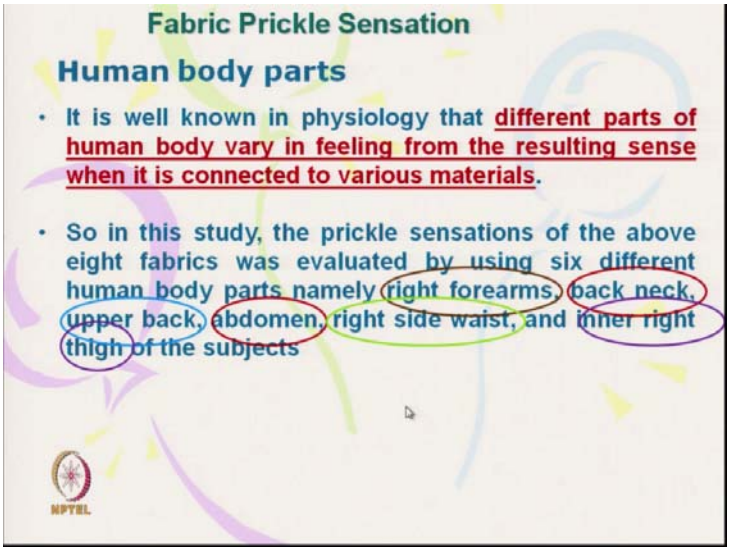

And, it is well known in physiology that different parts of the body gives different feeling of sensation, that is why all this fabrics were taken and the it was tested at different parts of the body. So, 6 different parts of the body is selected. So, right forearms, back neck, upper back, abdomen region, right side of the waist, and inner right side of the thigh so, inner right side of the thigh.

So, these 6 places were selected for evaluation, because for a particular fabric it was thought of that ok. The fabric may give up particular prickle sensation in one place; it may give prickle sensation different prickle sensation in other places. To actually test these things 6 different places were selected and we can see that no where it is a glabrous region. Everywhere it is a there are hairy skins are there and where we normally get the prickle sensation.

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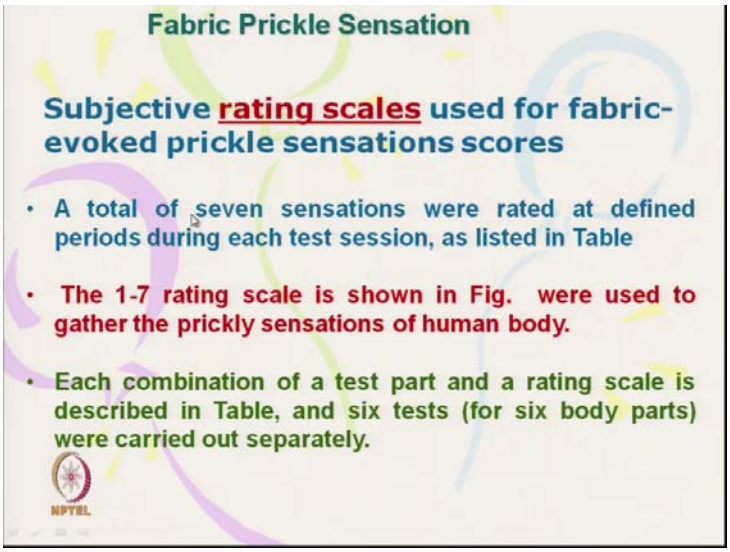

Total 7 sensations were rated. So, this 7 sensations were rated and this rating scales were actually the subjects here the students are taken, the subjects were actually trained for this rating scales or. So, 7 rating scale they must clearly understand, what does 1 mean? What does 7 mean? Each combination of test part and rating scale is described, we will describe the different rating scale and 6 test for 6 body parts were recorded. They have been trained and they have been asked to give the rating. Now, these are the different rating.

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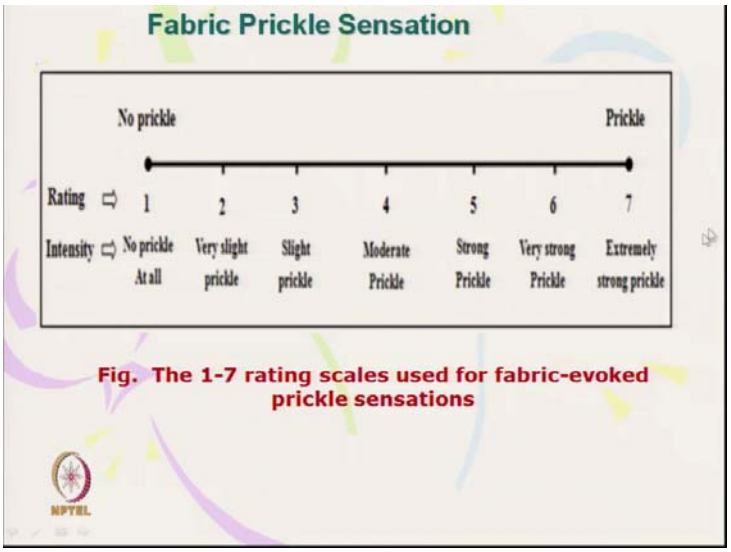

Fig. The 1-7 rating scales used for fabric-evoked prickle sensations

The ratings are 1 means no prickling, there is no prickle, they should understand there is no prickle, 2 is very slight prickling sensation, 3 slight prickling sensation, 4th moderate prickling sensation, 5th severe strong prickling sensation, very strong pickling and extremely strong prickling. So, they have been asked they have been trained to understand these things.

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Rating scale used to describe each of the sensations in each period of prickle sensation

Prickle rating scale	Tactile prickle attributes	Human stimuli when in contact to the fabric
1	No prickle at all	The fabric surface is soft, smooth and comfortable when in contact human skin.
2	Very slight prickle	The fabric surface has few protruding fibers and scratches the human skin slightly when in contact.
3	Slight prickle	The fabric surface has a lot of protruding fibers which irritates the skin, but can be tolerated when in contact human skin.
4	Moderate Prickle	At this intensity, the fabric surface has normal freckles itch and pain impact on human skin when it contacts the fabric. But can be tolerated when in contact.
5	Strong prickle	The fabric evokes a desire to scratch and the surface has a lot of protruding fibers which causes irritation and slight itching of the human skin, but can be tolerated when in contact.
6	Very strong Prickle	The fabric is harsh or abrasive on the skin, its surface is very rough and arouses strong stimulation to the skin, in addition, it makes the skin itchy, irritating and causes scratchiness when in contact with the human skin.
7	Extremely strong prickle	The fabric evokes a sensation of discomfort and the fabric surface is extremely rough, stiff and scratching the skin a lot, which is intolerable. The fabric immediately evokes sensation and makes very gentle prickle pain.

And to make them more clear about this that is this tables were formed that this table was formed and they have been clearly trained for some time. So,1 means no prickling at all,

what does it mean? The fabric surface is soft, smooth, and comfortable, when in contact with the body. Then you give 1 as sense ok. Very slight prickling means the fabric surface has few protruding fibre, scratches the human skin slightly in contact. That is very slightly prickling. Similarly the slight prickling, the prickling surface the fabric surface has got lot of protruding fibre.

Moderate prickling, this intensity the fibre at this intensity the fibre fabric gives little bit higher prickling sensation, more number of prickling fibers are there. Similarly strong prickling is that are slightly more prickling sensation and very strong prickling and coming to the extremely strong prickling sensation means, the fabric evokes sensation of discomfort. It will give extreme discomfort ok. The fabric surface is extremely rough stiff, scratching the skin at lot which is intolerable. So, this gives the extremely strong prickling sensation and they have been trained so, to give these sensations.

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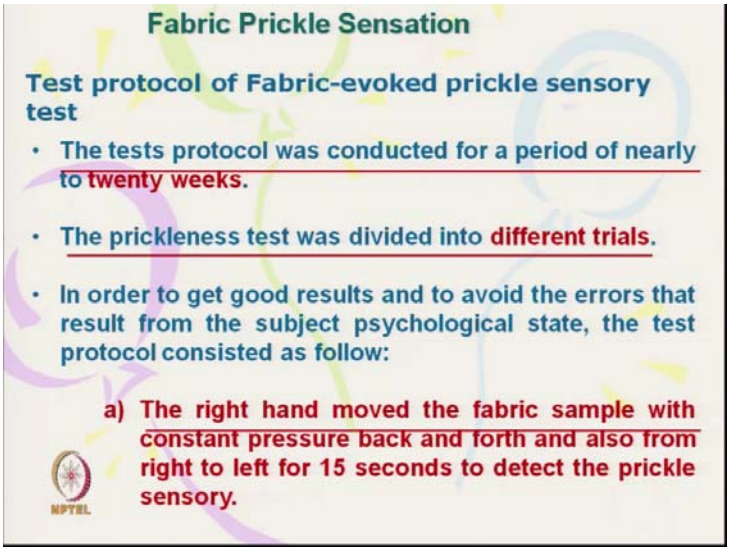

The test protocol is that it is actually conducted in 20 weeks' time, long time with the same subjects. And the prickliness test was divided into different trials, different trial and average has been taken. And, here as this the 6 different stages locations were tested separately, they have not been tested based on the garment, full garments were not tested it is a patch of fabric was taken.

So, to avoid error the results from the subjects of psychological skin test that (Refer Time: 17:38) like standard protocols were followed. And the experts were trained for this

to have to conduct this test. So, the subject is one part who will give the sensation, but the expert will actually who will conduct the test they should also have clear knowledge about the protocol.

So, this protocols are first is that the how to get the fabric in contact with the particular part? How to move the fabric? These are the different streak protocol is there, like test protocol was conducted. So, different trials were there the protocol is first is that the right hand moved the fabric sample with constant pressure back and forth. So, the particular that the may be by other person or may be that particular person here, that particular person moves the fabric right hand the taking the fabric and hoop at a certain pressure. He moves the fabric right with the constant pressure back and forth.

So, he will move fabric and from right to left. So, right to left back and forth for 15 second, after get after moving he will sense the prickle sensation.

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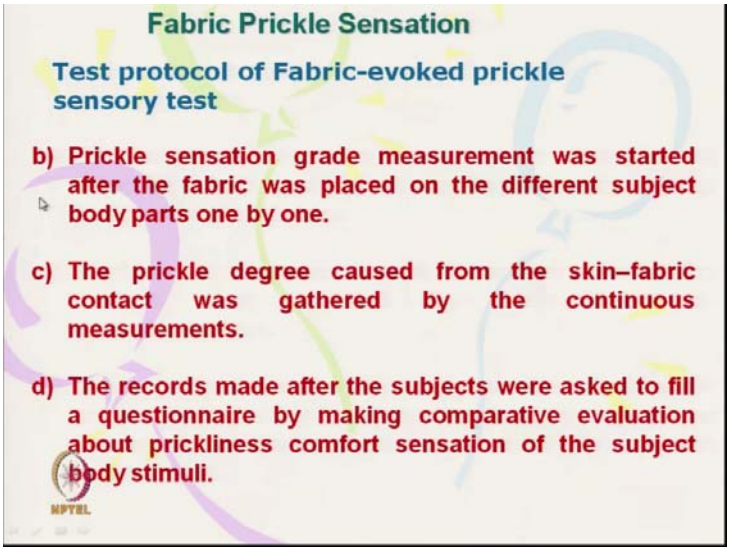

The prickle sensation grade measurement was started after the fabric was placed on different subject body part one by one. So, it is not at that all the in all the body part at a time of one by one it gets they start rubbing and then sense. The degree of prickle, they actual then they measure the degree of prickle sensation 1 to 7 scale and they are record. And, the records made after the subjects were asked to fill the questionnaire by making comparative evaluation about the prickling comfort sensation by the body stimuli. So, after that they are asked to record these things.

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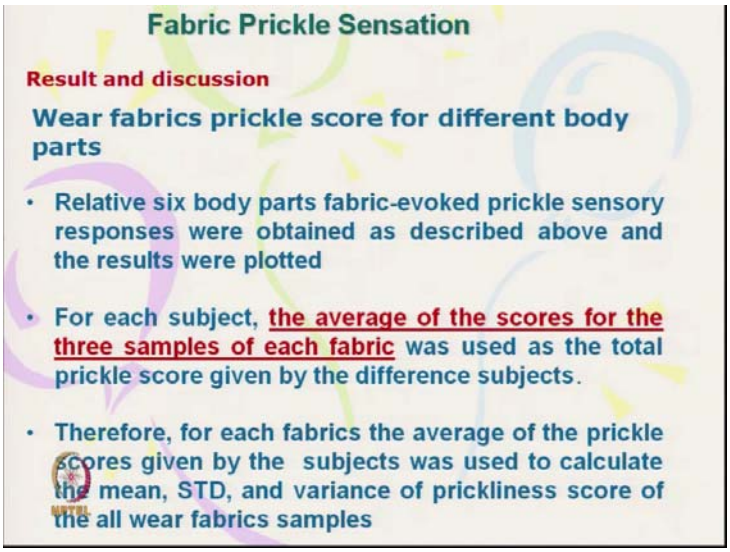

So, the wear fabrics prickle score for body parts. So, relative six body parts were taken, then and from each part 3 sensations were there, 3 at 3 different time, 3 different tests were carried out and averages were taken. The average of the average scores of here samples each. So, for a particular fabric, 3 patches were made. So, average of 3 prickle sensations were taken and then the statistical techniques were adapted, mean standard deviation, variance of prickle sensation were taken.

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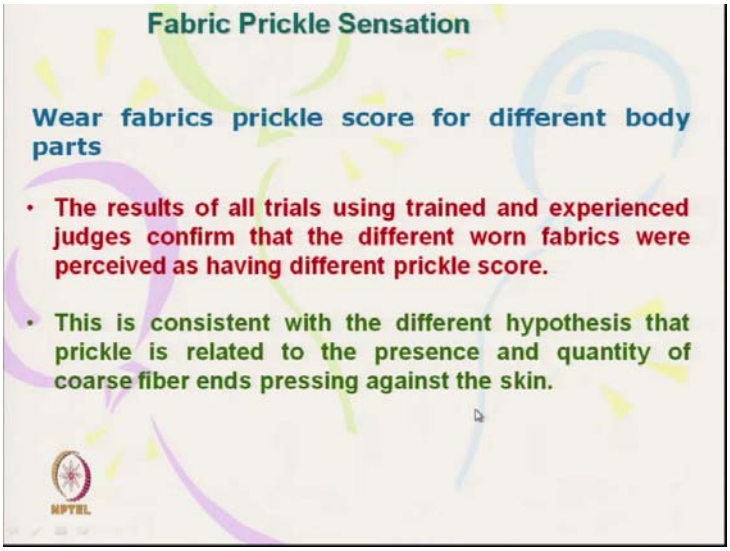

And the results of all trials using the trained and experienced judges confirmed that the different fabric gives different type of sensation. And, but for a particular fabric gives the sensation which is almost same; that means, the difference is insignificant for a particular type of fabric, in a particular place.

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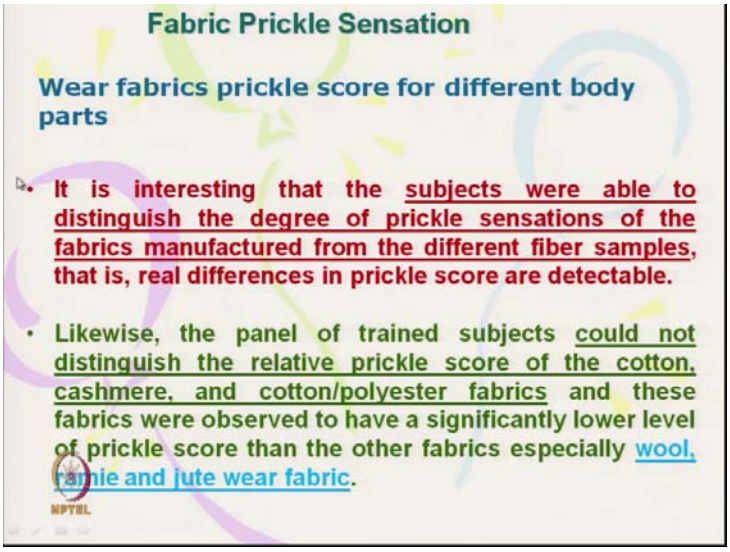

Now, it is interesting that the subjects were able to distinguish the different types of fabrics. They are able to distinguish as far as the prickle sensation is concerned, but they were not able to distinguish the cotton, cashmere, and cotton polyester fabrics. They have placed all this sensation in close range, but these are, as these are significantly lower prickle sensation.

So, cotton gives cotton, cashmere and cotton polyester gives significantly lower prickle sensation. Whereas, that means, it is becomes 1-2 like that range, but particularly wool, ramie and jute fabric, they gives very high prickle sensation. So, these are obvious that due to the presence of stiffer fibre, projected fibre.

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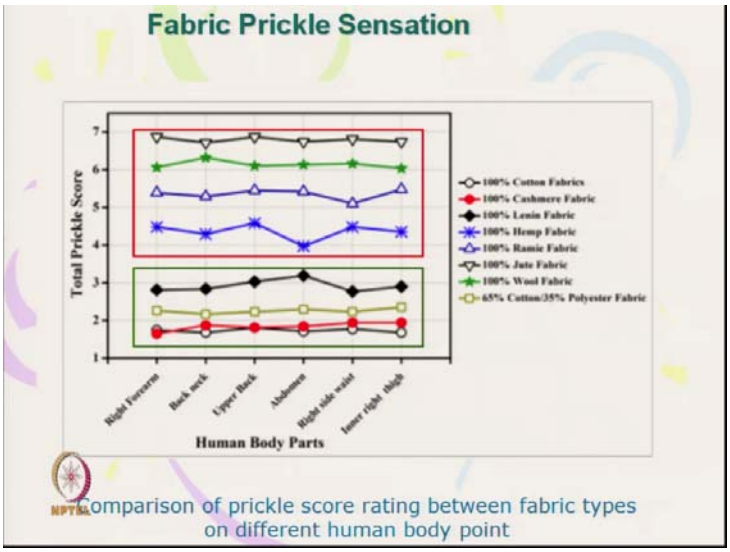

So, you can see this picture here, 4 fabrics gives relatively high prickle sensation, which is this highest prickle sensation is the jute fabric, jute fabric gives highest prickle sensation followed by the wool fabric. The green one is wool fabric gives a little bit lower, but it is also gives a very high prickle sensation, then it comes ramie and after that it is a hemp fibre. All this fibres are they give higher prickle sensation. Whereas cashmere cotton, like cashmere polyester, cotton polyester and also linen fibre. So fibres give lower prickle sensation. And, it has been observed that this prickle sensations are due to the projecting fibre and the hard fibre basically that is a stiffer fibre.

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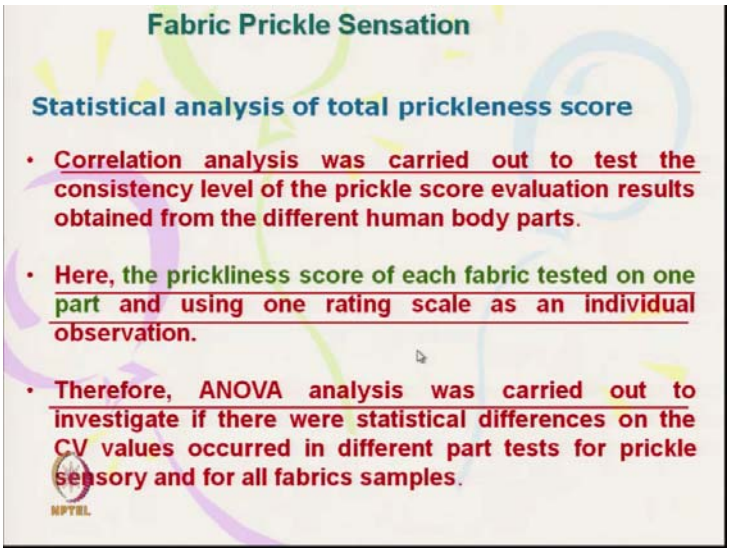

So, statistical analysis they have carried out and which gives the detailed information about the prickle sensation. So, prickle score of each fabric are at different part. So, what we can see? At different parts of the body, the difference is not that, but if we see different fabric it gives; that means, the say jute fabric, it gives prickle sensation through the body, it gives.

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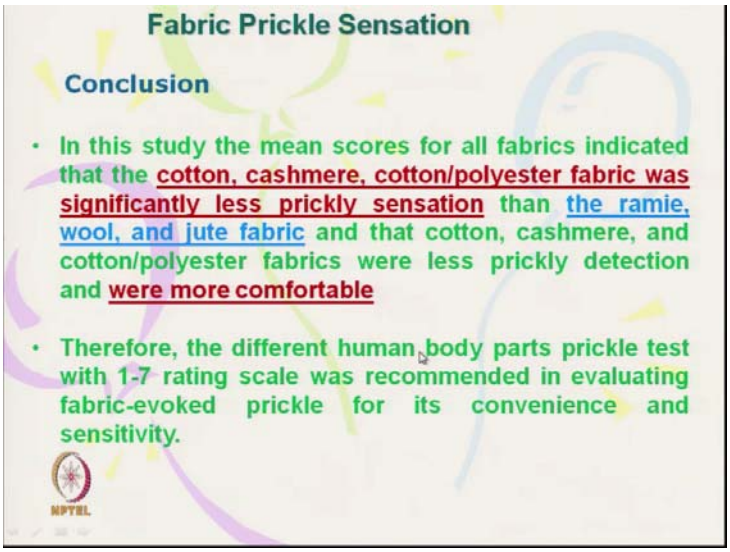

Similarly cotton gives soft sensation throughout our body this is so, this is conclusion. So, cotton, cashmere, cotton polyester fabrics were significantly less prickle sensation. Ramie, wool and jute fabric so, they are giving high prickle sensation.

Now, we will discuss the fabric itching sensation. So, as we have discussed the itching sensation is actually it is evoked by the pain sensation.

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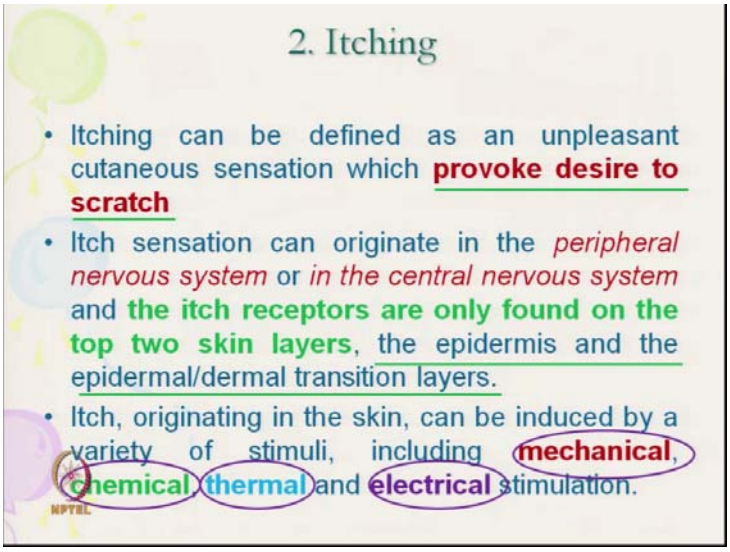

So, itching can be defined as the unpleasant cutaneous sensation which provokes desire to scratch, that is itching sensation. And, it is related with the peripheral nerve system. And, the sensors, the receptors, it is found only in the top 2 layers of the epidermis, epidermis and epidermal dermal transition layer. So, in this layer the itching sensation that sensor for itching sensation that is free nervous are present.

And, the itching sensation originates by different types of stimuli. This stimuli are mechanical stimuli. So, we can have like prickling sensation and we get start itching sensation, it is it may be due to the chemical stimuli, thermal stimuli and electrical stimuli. So, all these things gives the itching sensation, suppose a fabric is not giving prickle sensation, it is with cotton we have as we have seen earlier. So, for cotton fabric, but if we treat the cotton fabric with some chemical, which actually send signal to the chemical receptors or this type of nerve endings, that will start feeling itching sensation. It is not the direct related to mechanical receptors are related with the prickle sensation.

But, chemical sensation, some chemical receptors with stimuli gives also itching sensation due to the chemical receptors they received this sensation. Like thermal receptor at hot, very hot temperature, we can get the itching sensation even with a electrical stimulus, we can get itching sensation.

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So, normally itch sensation as we have discussed that it is a superficial pain fibres. And the pain receptors respond for itching may be of different type than those prickle sensation.

Sometime these pain receptors, they give they start immediately scratching sensation. So, this and the sensors of itch and pain are generally considered to be dependent on each other.

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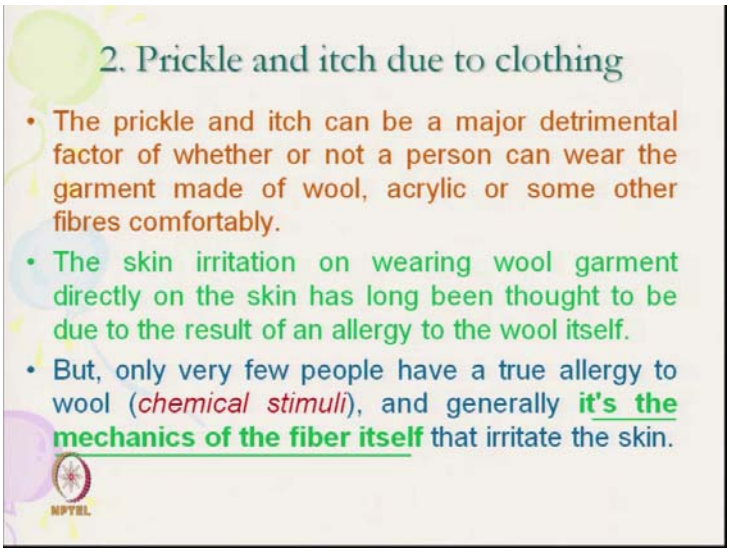

So, the prickle and itch can be a major detrimental factor for a person that is why they do not use the wool or acrylic fibre ok. And some other fibres they cannot use this fibre comfortably. So, if my skin is very sensitive, I cannot wear wool, I can I cannot use wool directly on my skin. So, the skin irritation on wearing wool garment directly on the skin has long been actually assumed that it is an allergy, but it is not allergy it is provoked by the prickle sensation, because very few people have truly allergy to the wool. So, it is generally mechanical receptors, mechanics of the fibre, which gives, which irritates the skin.

What are the mechanics of fibre? It is actually the bending rigidity of the fibre or it is a projected end this gives the irritation.

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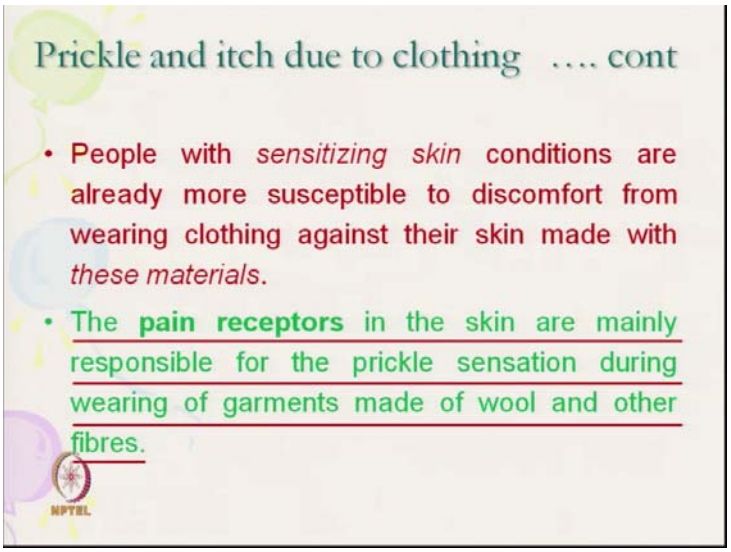

So, people with sensitizing skin conditions are already more susceptible to discomfort from wearing clothing against their skin made up of this materials, wool very sensitive skin they cannot they will start immediately, it will start prickle then will start itching. So, the pain receptors in the skin are mainly responsible for prickle sensation during wearing of garment made of wool and other fibres.

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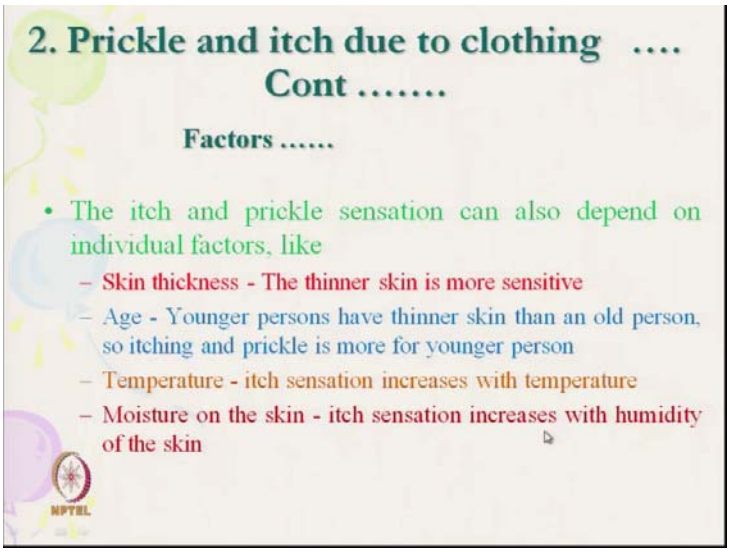

And the itch and prickle sensation can also be dependent on the skin thickness. So, the thinner skin will give more actually since it is a more sensitive towards the itching

sensation or even prickle sensation. So age, young person have thinner skin. So, they may sometime feel more itching sensation or prickle sensation. Temperature; so, itching sensation increases with the temperature as we have discussed we have seen the prickle sensation. So, moisture content in the itching sensation is more in moist and humid condition, moist skin as far as the mechanical receptors are concerned, but chemical receptors it may not have, may not need the humid humidity in the skin.

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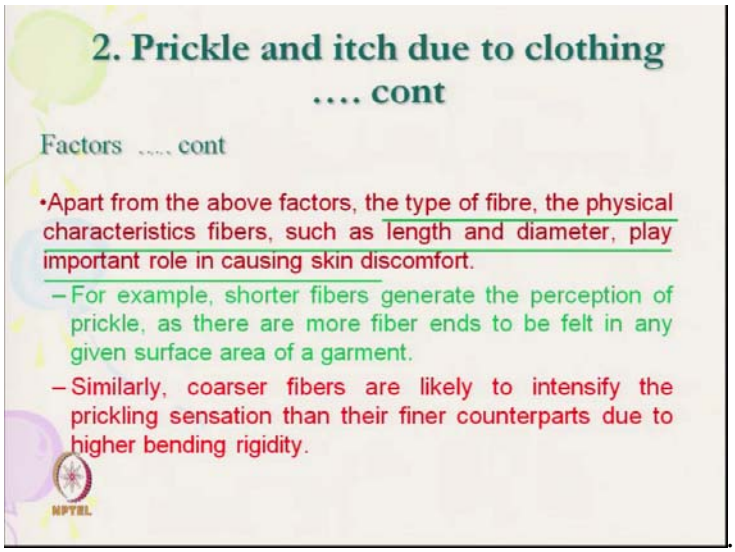

So, apart from this factors the type of factor, which is very important. Physical characteristics of fibre, like fibre length. So, a particular fibre may give itching or prickle sensation, but if we increase the length of the fibre, then itching sensation or prickle sensation will drop. One simple example, if we take the example of wool. If, we take wool fibre normal directly, if we produce yarn the it will it may give the prickle sensation and itching sensation, but if we remove the short fibres from the wool by a combing only keeping the longer fibres, that will not give the prickle sensation. Best example is the woolen spinning and worsted spinning.

In woolen spinning we directly use the short fibres and coarse yarns are produced and that gives a prickle sensation itching sensation like coarse wool. Similarly for worsted fabric worsted garment it takes care about longer fibre, gives the relatively softer feeling. We do not feel itching or prickle sensation. Similarly diameter of wool fibre so, diameter means fine wool fibre means, it gives the flexibility, it is a bending rigidity of fine wool

fibre is much less than the coarse wool fibre. So, coarse wool fibre it is if we use, it actually it is due to it is higher bending rigidity, it penetrates inside the skin and gives prickle sensation.

So, to avoid, to develop a fabric comfortable fabric as far as prickle or itchiness is concerned, we have to take care of the fibre physical characteristics. So, this is the physical characteristics, it is very important. Then say for example, shorter fibres generates the perception of prickle, as there are more fibre ends in the fabric, if there are shorter fibres, the more number of fibre ends will also be there, So, it will give the prickle sensation. Similarly, coarser fibre will give prickle sensation due to higher bending rigidity.

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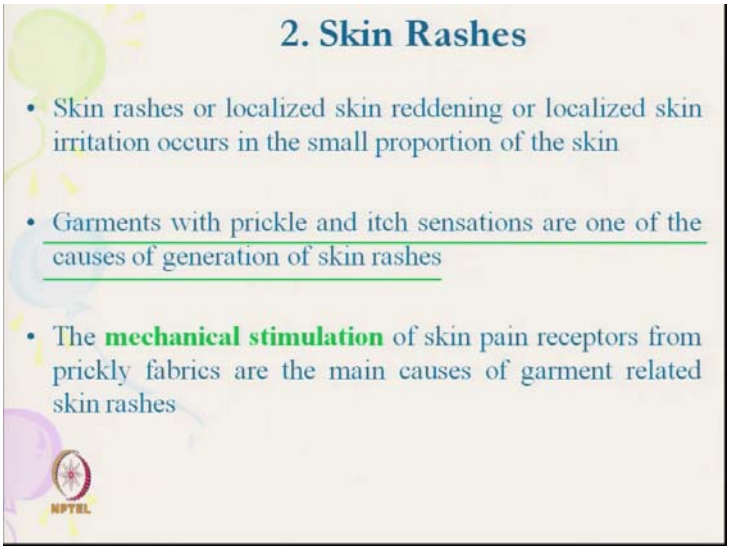

So, next comes the skin rashes, skin rashes are actually related with itching sensation. So, it is a localized skin redness, localized skin irritation, it occurs in the small portion of the skin. Garments with prickle and itch sensation are one of the most important causes of skin rashes. So, to avoid skin rashes we have to first take care of the fabric should not prickle or it should not give the itching sensation. So, this the mechanical simulation of skin receptors from the prickly fibre are the main causes of the garment related skin rashes. So, these are interrelated.

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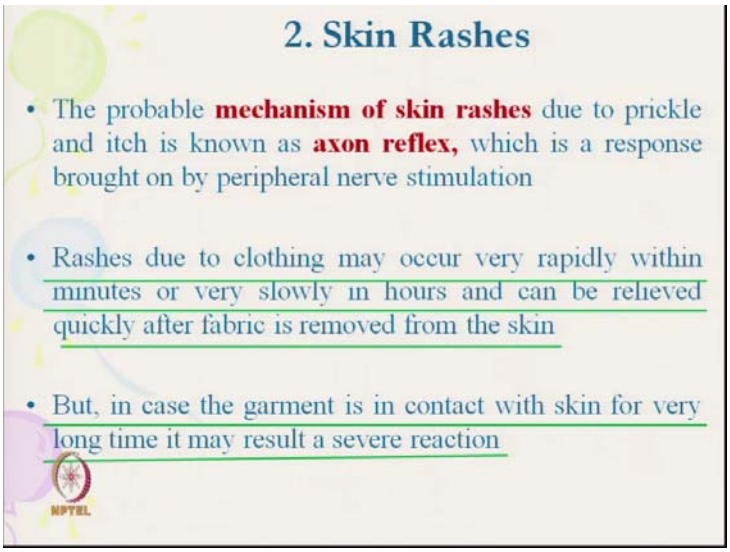

The problem with the mechanical mechanism of skin rashes due to the prickle and itch are known as axon reflex. So, this is normally which is a response brought on by peripheral nerve stimulation. So, peripheral nerves again comes into picture. The rashes due to clothing may occur very rapidly within a minute, it may occur depending on the type of fibre used, it may occur immediately or it may take some time, it may after hours it generates depending on the type of fibre.

And can be relieved quickly when the fibre; the fabric cloth is actually taken out. So, that so, it directly related with the type of fabric. And, but in case of garment, the garment is in contact with a skin for very long time, it may result severe reaction. So, as soon as our fabrics start giving skin rashes, we should remove the fabric. So, that otherwise it will damage the skin. For, we should avoid wearing that type of cloth for long time.

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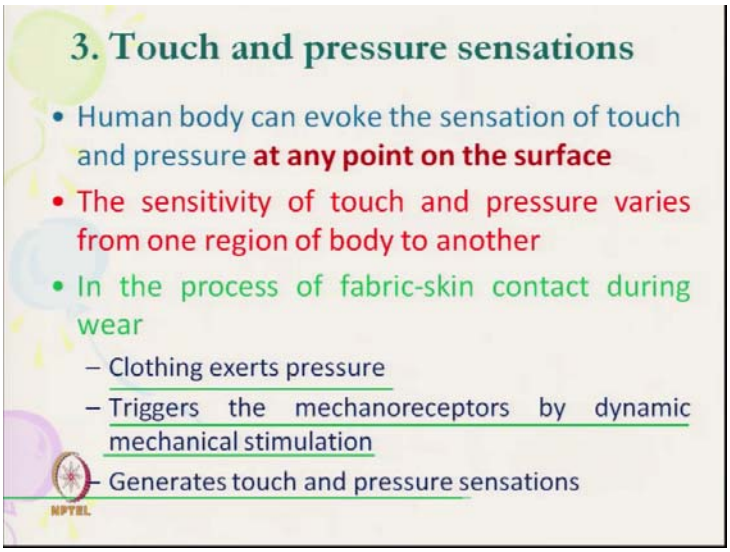

Then comes another garment related sensation, which is important touch and pressure related sensation. So, what we have initially discussed where wear related sensation, then prickle rash related sensation, itching related sensation and then comes the touch and pressure related sensation. So, human body can evoke the sensation of touch and pressure at any point of the surface. After wearing cloth, because fabric is in contact; so, touch means the receptors which actually sense the light touch.

So, when we wear cloth in touch with the body, we get sensation. So, one as we have discussed it varies from one zone one region to another region, depending on the type of sensors available in that zone. The process fabric and skin contact is actually is that the clothing exerts pressure on the body, on the skin and triggers mechanoreceptors by dynamic mechanical stimuli.

So, when we move that it is triggers the mechanical receptors. So, of touch and pressure and generates touch and pressure sensation. So, clothing in the body, it actually sends signal through the mechanical receptors, it exerts pressure that triggers mechanoreceptors by dynamic mechanical stimuli, when we move and then generates touch and pressure sensation. So, these sensations are different at different zone depending on the level of touch level of contact point.

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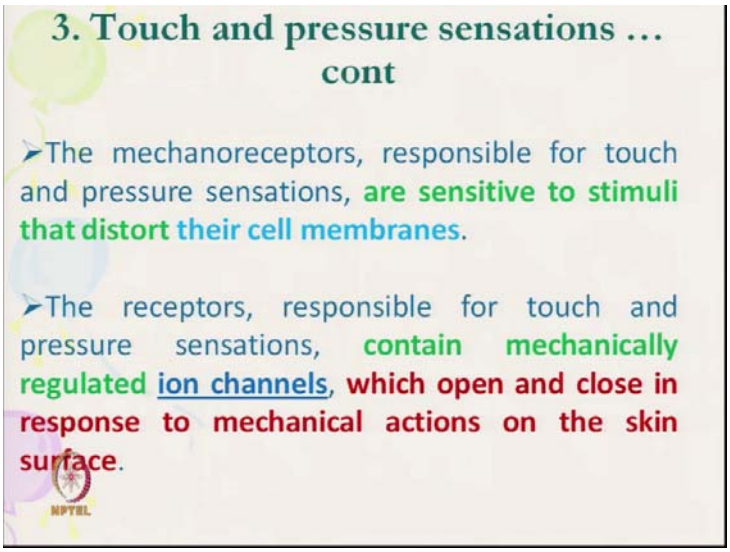

And, this mechanoreceptors are responsible for touch and pressures are sensitive to stimuli that distort their cell membrane. So, this we have discussed and these receptors after distortion they sends some chemical sensation. Certain mechanically regulated ion channels, which opens and close in the response of mechanical actions in the skin. So, that gives signal.

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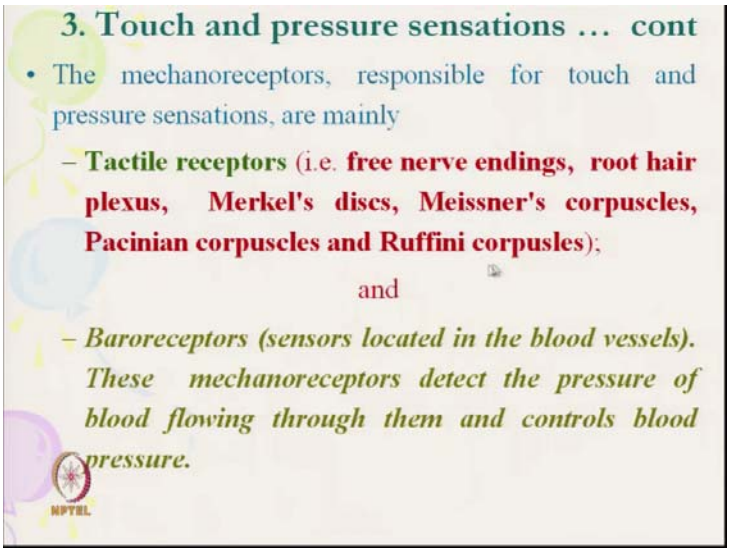

So, the mechanoreceptors, which are responsible for touch and pressure that we have discussed tactile responses receptors free nerve ending, hair follicle nerve endings are

there Merkel's discs, see all this tactile responses tactile receptors are responsible for this sensations. And, another sensors, which we have not discussed yet it is a baroreceptors, these are actually present in the blood vessel with the flow of blood due to the pressure blood pressure, it also gets signal. So, depending on the different pressure level so, flowing when this mechanoreceptors detects the pressure of flowing blood through them, and controls the blood pressure.

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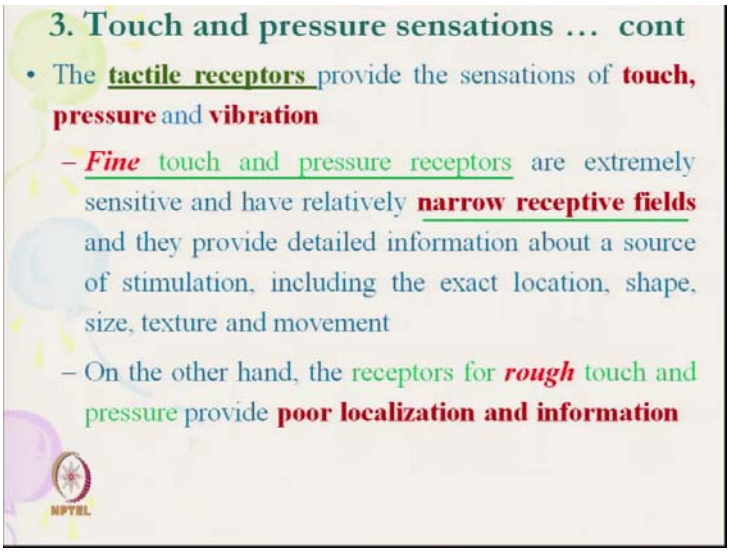

These baroreceptors are also responsible for this touch sensation and these tactile receptors provide the sensation of touch, pressure and vibration we have discussed. And it actually it gives the fine touch and coarse touch, there are 2 types of touches are there; One is the fine touch is that which is basically these are the receptors, which are extremely sensitive receptors. And, they can actually work in relatively narrow field of sensitivity, what does it mean? Even a small change in pressure this fine touch that sensors will act and gives information.

And another is that a rough touch which actually these receptors provide poor localized information. Local poor localized information means it cannot differentiate the sensation 2 types of sensors are there.

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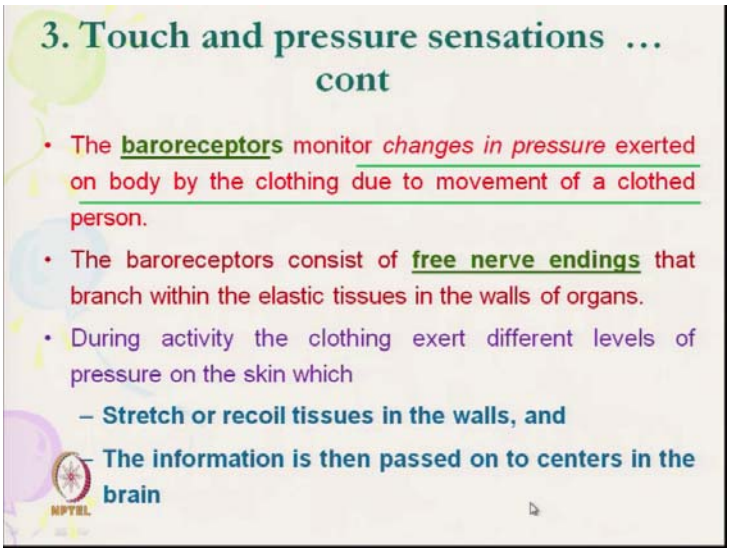

And the baroreceptors, I have discussed, it changes with the pressure applied. It monitors the pressure change in pressure applied when body movement. So, one is pressure sensor, another is change in pressure.

So, when our body moves. So, that is the clothing gave gives the different types of sensor suppose it when it I am moving. So, the pressure here exerted by my cloth is gradually increasing and decreasing. This change in pressure sensation is provided by baroreceptors. And, these are free nerve ends during activity. So, it gives signal only during activity of clothing and it stretches recoils the tissue wall.

So, when activity or pressure clothing imparts different types of pressure, keeps on changing and it gives signal. So, touch and pressure sensor the information is then transmitted to the brain.

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So, these are all about the touch and pressure sensor and roughness and scratchiness that these are related with the different types of sensors, the way fabric moves over the body. So, if the fabric is rough enough and if it moves through the body then it will give the roughness sensor or scratchiness sensor, it gets body gets some redness will take place, but same fabric if it does not move, will not give our scratchiness. So, for scratchiness or roughness characteristics the important part is that the fabric has to move, then only we will get scratchiness and the fabric surface has to be rough.

So, if a fabric is a smooth enough. Even, if it is during activity, it moves throughout the body it will not give us the roughness or scratchiness sensation.

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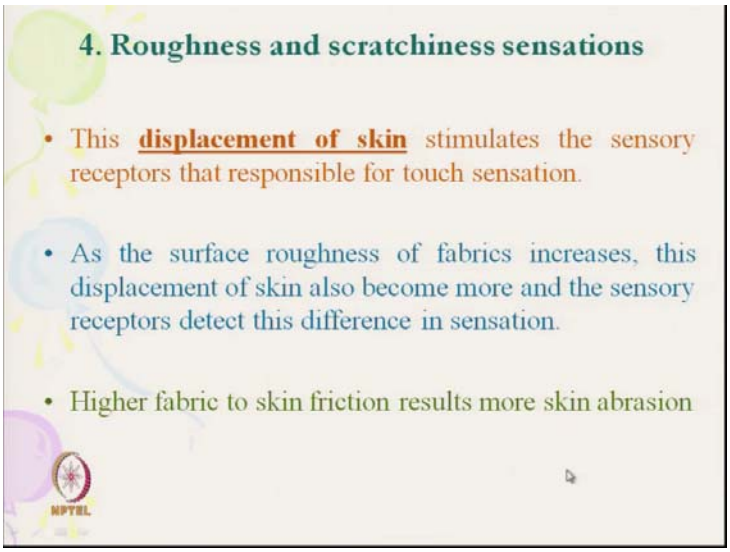

So, and it is actually displace to the skin. So, if it is rough, the friction between the skin and the fabric is high, then it will start displacing the skin and we will get the roughness or scratchiness sensation.

The higher fabric to skin friction will give more abrasion. So, this is all about the thermal mechanical receptor and we have discussed different types of mechanical stimulation during clothing. Now, we will start the thermal receptors, which is related to the cold and hot type of receptors and we will do it in next class.

Thank you.