Textile Product Design and Development
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Lecture – 26
Sports Textile: Design Guideline

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This section covers design guidelines for sports textiles. Given the wide range of sports, each requiring specific functional features, the design process must account for these variations. Many types of sports have been shown in this slide to illustrate this diversity.

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Adventure sports, for example, include activities such as rowing, sky jumping, bungee jumping, mountaineering, scuba diving, and racing, among others.

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With every sport comes the potential for injuries, including muscle sprains, bruises, falls, fractures, tendon and ligament tears, and ankle sprains. These injuries are especially common in high-activity sports.

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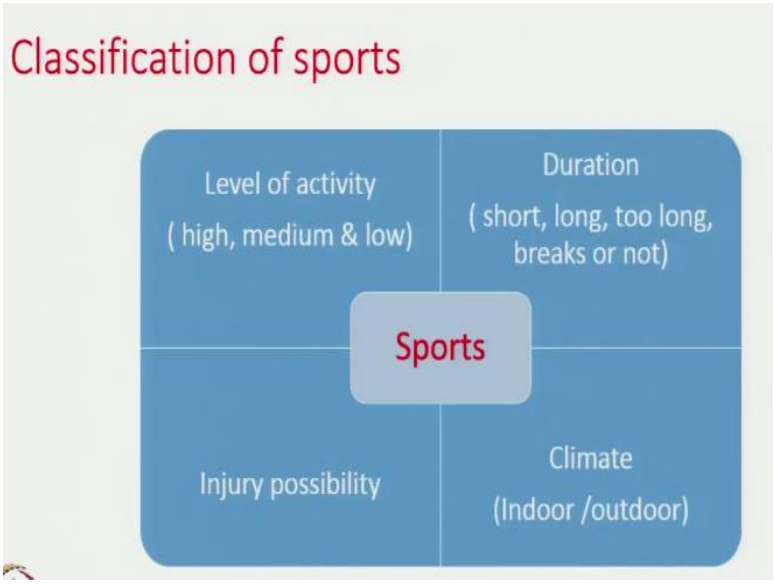

There are so many types of sports available, and they can be classified based on the level of activity (high, medium and low). Next, it could be based on the duration of play (short duration, long duration, too long duration). There could be breaks in between, or there may

not be breaks like a football game. There is a break in the tennis game; there could be breaks after every match. Whereas in the case of marathon running, it is a very long duration of run. Too short duration sports could be swimming. So therefore, the duration of the sports can be divided into short, long, and too long, whether breaks could be there, or breaks may not be there. Then, we can also classify according to the injury possibility.

Some sports are highly injurious, and sometimes they could be fatal. We can also classify sports according to climate, such as indoor or outdoor sports. An example of an indoor sport is badminton, and examples of outdoor sports are football, hockey, etc.; so, the classification of the sports is very important when someone thinks of designing sports gear for the players.

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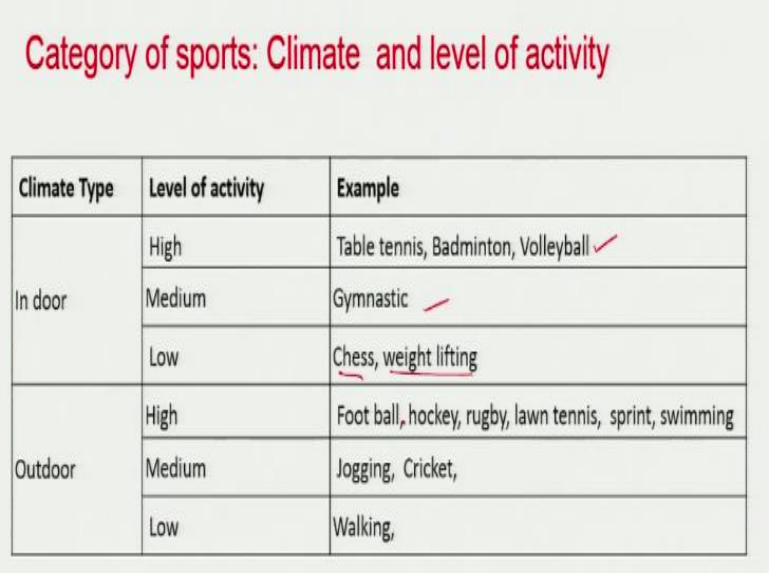

Category of sports: Climate and level of activity. An example of indoor sports with a high level of activity are table tennis, badminton, and volleyball; we can add some other examples as well. Indoor sports with medium levels of activity could be gymnastics, and very low levels of activity could be chess or weightlifting.

There are outdoor sports where a high level of activity is football, hockey, rugby, lawn tennis, sprint, and swimming. In these sports, the activity levels are very high. Examples of medium level activity could be jogging or cricket. A very low level of activity could be just walking or jogging.

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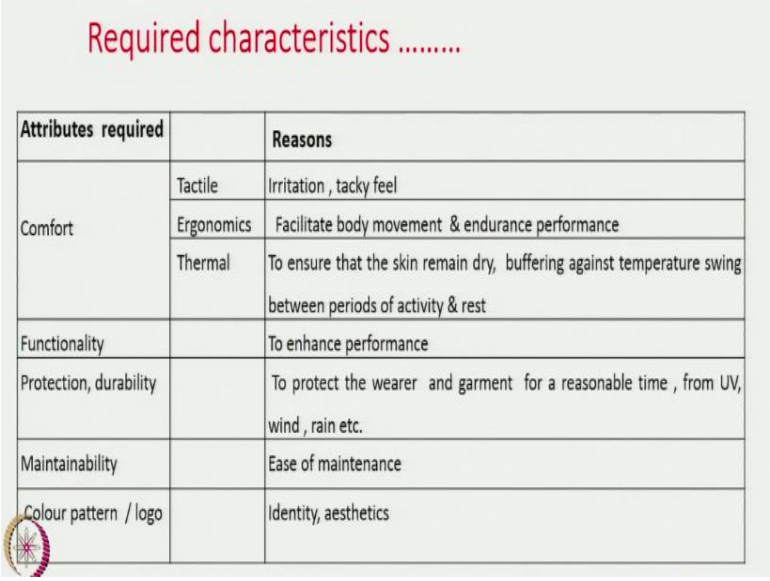

The required characteristics of sportswear are listed in the table. The activity levels are different, indicating that the body perspiration very fast, and sweating starts very soon. If the activity is low, sweating may not be there sometimes. With a high level of activity, the body itself will generate a lot of heat as well. So, indoor and outdoor conditions are also very important. In outdoor, the climate could be different.

In the indoor, there is a possibility of climate control in terms of temperature or humidity, but if it is outdoor sports, we may not be able to control that. Sometimes the wind will be blowing at a high speed also. So, these are the different aspects that one must keep in mind while thinking of designing sportswear. obviously, there cannot be one unique design that can suit all types of sports. So, what is generally required in sportswear?

The first thing is comfort. The person's performance in a sport depends on whether the garment that he or she wearing is comfortable or not. So, what matters is tactile sensations, i.e., whether there could be irritations or tacky feelings or dampness. The other thing is the ergonomics of the design. The ergonomics is important because it must facilitate the body movement and endurance performance. The third thing is the thermal aspect, i.e., the skin remains dry.

Buffering against temperature swings between periods of activity and rest is also we must be kept in mind while designing the sportswear for a specific sport. Functionality is another aspect that focuses on how to enhance the performance of the player. Therefore, performance

enhancement sportswear is also available and can be used by swimmers, football or hockey players, and many other sports. This kind of functionality is important to enhance the performance of the player.

The next aspect is protection and durability, to protect the wearer and the garment for a reasonable time; that is, the sportswear should be able to protect the person because there is the possibility of injury. While playing high-activity sports, the person can fall on the ground, and there could be bruises on the skin. So, if we have a proper fabric which can protect the person from abrasion, probably bruises may not be there. This is one example, there could be many more examples.

Also, the same time we have to protect the garment as well especially from UV, wind, rain. Whoever buys sportswear, the expectation is that in a certain life; the sportswear or the sports uniform suit lasts for a certain period of time. The next one is maintainability. It should be easy to maintain. Another is washing, whether you need a washing machine to wash it or whether you need to go for dry cleaning or not.

The other required characteristics are a colour pattern and the logo. The logo gives the identity that he belongs to a particular club, or the person belongs to this country. So, their logo and a specific colour pattern both become important, and they must give a very aesthetically pleasant look as well. So, we need to keep all these aspects or attributes in mind when we are trying to design sportswear.

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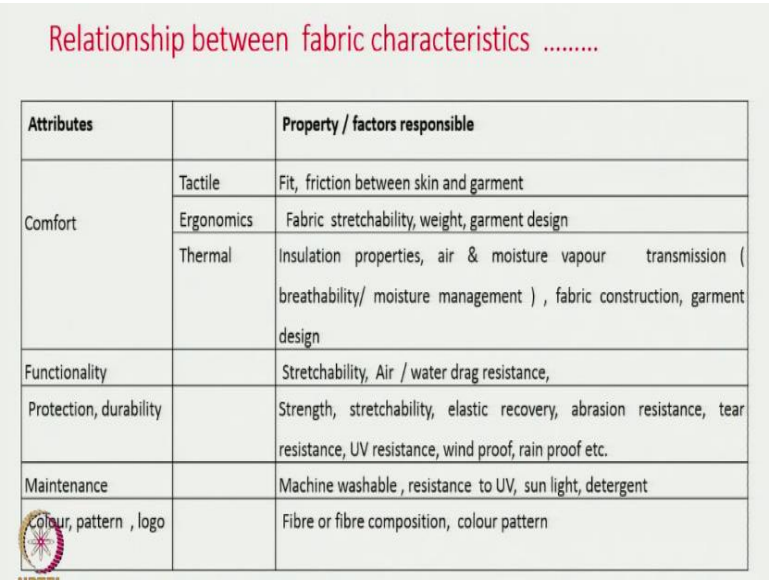

Comfort related to three aspects: tactile comfort, ergonomics comfort and thermal comfort. Comfort is very general term. Comfort is a function of tactile i.e., sensations; the feel the person gets when he or she wears a garment; the ergonomics where the mobility of the person becomes most important and the thermal insulation.

The relationship between fabric characteristics and the properties or fabric attributes and the relevant properties are discussed in the following section. As discussed, comfort attribute has three different aspects: tactile, ergonomics and thermal. Tactile is affected by the fit of the garment, friction between skin and garment.

Ergonomics is related to stretchability of the fabric, the weight and the designing aspect of the garment because it must give mobility and hence fabric stretchability. The fabric should not be neither too heavy nor too bulky. Therefore, weight and garment design also matter so that the mobility could be there.

Thermal comfort: insulation properties, air & moisture vapour transmission, breathability of the fabric, fabric constructions, the garment design contributes to the comfort. From the perspective of functionality, the stretchability of the garment is very important. The drag resistance against air or wind must be minimized, especially for a swimmer so that he or she can swim fast.

In some cases, the air drag may also negatively affect the performance of a player and that has to be minimized. Protection and durability: the important considerations are the strength, stretchability, elastic recovery, abrasion resistance, tear resistance, UV resistance, wind proofness, rain proof, etc. Maintenance indicates that it should be machine washable, and the colour should not fade. Therefore, it should be resistance to UV or sunlight. The colour should not fade because of the use of detergent. So, these are the aspects from the maintenance point of view.

Colour, pattern and logo depend on the fibre or fibre compositions. The type of dye that we choose and the way we dye it; whether we go for dyeing the fabric or we go for printing or use of colour thread to produce different designs, these things are related to the colour, pattern and logo.

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Stretch is one of the important aspects for many sports. The stretch in garments optimizes athlete's performance by providing freedom of movement. It can also give maximum comfort, and it can minimize the risk from injury or muscle fatigue. It reduces the friction and drag. There are many ways to introduce stretch into sports garment.

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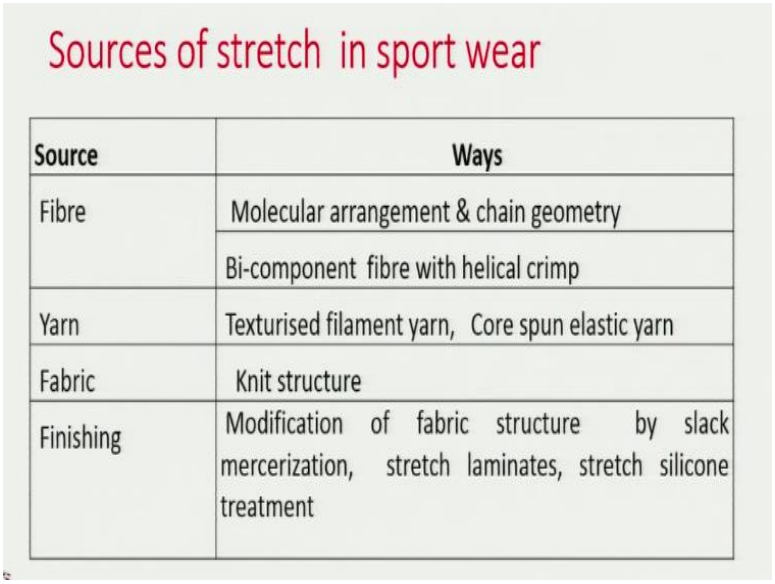

The first approach is through the fibre, i.e., at the fibre level, choosing fibres which are more stretchable. Fibre stretchability depends upon the molecule arrangement within the fibre and the geometry of the molecule chains. Bicomponent fibre with helical crimp can be chosen to introduce fibre stretchability.

The next approach is to introduce stretchability through yarn. When it comes to yarn, it could be texturized filament yarn or core spun elastic yarn. It can affect the yarn stretch and the fabric as well. The other approach is through choosing the fabric construction as it also affects stretch. Generally, knitted structures are much more stretchable than woven structures.

The finishing treatment at the fabric stage modifies the fabric structure, i.e., by slack mercerization or by stretch laminates or stretch silicone treatment. These treatments can also help in introducing stretch.

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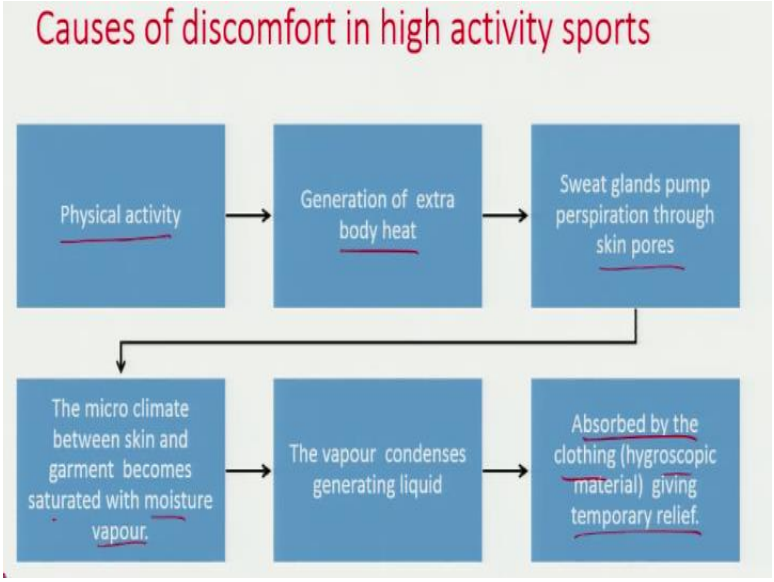

Why does discomfort occur while playing? If we observe a chain of events or any physical activity or most sports, it can generate extra body heat and therefore, sweat glands pump perspiration through the skin pores. In the medium to high activity sports, there is always a possibility of generation of sweat, i.e., liquid sweat. As a result, the microclimate between skin and garment becomes saturated with moisture vapour. At the initial stage, it is the vapour which will be generated from the skin and vapour accumulates between the fabric layer and the skin. The microclimate gets saturated after a certain time because the vapour may not be able to pass through the garment very fast if the moisture vapour resistance is higher through the garment.

Therefore, what happens when the vapour accumulates? The vapour gets condensed, and it generates liquid. The transformed liquid sweat will be absorbed by the clothing. If the fibres present in the garment are hygroscopic in nature, they absorb too much liquid sweat, and it

can give temporary relief as well. But as it proceeds, it tries to hold the liquid within it. If the garment is made of synthetic fibres, it will not be able to absorb liquid sweat. So, no temporary relief one can find, but it tries to transmit the liquid from the inner layer to the outer layer. The other possibility is that the liquid will get spread over a larger surface area because most of the synthetic fibres are hydrophobic in nature and it does not absorb liquid.

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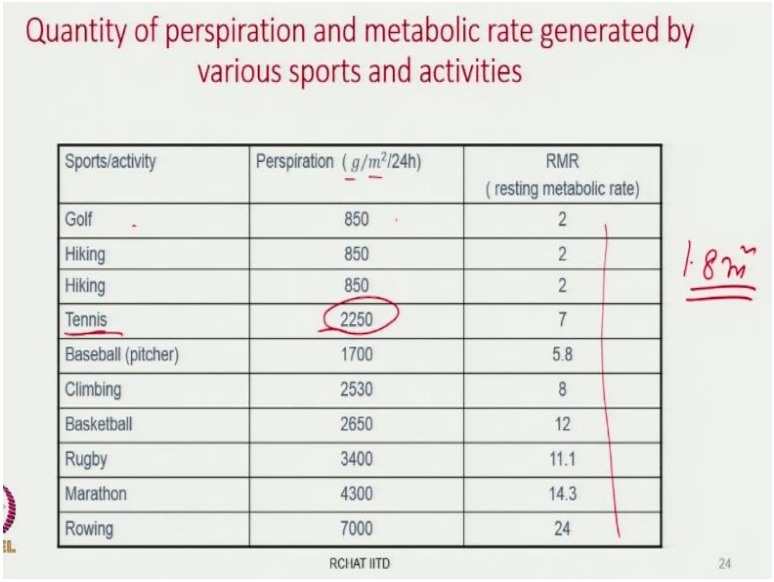

Sports/activity	Perspiration (g/m^2/24h)	RMR (resting metabolic rate)
Golf	850	2
Hiking	850	2
Hiking	850	2
Tennis	2250	7
Baseball (pitcher)	1700	5.8
Climbing	2530	8
Basketball	2650	12
Rugby	3400	11.1
Marathon	4300	14.3
Rowing	7000	24

Various sports/activities are listed along with the perspiration rate in g/m/24h, and resting metabolic rates are also stated in the table. It gives an idea about the amount of expected perspiration for various activities. Generally, the human body can be approximated as 1.8 m^2 of surface area. So, perspiration per metre square can be estimated, and roughly, we can understand how much perspiration could be there for a given sport.

The data available in the literature are quoted in the table. Tennis is a high-activity sport, and 2250 grams of perspiration could be generated in 24 hours. From this, we can say per 5 minutes, 10 minutes or whatever the required time. How do you tackle that extra perspiration? How do you take care of liquid sweat?

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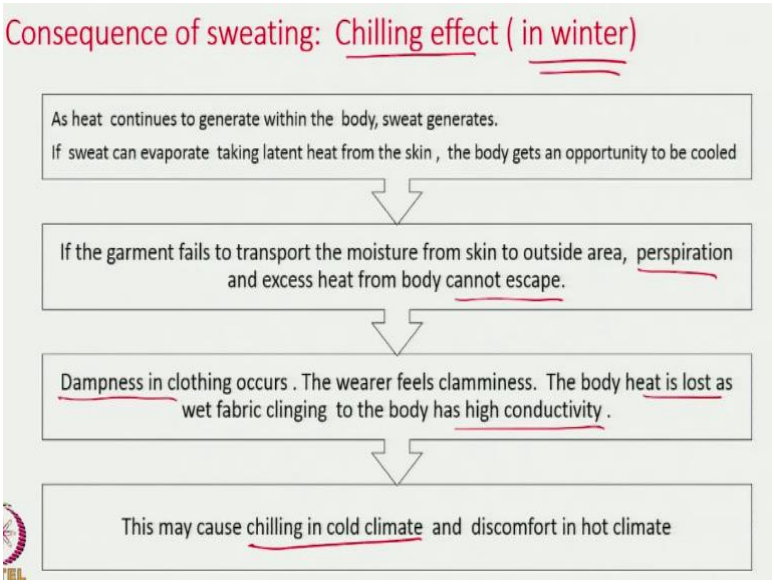

The consequence of sweating may sometimes lead to a chilling effect, especially in the winter season. Why? As heat continues to be generated within the body, sweat is generated, as discussed already. During sweat evaporation, it takes latent heat from the skin, and the body gets an opportunity to be cooled. If the possibility of evaporating the sweat is there, and if the wind is blowing or if the relative humidity is low, sweat evaporation is probably faster. It creates a possibility of a cooling effect. Otherwise, it may not be there.

The garment fails to transport the moisture from the skin to the outside area because of these reasons: it is not windy, or the humidity is not very low. So, in that case, the garment may not be able to transport the moisture from the skin. Therefore, the perspiration and excess heat from the body do not escape and are trapped within the structure of the fabric. As a result, what will happen? Dampness in the clothing occurs. The wearer feels clamminess. The body heat will be lost as wet fabric clinging to the body has high conductivity because the thermal conductivity of water is much higher than that of the fibre.

So, when the fibres are saturated with sweat, the conductivity is very high, and the heat loss is very fast from the body. Because of this, the chilling effect happens, and the person feels shivering. This would happen especially in the winter climate; there is a possibility that a chilling effect could be there because of the generation of sweat and sweat accumulation within the garment. We need to always avoid this situation.

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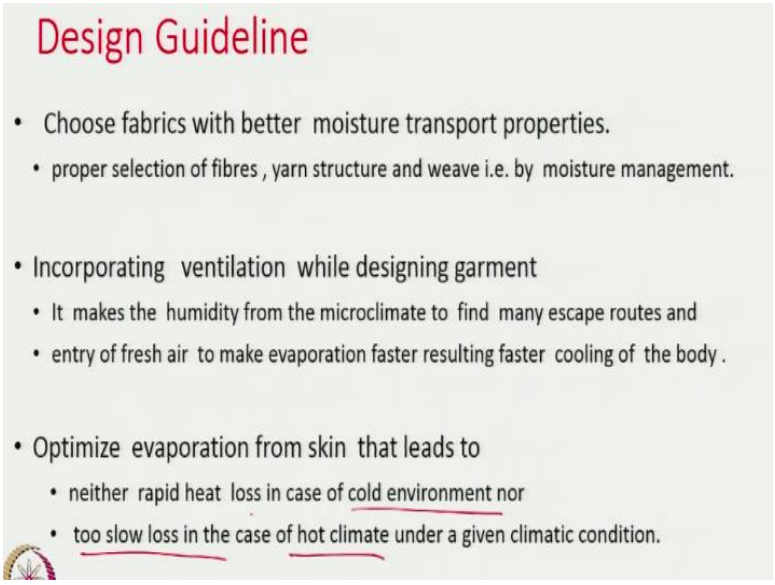

Design guideline: we have to choose fabrics with better moisture transport properties for sports that are high activity sports or medium activity sports and long duration sports. Proper selection of fibres, the structure of the yarn, and the weave of the fabric become important for ensuring that the moisture transport is good. Incorporating ventilation while designing the garment is another aspect so that moist air can move out of the body from the microclimatic region.

So, we should have openings for fresh air entry in some places so the moist air can escape. Optimize evaporation from the skin that leads to neither rapid heat loss in the case of a cold environment nor too slow loss in the case of a hot climate under given climatic conditions. So, this is a very important exercise that neither rapid heat loss must be avoided, especially in cold climates, nor should it be too slow in the case of hot climates, where sweating starts very fast. Therefore, optimization is very important for these two important aspects.

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Three important criteria for the selection of sports fabric are listed in this slide. The first one is the level of activity; the other one is climatic conditions during use, and the third is the duration of engagement in the sports or what duration the person is engaged, how long, is it a short duration sport or is it a long duration sport? All the three things we must keep in mind.

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Sport fabric architecture: Generally, a two-layer or three-layer architecture. Three layers, especially when it is to be worn in the case of winter environments, should provide warmth to the person. First is the base layer or inner layer, and the purpose is to control the microclimate for temperature control, humidity, perspirations, and wicking. These parts will be very important for the base or inner layers.

The middle layer is designed for the purpose of warmth. The outer protection shell is the third layer, which gives waterproofness, wind proofness, or breathability also should be there.

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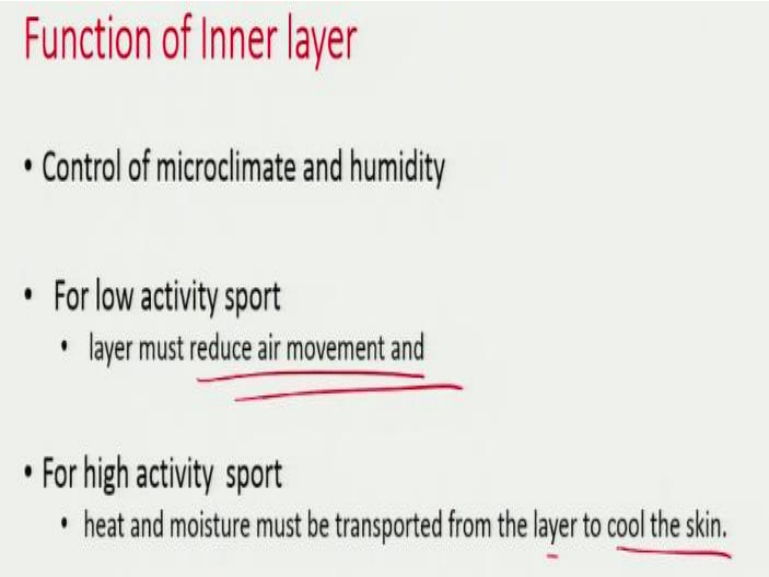

The important function of inner layer is to control the microclimate, i.e., control of humidity and the temperature of the skin. Skin temperature should not be allowed to rise. For low activity sports, the inner layer must reduce air movement so that the body heat is not lost very fast. For high activity sports, heat and moisture must be transported from the layer to cool the skin; they should not be allowed to accumulate there. So, the function of the inner layer depends upon the level of activity.

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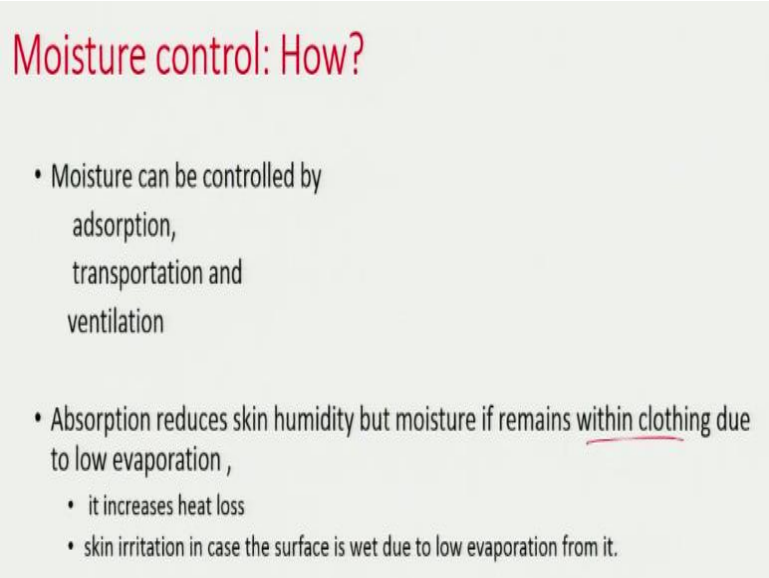

Moisture control: how? Moisture can be controlled by mechanisms like adsorptions, transportation and ventilation. With the help of these mechanisms, the moisture accumulations can be controlled. Absorption reduces skin humidity. So, if there are some fibres which can absorb moisture, it initially helps to reduce the skin humidity, but the moisture remains within the clothing due to low evaporation, which increases heat loss.

Skin irritation occurs when the surface is wet due to low evaporation from it. The absorption may be beneficial initially when the moisture accumulates between the first layer and the skin. If the fibres in the garment are hygroscopic in nature, they can absorb moisture and the relative humidity of the microclimate increases.

Therefore, the hygroscopic fibres act as a buffer. So, in that way, it may help at the initial stage. However, once they absorb the moisture, they get saturated by the absorption of moisture. Still, the moisture is generated, and as the fibres are saturated, they cannot absorb any more moisture.

The moisture that is generated after the saturation of fibres in the garment is not able to escape from the skin; they are transformed into liquid sweat. Liquid sweat increases heat loss because the conductivity of sweat is very high, and there could be skin irritation as well.

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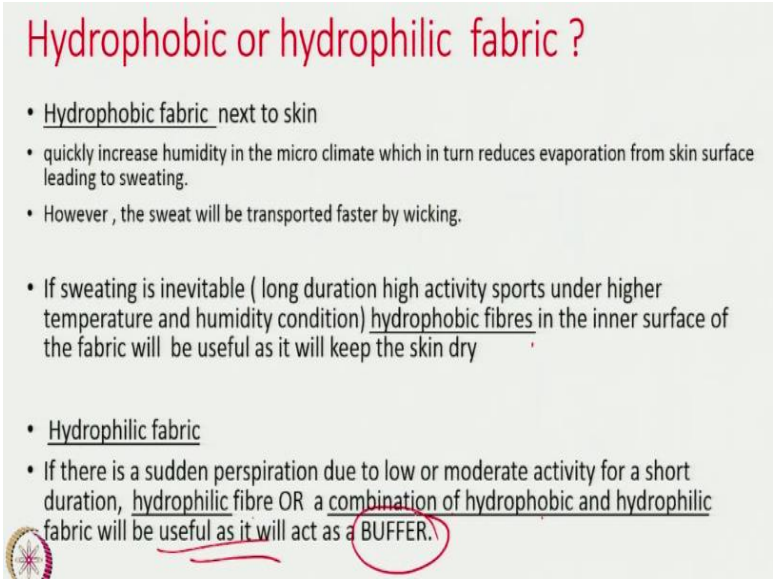

Hydrophobic vs hydrophilic fabric: as stated earlier, the hydrophilic fabric or fabric containing a lot of hydrophilic fibres can help initially for sweat absorption and evaporation,

but it can act as a buffer after saturation. However, sweat development is inevitable in high activity sports and in long duration sports. In such cases, the hydrophilic fibres or hydrophilic fabric may not be helpful. So, hydrophobic fibre fabrics are helpful to tackle those situations because they can wick away the liquid from the inner layer of the fabric to the outer layer and expose it to the outside environment, and then it can probably evaporate.

So, it all depends on the type of activity during the sports and duration. We should decide whether we go for 100% hydrophobic fibres in the inner layer or a mixture of hydrophilic hydrophobic fibre as we expect that moisture generation cannot be so high. In that case, a mixture of hydrophilic fibre may be helpful as it reduces the humidity in the microclimate.

The fabric behaves like a buffer layer, which can delay the process of accumulation of sweat. So, in the hydrophilic fabric, if there is sudden perspiration due to low or moderate activity for a short duration, hydrophilic fibre or a combination of hydrophobic-hydrophilic fibre could be useful, as stated earlier. So, it all depends on the level of activity and duration of sports.

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Next is the selection of fabric structure. What type of fabric should we choose, woven or knitted? Woven fabrics are always much more durable than knitted fabrics. So, in some sports, it is preferred to woven fabrics and the most suitable construction or the weave type is either plain or twill. Examples of such sportswear are football shorts or hockey shorts. So, in these sports, woven fabric is very useful, and it has better strength also.

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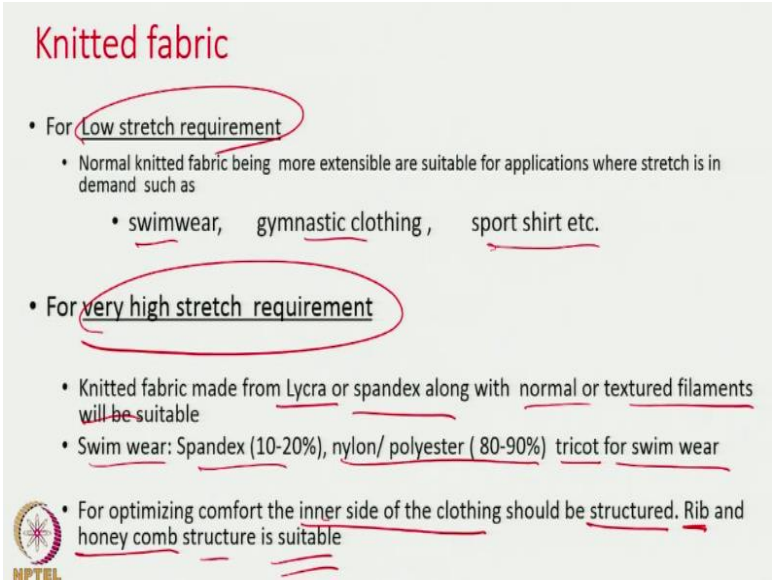

Knitted fabric is required wherever stretch is very important. We may also have a low stretch requirement in some cases or high stretch requirements in some other cases. Knitted fabrics, being more extensible are suitable for application whereas stretch is in the demand such as swimwear, gymnastic clothing or sports shirt, etc. In these applications, we do not need low stretch fabrics. But there are certain games or sports where very high stretch is required; in those cases, preference is for knitted fabrics made from lycra or spandex fibres along with normal or texturized filaments.

Swimwear also could be made from spandex along with nylon, polyester fibres and tricot weave for swimwear. So, it depends on the requirements of specific applications. To optimize comfort, the inner side of the fabric or the clothing should be structured, i.e., rib and honeycomb type structures are suitable because they will reduce the contact area between the skin and the fabric. So, in some cases, this is very helpful. The fabric is not going to really get stuck to the skin. Sometimes, the fabric on the skin gets moisture. If the fabric is too smooth, it may get stuck to the skin, and that gives a different kind of sensation, which is not very pleasurable.

Comfort can affect the performance of the player as well. So, a rib structure or a honeycomb structure means the contact area between the skin and the fabric is less. Therefore, the air present in the fabric structure also helps in breaking the contact between the fabric and skin

during any physical activity. Additionally, there will be some exchange of air between the inner and outer portions of the garment.

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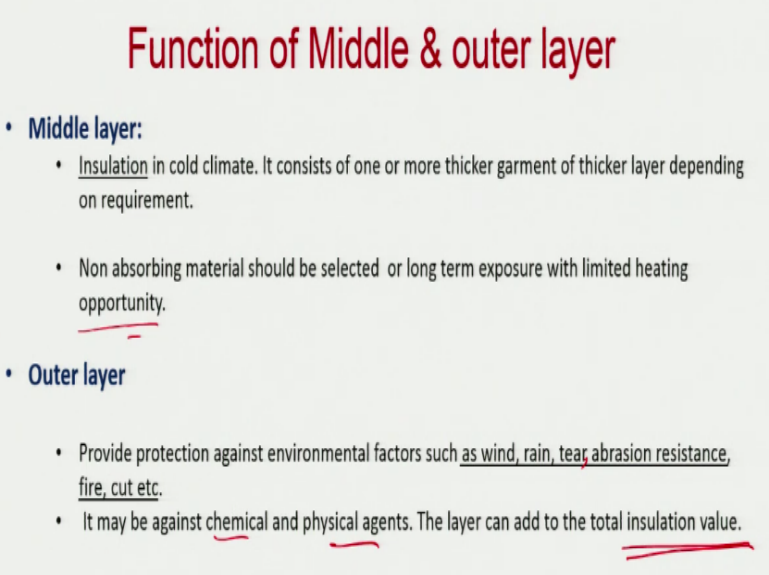

Next is the function of the middle layer, which is also known as insulations. So, wherever we are playing games which is specific to winter, like ice hockey or skiing, then we need a garment where there must be thick insulation, and the middle layer is going to be an insulating layer. So, non-absorbing materials are to be selected for long-term exposure with limited heating so that the moisture is not held in the spaces between the fibres or within the fibres, which becomes very important.

The other thing is the purpose of the outer layer is to protect the wearer from the external wind and rain. So, it must give tear resistance and abrasion resistance and protect from fire or cut. Accordingly, the outer layer must be chosen. It may be protection against chemical or physical agents. The outer layer can add to the total insulation value. However, the main part of the outer layer is to protect, not to allow the wind or rain to penetrate, and it should have adequate tear resistance and abrasion resistance. So, in case of an accidental fall, the injury that can occur can be minimized.

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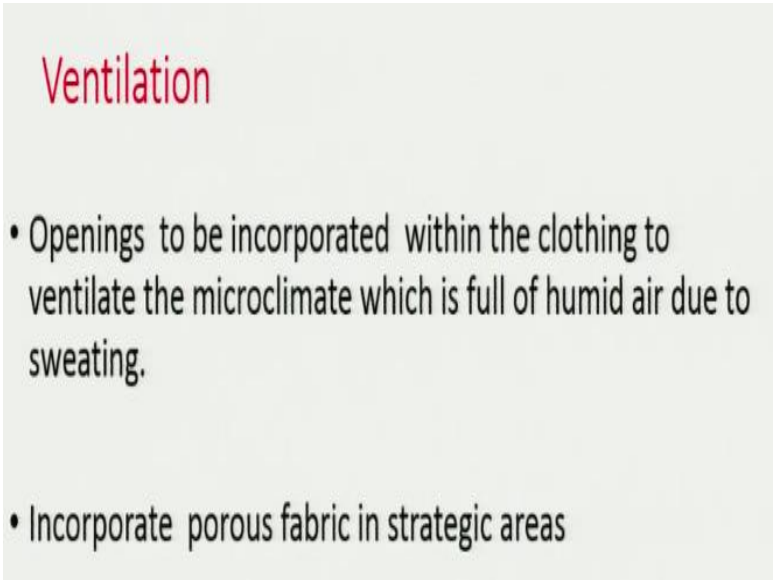

Ventilation is another important aspect. Opening to be incorporated within the clothing design so that if the person feels suffocated due to accumulation of moisture in between the skin and the garment, it helps the wearer for relief. That means if there are openings in the garment, it can be easily opened out and allow the moisture to escape. So, the humid air should be allowed to escape. So, there must be some openings or incorporate a porous fabric in the strategic areas of the garments. If we have perforations or pores, then through those pores, fresh air can enter or moist air can escape.

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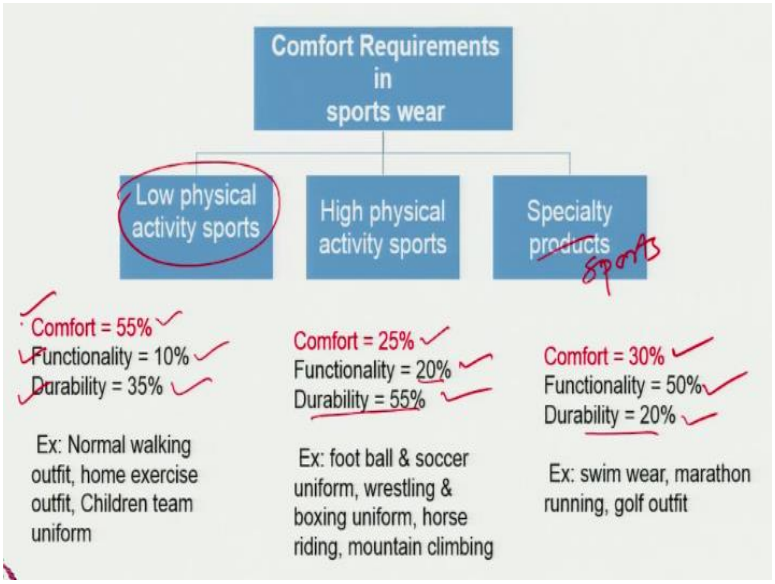

Comfort requirements in sportswear can be approximately quantified based on the level of activity. In low physical activity sports, comfort should be signified at 55%, followed by

durability at 35% and functionality at 10%. For high physical activity sports, the importance of comfort goes down at 25%, functionality at 20%, and durability at 55%. These data are generated through the study conducted by researchers and from the survey.

For speciality types of sports, the comfort requirement becomes only 30%. Functionality becomes very important; it gives a weightage of 50%, and durability becomes least important, only 20%. These requirements of the customers are important for the designer because if the customer is looking to give so much importance to these three important aspects: durability, functionality and comfort.

Then, during the design, these aspects can be incorporated because there cannot be one design which satisfies all the requirements. So, designing activity considers the balance between various aspects.

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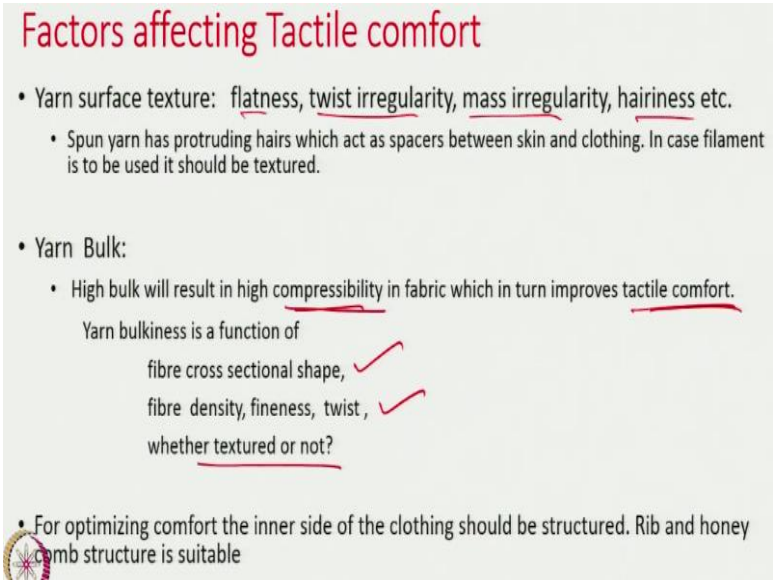

Factors affecting tactile comfort: the first parameter is the surface texture of the yarn. The tactile sensation is very important in some cases, as the person should feel comfortable. The yarn surface texture is decided by flatness, twist irregularity, mass irregularity, and hairiness of the yarn. Yarn bulk: high bulk yarns always give high compressibility properties to the fabric and improve tactile comfort. The fabric also feels soft when yarn bulkiness is high. These are the different ways to change the bulkiness of the yarn: the cross-sectional shape of fibres, fibre density, fineness, and twist in the yarn; in the case of filament yarn, texturing also affects the bulkiness.

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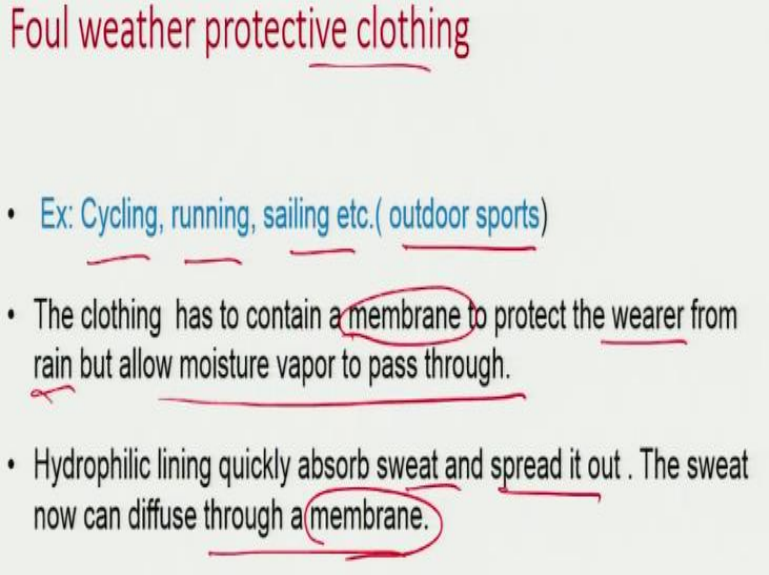

Foul weather protective clothing: examples of such climatic sports are cycling, running, sailing, etc., and all are outdoor sports. The clothing must contain a membrane to protect the wearer from rain and allow moisture vapour to pass through. As stated, the outer layer is supposed to protect the person from rain and reduce air drag. But at the same time, it should allow the moisture to pass through from the inner garment to the outside environment. This is very important. Otherwise, the person may feel very discomfort. Hydrophilic lining quickly absorbs sweat and spreads it out. Sweat can now diffuse through the membrane. The membrane contains a large number of micropores, and through those pores, the moisture can escape; that sort of fabric could be used.

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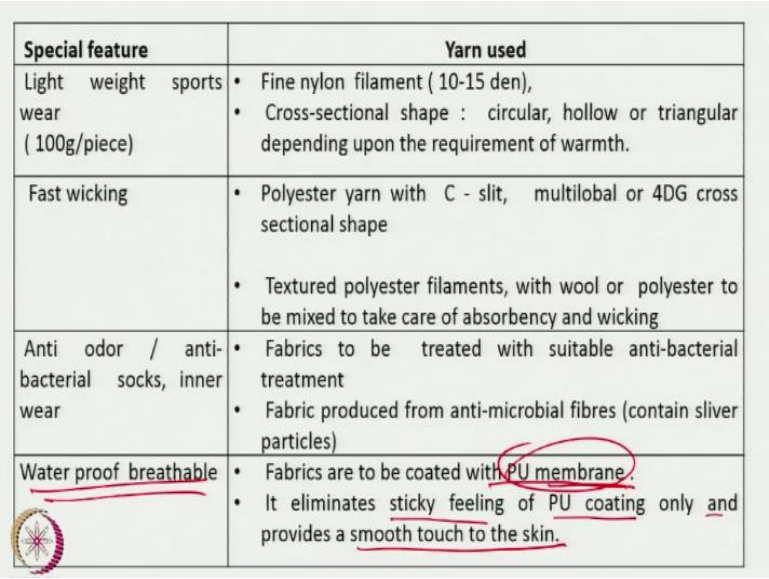

Special feature	Yarn used
Light weight sports wear (100g/piece)	• Fine nylon filament (10-15 den), • Cross-sectional shape : circular, hollow or triangular depending upon the requirement of warmth.
Fast wicking	• Polyester yarn with C - slit, multilobal or 4DG cross sectional shape • Textured polyester filaments, with wool or polyester to be mixed to take care of absorbency and wicking
Anti odor / anti-bacterial socks, inner wear	• Fabrics to be treated with suitable anti-bacterial treatment • Fabric produced from anti-microbial fibres (contain sliver particles)
Water proof breathable	• Fabrics are to be coated with PU membrane. • It eliminates sticky feeling of PU coating only and provides a smooth touch to the skin.

The table present in the slide gives an idea about the yarn to be used for special features. For lightweight sportswear, generally, nylon filament of 10 to 15 denier fineness is preferred. The cross-sectional shape could be circular, hollow or triangular, depending upon the requirement of the warmth. For fast wicking type features, polyester yarn with c-slit or multilobal cross-section or 4DG cross-sectional shapes are generally used, and textured polyester filament, wool or polyester can be mixed to take care of the absorbency and wicking. Wool can absorb a lot of moisture, but it can act as a buffer and wool can help in wicking.

Anti-odour or antibacterial socks and inner wear: If that is the special feature, the fabrics must be treated by antibacterial treatments or fabrics can be produced from antimicrobial fibres also. So, fibres available with antimicrobial properties can be used. Waterproof breathable feature: The fabrics are to be coated with PU membrane, which eliminates the sticky feeling of PU coating and provides a smooth touch to the skin. So, in the membrane, several micropores are present. So, it will not allow the water to penetrate but only allow the moisture to pass through because the size of the moisture vapour molecule is much less than the liquid water molecule. With this, we close this topic, and we will have another topic in the next class. Thank you.