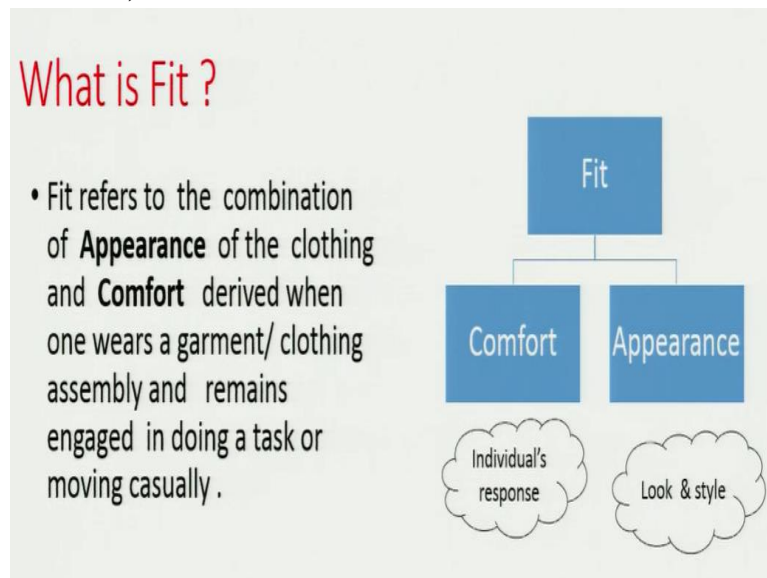


**Textile Product Design and Development**  
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**Lecture - 23**  
**Significance of Fit in Design**

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We will discuss the significance of fit in design. Fit refers to both the appearance of clothing and the comfort experienced while wearing a garment or clothing ensemble, whether a person is actively engaged in a task or simply moving around casually. Together, these two factors determine whether the fit is appropriate. Therefore, fit has two key aspects: one is comfort. This involves whether a person feels comfortable with what they are wearing, and there are various aspects of comfort related to fit.

The second aspect is appearance. These two factors are integral to the concept of fit. Comfort is primarily related to an individual's personal experience, while appearance is more about the garment's look and style. Since we design and produce different types of wearable products, both comfort and appearance must be carefully considered in the design process.

Some clothing is designed for standard, everyday apparel, while other types are for technical purposes. These are the two main categories of clothing materials, both of which remain in contact with the skin. For standard, everyday clothing, appearance is extremely important, and in the case of technical clothing, comfort is more important. Each factor is important to some extent, regardless of the purpose of clothing.

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## Why fit is important?

- As people move, skin belonging to different parts of the body elongates / stretches to varying extent ( maximum: 35 – 45%) and recover.
- A good fitted garment allows the skin to extend freely without any restriction
- Bad fit results in high contact pressure between garment and skin leading to restriction in blood flow, skin abrasion, pressure sores, irritation etc.
- Fit influences
  - tactile sensations as the contact area between skin and garment depends upon fit
  - aesthetic appearance of the garment in worn state

Fit is important because, as people move, the skin on different parts of the body stretches and elongates to varying degrees. The maximum extent of extension could be 35-45%, and the skin recovers after being stretched. When moving the limbs while performing tasks like bending, twisting, moving, and folding our arms or legs, the skin always stretches. The skin is always stretching, but it is a remarkable material that requires minimal force to stretch, so it is barely noticeable.

When the body changes position, such as moving from a bent to an unbent state, the skin naturally recovers its original shape. However, the degree of skin elongation varies depending on the location of the body. This is an important point to understand. A good-fitting garment should allow the skin to stretch freely without any restriction. When we wear clothing, it is important that it should not create any hindrance to the stretching of the skin.

Therefore, a good-fitting garment basically means that it will allow the skin to expand and retract. This flexibility is a key characteristic that will make the garment a good-fitting garment. A poor fit results in high contact pressure between the garment and the skin, which can lead to restricted blood flow, skin abrasion, and pressure sores over time, and there is a chance of irritation. These issues arise when a garment is ill-fitted. This is the fundamental difference between a well-fitted garment and a poorly-fitted one.

Fit significantly influences tactile sensation, as the contact area between the skin and the garment depends on how well the garment fits. This is especially important for clothing like

undergarments, which are always in direct contact with the skin. The sensations received through our nerves should be pleasant without causing irritation or itching. If the fit is not right, the sensations may become uncomfortable, leading to discomfort.

Fit also affects the aesthetic appearance of a garment, which refers to how the garment looks from the outside. This aspect of fit is about the visual appeal or the aesthetic value of the garment as perceived by others. These are the two important aspects influenced by fit.

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**Fit in Fashion garment**

- **Attributes**
- **Grain of the fabric**
  - Grain is the direction of the yarns in a fabric. Grain in terms of (i) lengthwise grain, (ii) crosswise grain, and (iii) bias.
- **Construction lines**
  - Lie on the body in proper position
- **Set of the garment**
  - Free from wrinkles when a person is standing still with garment on
- **Balance**
  - Symmetry and hangs away from the body identically on both sides
- **Ease**
  - Difference between body and garment dimension

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Prof: Lynn M. Boorady, "Functional clothing principle of fit", Indian Journal of fibre and textile research, Vol 36, Dec, 2011  
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When classifying garments into two groups, as mentioned earlier, one category is fashion garments or garments for daily use. In these, the fit is primarily influenced by the grain of the fabric. Grain refers to the direction of the yarns in a fabric, and it can be classified into three types: lengthwise grain, crosswise grain, and bias grain.

In woven fabrics, yarns generally follow two primary directions, which are orthogonal to each other. One direction consists of the warp threads, which run lengthwise, while the other consists of the weft threads, which run crosswise. When the warp threads are placed lengthwise in a fabric or garment, it defines the lengthwise grain. Similarly, the placement of weft threads determines the crosswise grain. Another important factor to consider is the construction lines of the garment, as garments are typically not made from a single piece.

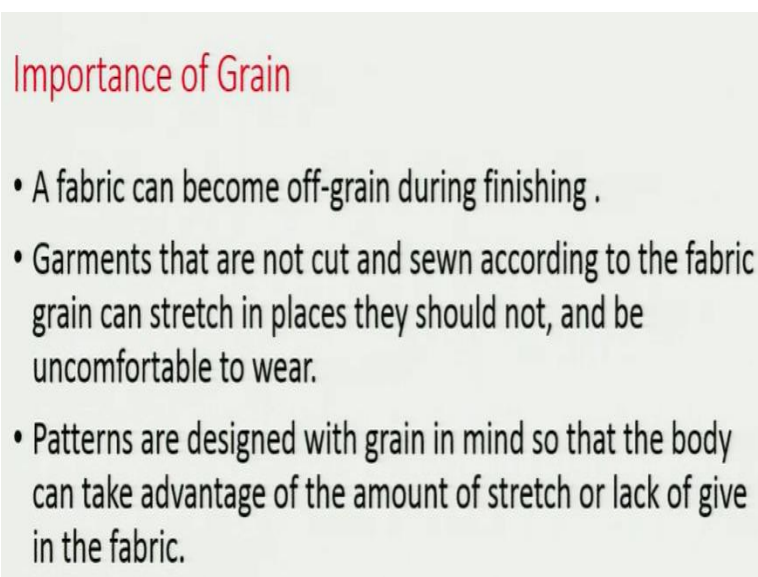
Multiple fabric pieces are joined together to create a three-dimensional shape, forming the garment we wear. There are always seams or joints between the pieces of fabric, and the

placement of these construction lines, or sewing lines, on the body plays an important role in determining the fit of the garment. Another aspect is the set of the garment, which should be free from wrinkles when the person is standing still wearing a garment. The human body does not follow a typical geometrical shape. This complex shape has to be covered by a piece of clothing. As a result, when someone wears a garment, it should be free from wrinkles or buckling. Otherwise, the fit would be considered poor.

Another important aspect of fit is balance; the garment should be symmetrical and hang evenly on both sides of the body. Fit also depends on how the garment falls on the body and whether the garment is properly balanced on the left-hand side and right-hand side of the garment. This is also an essential part of fit, and the other factor is ease. Ease is the difference between the body and the garment dimensions. There should be some amount of ease has to be present to allow the limbs to move freely. Ease refers to the difference between body dimensions and garment dimensions, which will be discussed in detail.

The five attributes, grains, construction lines, set, balance, and ease, are important when considering the fit of fashion garments. These principles apply specifically to everyday clothing rather than technical garments.

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**Importance of Grain**

- A fabric can become off-grain during finishing .
- Garments that are not cut and sewn according to the fabric grain can stretch in places they should not, and be uncomfortable to wear.
- Patterns are designed with grain in mind so that the body can take advantage of the amount of stretch or lack of give in the fabric.

Next is the importance of grain. A fabric can become off-grain during the finishing process. During finishing, factors such as uneven tension on machines like the stenter can cause the warp or weft threads to shift out from the straight line with respect to the edges of the fabric.

When part of the threads becomes inclined or skewed, the fabric is considered off-grain, which can affect both the appearance and fit of the final garment.

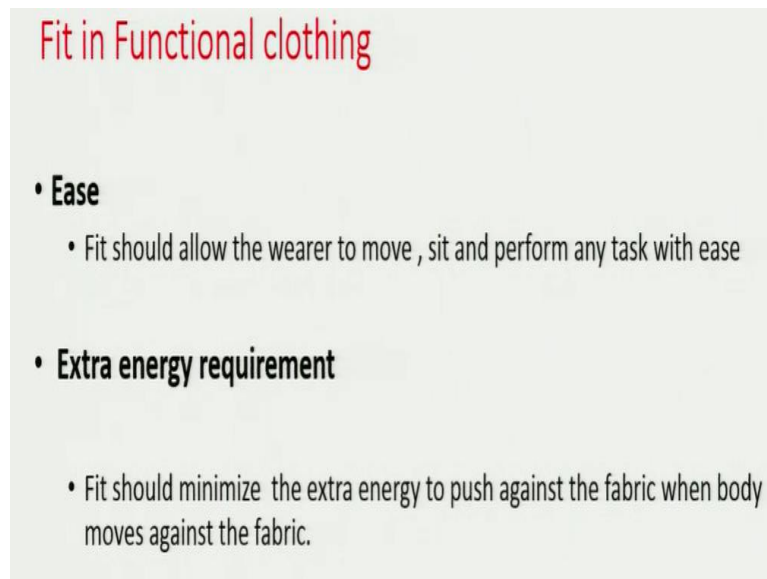
Ideally, all the warp threads should be perfectly parallel to each other, and the weft threads should lie perpendicular to the warp threads. However, if a garment is not cut and sewn in line with the fabric grain, it can lead to unwanted stretching in areas, which makes the person uncomfortable to wear. When cutting patterns and sewing garments, it is important to know how the fabric pieces are being cut, whether cutting them along the warp, the weft, or the bias directions. The properties of the fabric vary in these three directions.

In the bias direction, the fabric stretched more. Meanwhile, in the warp direction, the fabric usually stretches less. The weft direction usually offers slightly more stretch than the warp but less than the bias. The stretchability of the fabric can vary significantly, making it essential to consider the grain when cutting patterns. Patterns are specifically designed with the fabric grain in mind to ensure that the pieces join together and contribute to the three-dimensional shape of the garment. So, these patterns are actually designed with the grain in mind so that the body can take advantage of the amount of stretch or lack of given the fabric.

In pattern cutting, it is important to keep the grain in mind because different parts of the garment will be falling on various areas of the body, which stretch differently during movement. For example, when someone bends, twists, or sits or stands, specific areas of the skin stretch more than others.

Therefore, pattern pieces should be designed to allow for the necessary stretch in those specific areas. In that area, we should consider covering the areas with fabric that has been cut along the bias directions because it provides more stretch. It is important to understand why we require a bit more stretch in certain areas and less in others. Therefore, the pattern pieces should be cut from primarily woven fabrics to meet these needs.

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**Fit in Functional clothing**

- **Ease**
  - Fit should allow the wearer to move , sit and perform any task with ease
- **Extra energy requirement**
  - Fit should minimize the extra energy to push against the fabric when body moves against the fabric.

When it comes to functional clothing, the most important factor is fit. Fit should allow the wearer to move, sit and perform any task with ease. It is not important in the case of functional clothing. Some aspects which are not important are how the garment drapes on the body and the appearance of the garment. The predominant consideration is the ease of movement, which is connected to the ability of the body to move or to take any configuration while a person is performing some tasks. This becomes the most important part of the design.

Different professions, such as persons working in mines, firefighters, soldiers and police officers and depending on professions, the body must be mobile. Each profession demands various postures from the body, so the design must meet these diverse movements effectively. In those postures, the skin stretches differently in different directions. It is essential to have adequate ease in the design so that the wearer can feel comfortable and perform the tasks without any hindrance.

Additionally, the fit should minimize any extra energy required to move against the fabric. This means that fit should ensure that a person spends no unnecessary energy while performing any tasks. If the fabric needs to be elongated or extended during task performance, the physiological energy expended by the body will be spent primarily to stretch the fabric itself. Therefore, it is important to minimize these extra energy requirements.

For example, when someone is wearing multi-layer fabrics, there is a possibility that the two layers of fabric could rub against each other. If the layers rub against each other, friction can

occur, requiring the wearer who is performing a certain task to exert additional energy to overcome this frictional resistance. This means that part of their energy will be spent on pushing the fabrics against one another, which has to be avoided. Thus, managing friction and ensuring ease of movement are important considerations in the design of functional clothing.

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## Functional Ease

- Two types
  - Wearing ease – allows a person to move and perform every day task
  - Functional ease - allows movement ( functional garment)
- The extent of functional ease differs for type of garment and use
  - A garment next to body skin will have less ease and the one to be worn over other should have more ease.
  - When layer garments are used, one has to take care of friction between garments as well
  - Heavier fabrics requires more ease
  - Knitted garment requires less ease as they are stretchable

Wearing Ease guide lines	
Garment from woven fabric	Ease (inch)
Chest	3 ✓
Waist	½ ✓
Hips	2 ✓
Garment to be worn over other	
Suit jacket ( chest )	3-6 ✓

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If clothing is excessively heavy or bulky, the wearer needs to expend more energy simply to carry it. The bulky fabric may also create a hindrance to the movement of the person. Therefore, these considerations must be taken into account when designing technical clothing for the persons who are engaged in various technical activities. Functional clothing includes two types of ease: wearing ease and functional ease.

Wearing ease allows the person to move comfortably and perform everyday tasks, while functional ease specifically facilitates movement within functional garments. Wearing ease is generally associated with day-to-day activities that do not involve heavy or complicated tasks. Functional ease, on the other hand, is focused on allowing the movement of limbs without any hindrance. The amount of functional ease varies depending on the type of garment and its intended use.

A garment worn next to the skin will typically have less ease, while one designed to be worn over another layer should provide more ease. This is important because most of us wear multiple layers of fabric. The first layer typically consists of undergarments, followed by a second layer, such as shorts or trousers. In colder weather, we might add additional layers, like

sweaters or jackets, and in extreme cold, another layer of an overcoat may be necessary. We continuously add layers depending on the situation and the climate and environmental conditions we encounter.

So, the ease of movement differs from the garment, which is close to the skin and the outermost layer of the garment. This variation in ease is essential to consider, as it affects comfort and movement. Additionally, it is important to consider friction, which becomes increasingly important as we layer garments on top of one another. That is, friction exists between the two layers of the fabric. This friction also creates noise generation and increases the force required to move limbs; hence, friction must be an important consideration.

Therefore, minimizing friction is essential. The choice of fabric for both the inner and outer layers of a garment is important, especially when layers are already worn by the person. Between these two layers, let us consider a person wearing garments. The inner layer will have two surfaces: the interior surface that touches the body and the outer surface that faces the next layer. So, any piece of clothing has two sides, the upper and lower faces or the front and back faces, as we might refer to them. Now, if we consider the inner surface of the second layer of the garment and the outer surface of the first layer, these two surfaces interact as they rub against each other.

To minimize the friction between them, we should consider altering the surface characteristics of these layers. This can be achieved by applying coatings or finishes that reduce friction or selecting fabrics known for their low resistance and friction values. Hence, in technical garments, the choice of material for the inner surface of garment two and the outer surface of Garment 1 is essential. This is because when the person wears it, these two surfaces will rub against each other, and friction must be minimized.

Therefore, it is important to determine the appropriate fabric type for the inner face of Garment 2 and for the outer face of Garment 1 or even Garment Layer 1. This consideration is particularly important when designing a garment from the point of view of functional ease. Additionally, it is essential to remember that heavier fabrics require more ease in the design. The fabric must be heavy, especially when creating a garment designed to protect a person from heat and high temperatures; in such cases, a thicker fabric is necessary.



Similarly, for cold climates, a thicker fabric is essential, which will also make the garment heavier. Heavier fabrics require more ease compared to thinner fabrics. In contrast, knitted garments or knitted fabrics require less ease due to their stretchable nature. This property has been discussed in previous lectures, where fabric properties vary with changes in construction has been discussed.

Generally, knitted garments or fabrics are stretchable; however, it is possible to produce knitted fabrics that are less stretchable. On average, the knitted construction, which involves the formation of a number of loops, inherently makes the fabric stretchable. Hence, knitted fabrics require much less ease compared to woven fabrics. Here, a table is provided that shows some insights about ease. It is seen that typical ease values for garments made from woven fabric are listed. For the chest, an ease of 3 inches is needed; for the waist, half an inch; and for the hips, 2 inches.

For a suit jacket, the ease at the chest should be around 3 to 6 inches because the jacket is typically worn over inner garments like a vest and a shirt, and therefore, it needs more ease. In contrast, for a normal shirt, a 3-inch ease is sufficient. This shows that the requirements are different for different parts of the body, and according to the type of garment, the requirement for ease varies.

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### Considerations for Right Fit

- For achieving right fit , one must take into account
  1. Body size and its variation
  2. Body shape
  3. Change in Body dimension due to different posture at work
  4. Fabric properties ( level of stretch)
  5. Garment weight ✓
  6. Garment bulkiness

Next is the considerations for the right fit. When developing a garment or wearable product that ensures the right fit, it is essential to keep certain points in mind. The first and foremost

consideration that must be taken into account is the body size and its variations. It is important to know the dimensions of the individual who will be wearing the garment and understand any variations in their body measurements.

When designing for a group of people, it is important to consider that body dimensions will vary from person to person. If the garment is intended for individuals of different body sizes, this variability must be taken into account. Then comes the shape of the body. Body shape may also differ from person to person, with changes in body dimension and different postures at work. If we are designing for someone performing a specific technical function, we need to consider how body dimensions change with various postures.

It is necessary to understand the properties of the fabric we intend to use. It is important to know the level of stretch in the fabric, whether it is made of cotton, a polyester-cotton blend, or 100% polyester or nylon. Additionally, whether the fabric has a woven or knitted construction is important, as these factors significantly influence its properties. Therefore, it is essential to keep the fabric properties, particularly its stretchability, in mind.


Next, the weight of the garment must be considered because the fit requirements vary depending upon the overall weight of the garments. Bulkiness is another important factor to keep in mind. When designing garments for winter or very cold climates, we often increase bulkiness to enhance insulation, making the garment thicker. This allows us to trap more air and increase the insulation value of the garment.

However, if the garment is excessively bulky, we must also increase the ease. These aspects are important to consider when designing for warmth and comfort.

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**Fit and skin extension**

- When people move, skin stretches and recovers.
- Critical strain area of body are : Knee, the seat, the back and elbows
- In tight fitting garment, the fabric must elongate to accommodate body movement and then recover.
- Three essential component to meet skin strain requirement are
  - Garment fit , Garment slip and Fabric stretch
- Garment fit is provided by the space allowance for skin strain which is determined by the ratio of body size and construction of garment design.
- Garment slip is influenced by friction between
  - (i) fabric and skin, and (ii) different layers of garment

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Next comes the fit and skin extension, which are important. When people move, their skin stretches and then recovers. The critical strain areas of the body include the knees, seat, back, and elbows, as these regions experience significant dimensional changes due to skin stretching. The skin is a material that easily stretches with minimal force. In tight-fitting garments, the fabric must not only elongate to accommodate body movement but also recover afterwards. This means that both the extension and recovery aspects of the fabric are important. Only extensibility is not sufficient. The material must also be capable of returning to its original shape after being stretched.

The following are the three essential components that a designer can take into account to meet skin strain. They are garment fit, garment slip, and fabric stretch. Allowing the garment to slip over the skin can help ensure that it does not hinder the movement of the limb. Additionally, if we use stretchable fabrics, they will also adapt to changes in body dimensions, allowing for greater flexibility and comfort. Fit, slip, and fabric stretch are all important factors to consider to ensure that the skin is allowed to extend freely during body movement.

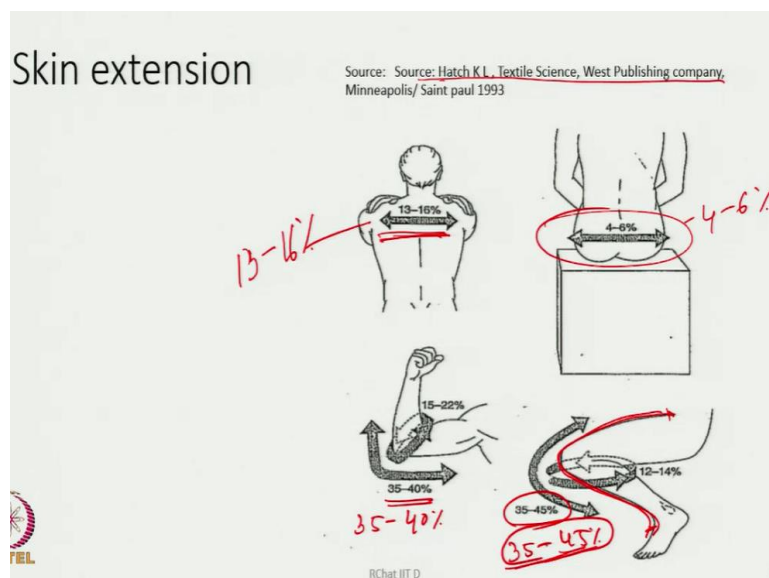
Garment fit is achieved by space or allowance for the skin strain, which is determined by the ratio of body size and construction of the garment design. Essentially, garment fit refers to the ratio of the body size and the size of the garment. This indicates how much extra allowance is provided in relation to the body's dimensions. Garment slip is influenced by two main factors. They are the friction between the fabric and the skin and the friction between different layers of the garment.

As mentioned in the previous slide, when dealing with multi-layered garments, there is a potential for the layers to rub against each other. Additionally, garment slip also refers to the slip friction between the fabric and the skin. Research has shown that the friction between fabric and skin varies based on several factors, such as the type of fabric, like cotton or polyester and the condition of the skin. For instance, skin may have sweat and hairiness, which can influence the contact area between the skin and the fabric.

Numerous other parameters can also influence the friction value between the fabric and the skin. The contact pressure at a given point and the contact area are influenced by several factors, including the surface roughness of the fabric, whether the skin has a lot of hair, and whether the skin is partially wet. Additionally, this friction is affected by various parameters that can differ from person to person and may vary depending on the type of activity. For instance, the wetness of the skin can change during different activities.

Designing a garment that meets the requirements of every individual, especially during different types of activities, is not an easy task. However, it is essential to consider that slip is influenced by the friction between the skin and the fabric, as well as the friction between different layers of the garment.

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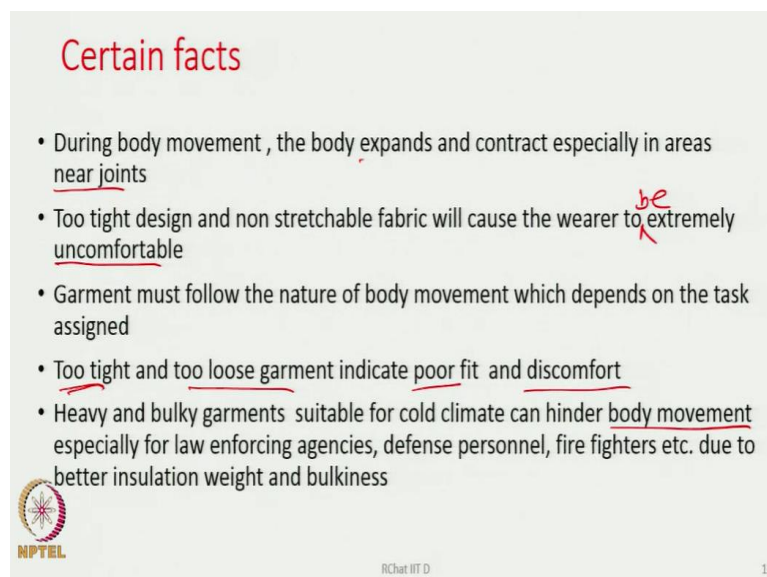


This diagram illustrates the level of skin extension in various body positions. According to the source provided, shoulder extension can range from 13% to 16%. In a sitting posture, the

extension is between 4% and 6%. The most significant stretch occurs when folding the arm, with an extension of 35% to 40%. Similarly, when folding the knee, the extension can reach 35% to 45%. This indicates a substantial change, meaning the length increases by 35% to 45% in those positions.


In a standing posture, the length from one point to another differs from that in a bent or sitting posture, with the difference potentially reaching a maximum of 45%. This significant skin stretch means that body dimensions can change substantially. The skin extends to accommodate these changes because it is highly stretchable, allowing us to move comfortably without feeling restricted. Hence, this gives an idea about the stretching of the skin in different regions and in different postures.

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**Certain facts**

- During body movement, the body expands and contracts especially in areas near joints
- Too tight design and non stretchable fabric will cause the wearer to <sup>be</sup> extremely uncomfortable
- Garment must follow the nature of body movement which depends on the task assigned
- Too tight and too loose garment indicate poor fit and discomfort
- Heavy and bulky garments suitable for cold climate can hinder body movement especially for law enforcing agencies, defense personnel, fire fighters etc. due to better insulation weight and bulkiness

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Certain facts regarding garment fit must be considered. During body movement, the body expands and contracts, particularly in areas near the joints. As we have discussed, the body can undergo these changes. Consequently, a design that is too tight combined with non-stretchable fabric will lead to extreme discomfort for the wearer, as the body expands while the garment remains restrictive. This discomfort can lead to pain because the body will attempt to extend a fabric that is difficult to stretch, resulting in pressure buildup, and the person will feel uncomfortable.

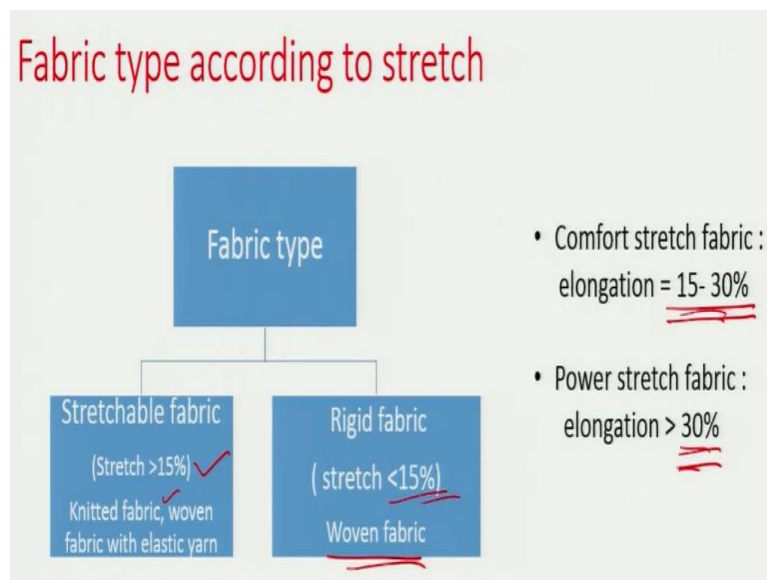
Therefore, the garment must accommodate the body's natural movements, which depend on the tasks the person is performing. It is essential to understand in advance how body dimensions

change with movement. Garments that are too tight or too loose both indicate poor fit and can lead to discomfort. If the garment is too loose, it can also lead to discomfort. It may also hinder the movement of the body or movement of the person. It is important to keep in mind these aspects that a loose garment also does not meet the good fit.

Garments that are too tight do not provide a good fit, nor do those that are too loose. Both can create hindrances to a person's activity. For example, when someone wants to run, loose garments can create additional problems. Achieving the right fit is essential. Additionally, heavy and bulky garments suitable for cold climates can also restrict body movement. As discussed earlier, heavy and bulky garments can also create problems with body movement. This is particularly important for personnel in law-enforcement agencies, such as defence, firefighting, and police work.

So, this can create problems, especially when the garment is either heavy or bulky. Therefore, when designing uniforms or garments for these individuals, it is important to consider their specific roles and the types of activities they engage in.

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Let us consider a general overview of fabric types based on their stretchability. Fabrics can be broadly classified into two groups: stretchable and rigid. Stretchable fabrics are those with a stretch value greater than 15%, while fabrics with a stretch value of less than 15% are categorized as rigid. Typically, knitted fabrics are usually stretchable, whereas woven fabrics are generally rigid. Today, stretchable woven fabrics and rigid knitted fabrics are also

produced. However, on average, woven fabrics are typically rigid, while knitted fabrics are stretchable. By incorporating materials like lycra, spandex, or other elastic yarns into woven fabrics, we can create stretchable options as well.

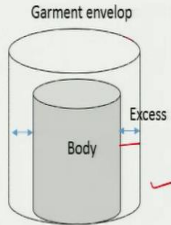
Similarly, it is possible to have knitted fabrics that are quite rigid, with an extension of less than 15%. Regarding stretchability, stretchable fabrics can be classified into two categories: comfort stretch, which falls between 15%-30% elongation, and power stretch, which has an elongation greater than 30%. Thus, even among stretchable fabrics, there are distinct groups based on their stretch capabilities.

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### Woven / Knitted fabric

- Since **woven fabric** do not stretch much , one can make them less restrictive by allowing the fabric to slip
- Design options
  - Keep appropriate allowance (excess) between body size and garment envelop.
  - The excess will help the fabric part to slip over the body during movement.
- **Knitted fabric** are stretchable and thus they can stretch in sympathy with the skin for different body postures .

They are suitable for skin fit garment such as swim wear, foundation garment, stretch sky pants, active sports wear.



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For woven and knitted fabrics, since woven fabrics do not stretch much, they can be made less restrictive by allowing the fabric to slip. For example, if the body is surrounded by a garment envelope surrounds the body, the excess fabric allows for this slip. When the body moves, the garment can shift, similar to how sleeves are designed for shirts to accommodate movement. Typically, the diameter of the sleeves is larger than the circumference of the arm. This design allows the sleeves to slip easily over the body when we move our arms because there is minimum contact. It can slip easily and the other advantage is that this provides better air circulation.

From a fit perspective, it is important to create appropriate allowances or excess between the body size and the garment envelope. This excess fabric allows the garment to slip over the body easily, minimizing friction. Because of the minimum force between the body and the fabric,



whenever the body bends, twists or stretches, this facilitates comfortable movement. With minimal contact, the pressure between the body and the garment remains very low, allowing the fabric to slip easily.

In contrast, knitted fabrics are known for their stretchability and can easily accommodate changes in body dimensions, stretching in harmony with the skin. They behave like the skin itself. Therefore, knitted fabric will always be suitable for skin-fit garments. There are certain garments that have to be skin-fit. Examples of skin-fit garments include swimwear, foundation garments, stretchy sky pants, and uniforms for ballet dancers. In many cases, stockings and skin-fit garments are required. In these cases, minimal ease is required, meaning there is little to no excess fabric.

Therefore, it is essential to select fabrics which can easily extend, which is why we often choose knitted constructions made from highly stretchable fibres, such as polyester. We typically avoid using cotton for skin-fit garments because polyester fibres stretch more effectively. Additionally, the knitted construction enhances the overall stretch of the fabric, ensuring it meets the necessary stretch requirements for various activities. For swimwear, it must be body-tight to reduce the drag between the water and the garment, allowing for optimal performance. To minimize drag, it is essential to reduce the overall surface area of the garment. This means that it requires a skin-tight design, making knitted constructions the ideal choice for achieving that skin fit.

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Typical weight of garments			
Item	Weight (g)	Item	Weight (g)
Underpants	70 - 100	Jacket	1000 - 1200
Sports shirt, T-shirt	220 - 300	Coat	900 - 1500
Underpants	70 - 100	Jacket	1000 - 1200
Business suit	1200- 1800	Winter jacket	1400 - 1800
Pants	600 --700 ✓	Fur coat	3000- 8000
Jeans	650-800 ✓		

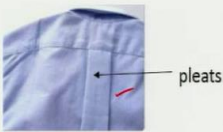




Here are some typical garment weights: underpants, sports shirts, and T-shirts are quite lightweight, often weighing only a few grams. In contrast, a business suit is heavier, with trousers typically weighing between 600 and 700 grams, while jeans can range from 650 to 800 grams. Fur coats are significantly heavier, with weights ranging from 3 to 8 kg. This provides a typical understanding of garment weights, varying depending on the design. It is essential to consider these weight differences, as they directly impact the fit requirements for each garment.

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**Design options for right fit**

- When a person bends or crotch, additional fabric is required in the place of expansion such as buttocks and knees

1. Shirt with adequate width or pleats in back 
2. Crotch gusset to allow leg extension 

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Design options for achieving the right fit must consider areas where additional fabric is needed during movement, such as the buttocks and knees. For example, a shirt can be designed with adequate width or pleats to accommodate shoulder movement. Similarly, a crotch gusset can be added to allow for leg expansion. These design features provide extra material in critical areas, ensuring comfort and freedom of movement.

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Raglan, dolman, and kimono sleeves are excellent design choices for achieving a better fit for rounded shoulders. These types of sleeves enhance ease of movement for the arms, providing greater comfort and flexibility.

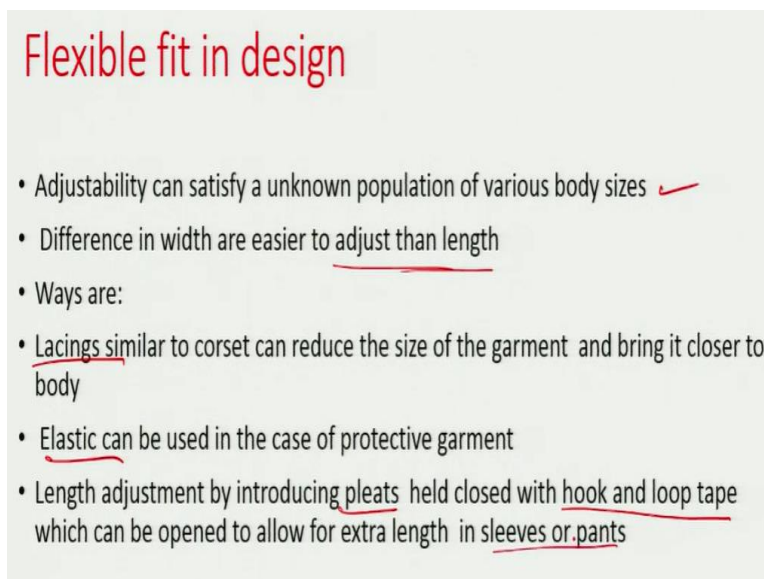
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Another design option is to ensure that sleeves have adequate shoulder width and are not too tight. The waistline should also be loose enough to accommodate expansion when a person sits, as the waist can differ significantly in length between standing and sitting postures. Front opening styles are particularly beneficial in many garments, allowing easy buttoning and unbuttoning.

However, in some cases, back-opening styles may be required. For example, a surgeon's gown typically has a back opening. This design ensures that the front side is completely covered, protecting the surgeon from potential infections from patients during procedures, while buttons or ties at the back allow for secure closure. Large neck openings and pant legs to be large enough to pull over the cast or brace. A two-piece garment rather than a single piece is preferable. But in some cases, a single-piece garment is only required. Accessible front and side pockets are required for carrying field items. These are the various types of design.

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### Flexible fit in design

- Adjustability can satisfy a unknown population of various body sizes ✓
- Difference in width are easier to adjust than length
- Ways are:
- Lacings similar to corset can reduce the size of the garment and bring it closer to body
- Elastic can be used in the case of protective garment
- Length adjustment by introducing pleats held closed with hook and loop tape which can be opened to allow for extra length in sleeves or pants

Flexible fit in design is that adjustability can also be introduced to satisfy an unknown population of various body sizes. When a company is manufacturing a product, then the product has to service a large population. In a large population, the size and shape of a person will differ. If adjustability is introduced, then it will be a good aspect of design. The differences in width are easier to adjust than differences in length.

Lacings are similar to corsets and can reduce the size of the garment and bring it closer to the body. Elastic can be used in the case of protective garments. Hence, length or height adjustment is difficult, though not impossible, but adjustment of the width of a garment is a little bit easier. Length adjustment is introduced in the form of pleats and held closed with the hook and loop tape, which can open to allow for extra length in sleeves or pants. This type of design of pants and sleeves is also available.

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## Fit for dresses meant for old people

- Old people's skeleton deforms leading to tilted backward posture
- Gait changes
- Hump back occurs
- Pattern must be adjusted to accommodate body change
- Front fasteners are to be provided

These are some of the options available for designing clothing which is fit for elderly individuals. As people age, their skeletal structures may deform, often resulting in a backward-leaning posture. This is quite common, and it can also affect their gait, leading to a humpback. To ensure a proper fit, the garment's pattern must be adjusted to accommodate these body changes. Therefore, garments meant for old people will be different in design than those made for normal populations. Another consideration is that front fasteners should be provided, especially for older individuals. The buttons need to be larger so that they can easily be located and buttoned or unbuttoned without difficulty. Alternatively, buttons could be replaced with other fastening methods, such as velcro, to make it easier for them to put on or take-off the garment whenever needed.

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## Fit and Pressure comfort

- Excessive pressure can cause physiological effects
- Pressure comfort is required for
  - Close fitting garment ( swim wear, bras, stockings, girdles )
  - Pressure garment ✓
  - Pressure garment for skin healing ✓
  - Baby huggers ✓

Fit and pressure comfort are also crucial because the person must wear the garment, and in some cases, pressure may develop between the garment and the body. Excessive pressure can lead to physiological effects. Pressure comfort is especially important for close-fitting garments like swimwear, bras, stockings, and girdles, where managing pressure is essential for the wearer's comfort. There are also pressure garments, such as those used for skin healing and baby huggers. In these cases, some pressure on the body is inevitable. However, it is essential to ensure that the pressure remains within tolerable limits to avoid discomfort or harm to the wearer.

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### Consequences of pressure

- Cardiac output decreases linearly with increase in pressure
- Blood flow to lower leg decreases with increases in pressure

Pressure (mm hg)	
14.1	Adverse effect on blood circulation ✓
15- 25	Blood flow increases ✓
<u>30-40</u>	Discomfort ✓

When designing pressure garments, it's crucial to consider how much pressure is tolerable and ensure the garment stays within these limits. Excessive pressure can lead to physiological consequences, such as a linear decrease in cardiac output and reduced blood flow to the lower legs. For example, at a pressure of 14.1 mmHg, there could be adverse effects on blood circulation. Pressures between 15 and 25 mmHg may increase blood flow, but at 30 to 40 mmHg, discomfort could occur. Therefore, proper design is essential to balance these factors. It is important to understand the correct pressure range when designing pressure garments. For each individual, these factors must be taken into consideration.

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### Comfortable pressure range


Body part	Comfortable girdle pressure range ( mm Hg)
Waist	3.3- 6.0 ✓
Abdomen	5.9 – 9.2 ✓
Hip	4.4 – 8.1 ✓
Thigh	4.4 – 6.6 ✓
<u>Side waist</u>	12.5 – 20.6 ✓

The comfortable pressure range varies across different parts of the body. For example, in the waist area, a tolerable pressure range is between 3.3 to 6 mmHg, while for the abdomen, hip, and thigh areas, the ranges differ slightly, with the thigh tolerating 4.4 - 6.6 mmHg. The side waist can handle a higher range, typically between 12.5 - 20.6 mmHg. When designing lean garments, some pressure may develop, but as long as it stays within these tolerable limits, it will be acceptable. Therefore, it is essential to understand the comfortable pressure range for different body parts.

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### Pressure comfort

- $P = \frac{T_1}{r_1} + \frac{T_2}{r_2}$  ✓
- $T_1$  and  $T_2$  = fabric tension in two directions ( warp and weft)
- $r_1$  &  $r_2$  = radii of the body contour in two principal directions
- Pressure depends upon
  - Body curvature ✓
    - ( curvature is high near joints )
  - Fabric tension ✓
    - Depends upon fabric tensile property



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Pressure comfort and pressure garment design will be discussed in more detail in another lecture. The key theory related to pressure is expressed in the following equation:

$$P = \frac{T_1}{r_1} + \frac{T_2}{r_2}$$

In this equation, ' $T_1$ ' and ' $T_2$ ' represents the fabric tension in warp and weft directions while ' $r_1$ ' and ' $r_2$ ' denotes the radii of the body contour in warp and weft directions. This equation shows that pressure is a function of the amount of stretch in the garment relative to the body's contours.

Pressure in a garment is influenced by the stretch of the fabric and the resulting tension developed within it. Tension development in the fabric will depend upon the stretch of the fabric. The stretch of the fabric depends upon the change in the body dimension. Additionally, the curvature of the body plays a significant role in this relationship. Therefore, pressure is a function of body curvature and the tension developed in the fabric, which in turn is influenced by both the fabric's stretch and its tensile properties.

The load-elongation curve is an important concept to keep in mind. From this equation, we can understand that to maintain pressure within tolerable limits, we must avoid allowing the fabric tension to become excessively high. Therefore, appropriate measures must be taken to ensure that the pressure remains within acceptable limits. We will explore pressure garment design in more detail in future lectures. With this, we conclude today's discussion on how to incorporate fit into the design of various types of garments, whether for technical use or everyday activities. Thank you.