CHAPTER III

METHOD OF PROCEDURE

This was an experimental study to understand impact of Lycra on woven and knitted fabrics. In this study, fabric properties were examined for their relationship to shrinkage behavior, strength and recovery properties stretch and fit properties to determine whether incorporation of Lycra had its impact on performance properties of fabrics. Two fabrics under each woven and knitted fabric categories were selected to study stretch properties of Lycra with fabric geometry. This property was finally used for standardization of sizes for garments.

This chapter deals with materials and methods followed fulfilling objectives of the study. The experimental procedure has been discussed under the following sequence.

3.1   **Phase I: Preliminary testing of fabrics to obtain preliminary data of fabrics.**

3.1.1   Procurement of the samples

3.1.2   Preliminary data of the fabrics used

        3.1.2.1   Determination of fibre content of the fabrics

        3.1.2.2   Determination of thread count of fabrics

        3.1.2.3   Determination of cloth cover of fabrics

        3.1.2.4   Determination of tightness factor of fabrics

        3.1.2.5   Determination of thickness of the fabrics

        3.1.2.6   Determination of weight per unit area of fabrics

3.2   **Phase II: Physical testing for performance and serviceability of fabrics**

3.2.1   Determination of pilling and abrasion resistance properties

        3.2.1.1   Pilling resistance of fabrics

        3.2.1.2   Abrasion resistance of fabrics

3.2.2   Determination of growth and elastic recovery property of fabrics

3.2.3   Determination of strength and elongation properties

3.2.4   Determination of shrinkage behavior of fabrics

3.2.5   Determination of air permeability of fabrics

3.2.6   Determination of stress-strain behavior under cyclic loading

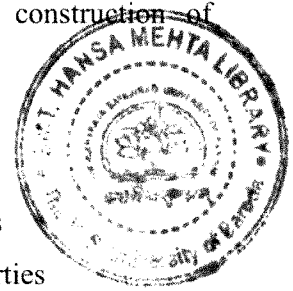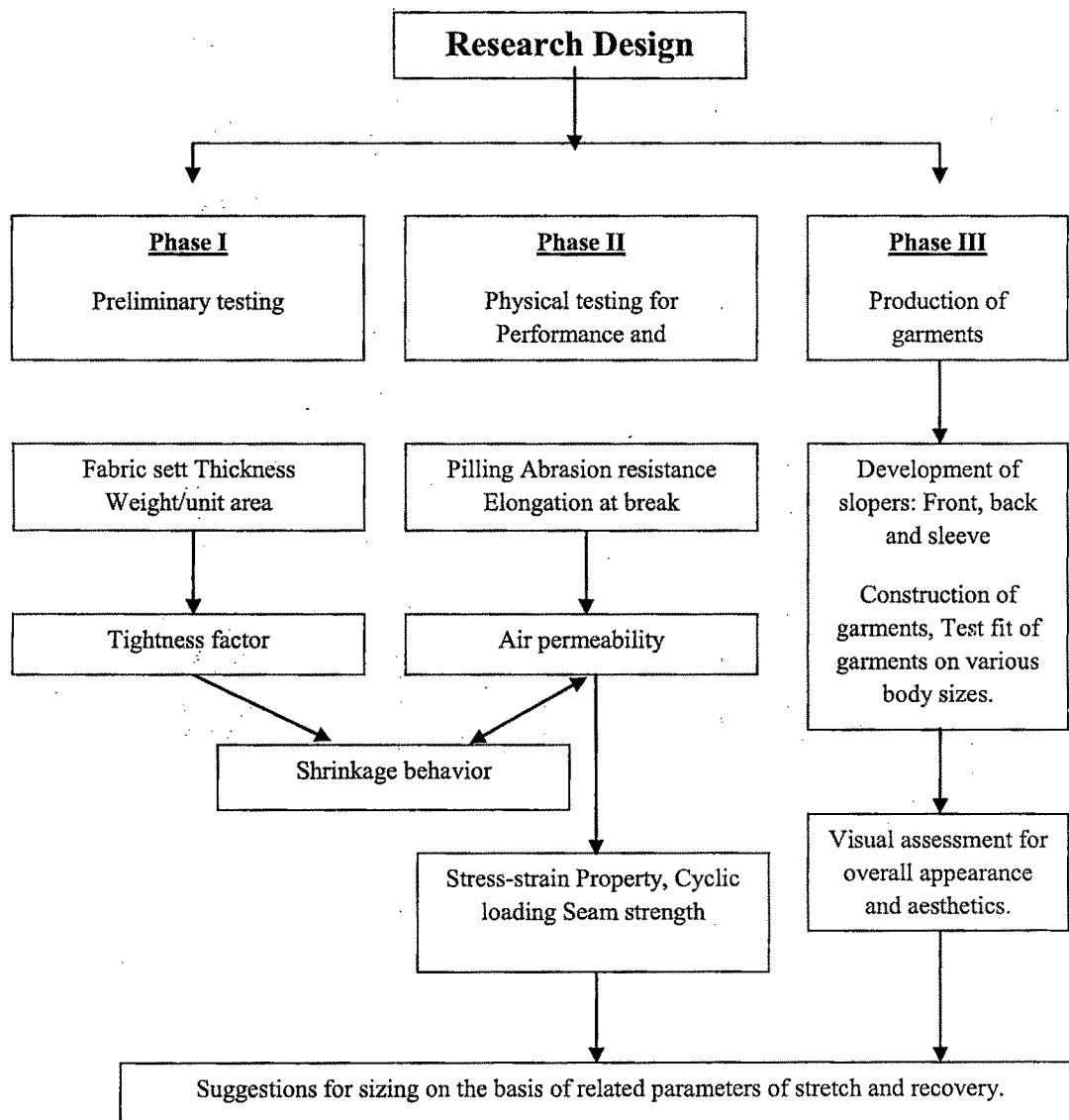| 3.2.7	Determination of seam strength of fabrics
3.3	**Phase III: Construction of garments**
3.3.1	Development of basic bodice and sleeve block for construction of garments
3.3.2	Adaptation of style for final garment construction
3.3.3	Visual assessment of garments for overall appearance
3.3.4	Assessment of garment recovery property after wear trials
3.3.5	Analysis of results of garment stretch and recovery properties

Research Design

Phase I	Phase II	Phase III
Preliminary testing	Physical testing for Performance and	Production of garments

Fabric sett Thickness Weight/unit area	Pilling Abrasion resistance Elongation at break	Development of slopers: Front, back and sleeve Construction of garments, Test fit of garments on various body sizes.
Tightness factor	Air permeability	

Shrinkage behavior

Stress-strain Property, Cyclic loading Seam strength

Visual assessment for overall appearance and aesthetics.

Suggestions for sizing on the basis of related parameters of stretch and recovery.

The experimental procedure has been described in detail as under:

3.1 Phase I: Preliminary testing of fabrics to obtain preliminary data of fabrics

3.1.1 Procurement of samples

Two fabrics under the category of each woven and knitted were selected for the study. They have been given codes as A, B, C and D. The fabrics with different geometry were taken in cotton/Lycra (93/3) combination as to study behaviour of Lycra with different geometry fabrics. These fabrics were mill finished and ready for garment construction. Arvind Mills, Ahmadabad, sponsored the fabrics for the study. Selection of the fabric was based on their utility and suitability as per physical activity of human being for the upper garment of females.

All physical tests were conducted at standard testing conditions maintaining 65% ± 2% R.H. and 20°± 2°C temperature. The samples were conditioned for 24 hours in the dessicator before testing to keep them free from moisture.

3.1.2 Preliminary data of the fabrics under study

3.1.2.1 Determination of fibre content of the fabrics

To confirm content of Lycra in fabrics the procedure followed was, woven samples were raveled and knitted samples were deknitted to find out how Lycra filament is present in the sample. The ravelled cotton and Lycra yarns from the samples were separated and placed on a glass slide and was observed under the compound microscope for fibre characteristics. To determine percentage of Lycra incorporated in the fabrics, samples of size 2.5 cm x 2.5 cm were treated with hot DMF (Dimethyl formamide) solution as Lycra is soluble in hot DMF solution. Weights of the samples were noted before and after the treatment. To find the percent of Lycra through solubility test, following was used:

$$\% \ of \ Lycra = \frac{Difference \ in \ weight}{original \ weight} \ x \ 100$$

3.1.2.2 Determination of thread count of fabrics

(i) Woven samples

Thread count (number of yarns/cm^2) in woven fabrics was determined according to ASTM 2775-98 standard. The fabric count was determined counting the number of threads in one square centimeter in length and width direction of fabrics using a pickglass. Five readings were taken from different places in each fabric. Average of five readings was noted for both fabrics respectively.

(ii) Knitted samples

The number of wales and courses per square centimeter were counted using a pick glass from five different places. Average of five readings was taken for both fabrics respectively.

3.1.2.3 Determination of cloth cover of fabrics

Cloth cover, a measure of the fraction of area covered by both the warp and weft threads in a given fabric, was calculated using thread count and yarn number (cotton count system) for woven fabrics.[6]

Equation for calculating cloth cover:

$$\text{Cloth cover} = \text{Cover factor}_{warp} + \text{Cover factor}_{weft}$$

$$[(cf_{warp} \times cf_{weft})/28]$$

$$\text{Where cover factor (cf)} = \frac{\text{threads per inch}}{\sqrt{\text{yarn number}}}$$

3.1.2.4 Determination of tightness factor of fabrics

It was determined for knitted fabrics.

Arvind Mills made the details of linear density available with the fabrics, so yarn linear density was already known. The stitch length was calculated. Two parallel slits were cut in a fabric, a convenient distance apart. A length of thread was removed from between the slits and its straightened length of 1 cm measured using a

magnifying glass, pen and ruler. The number of loops in 1 cm was then calculated. The stitch length was calculated using the formula:

$$Stitch\ length = \frac{straightened\ length\ (1\ cm)}{No.\ of\ loops\ in\ that\ length}$$

3.1.2.5   Determination of thickness of the fabrics

Compress-o-meter was used to determine the thickness of the fabric. Fabric thickness was measured according to ASTM D 1777-96 standard test method. Five samples of 5x5 square centimeters were cut without any creases or folds. Individual samples were placed on the anvil of the compress-o-meter and the pressure foot was lowered upon the sample gently by knob. The average of five readings was taken on each sample at different places.

3.1.2.6   Determination of weight per unit area of fabrics

The mass units (gm/m^2) were measured according to ASTM D 3776 – 96 standard test methods. Five samples of 12.5 cm x 12.5 cm were cut and conditioned in a dessicator for 24 hours. The samples were weight individually using an electronic weighing balance. An average of five readings was taken. The weight per square meter area was calculated using the formula given below:

$$Weight\ in\ gm/m^2 = \frac{w\ x\ 100\ x\ 100}{Area\ of\ the\ sample}$$

Where w = average weight of five samples

3.2   Phase II: Physical testing for performance and serviceability of fabrics

3.2.1   Determination of pilling and abrasion resistance properties

3.2.1.1   Pilling resistance of fabrics

Pilling, a fabric surface defect appears during wear and washing by the entanglement of loose fibres that protrude from a fabric surface under the influence of rubbing action. This test was carried out using Pilling tester.

The samples of 7.5 cm x 7.5 cm were cut and conditioned in the dessicator for 24 hours. The pilling resistance test was carried out under the load of 290 grams for 400

cycles. The number of cycles could be lowered for knitted fabrics and soft woven fabrics. The samples were observed with magnifying glass for pill formation.

3.2.1.2 Abrasion resistance of fabrics

Abrasion resistance of fabrics was done on Taber Abraser using ASTM D1175-61 standard. 13.0 cm round or square samples, five from each fabrics were cut and conditioned. All four fabrics had Lycra incorporated, so to avoid stretching and folding of the samples while abrading, the test samples were fixed in the abraser with S-36 mounting card and specimen holder; catalogue Number E 100-125. The abraser wheels and load ordinarily recommended with 500 grams load were used. The samples were subjected to abrasion. The samples were observed using magnifying glass for loss of luster, change of surface, colour change, appearance of first broken thread and a hole formation. The test was discontinued after the breakage of first thread. The samples were also checked for change in thickness due to abrasion.
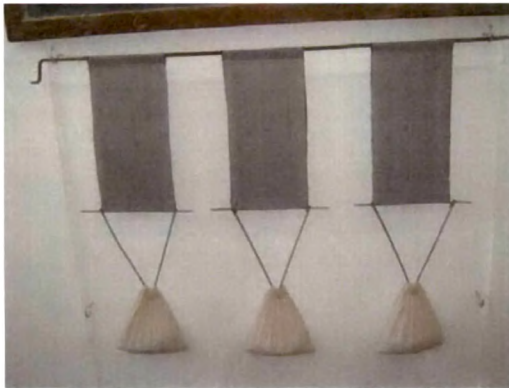
3.2.2 Determination of growth and elastic recovery property of fabrics

The instrument fabricated by **Mahiskar N. (1978) and Kunzru V (1982)** was modified and used for the study. The elastic properties of the samples were determined by the constant rate of loading.
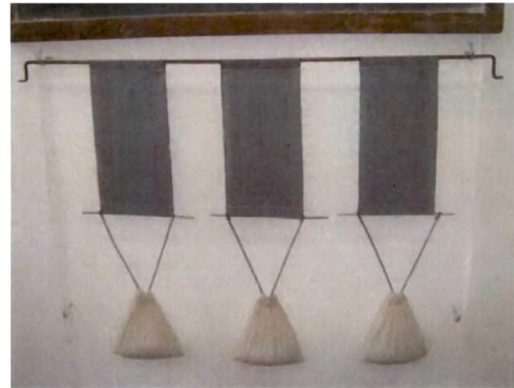
Three samples of 35 cm x 15 cm were cut from all the fabrics in warp wise and weft wise direction. Both the narrow ends were folded and hemmed to get ready fold of 3cms allowing enough space for aluminum rod to pass through. The samples were marked with 20 cm long benchmarks, three in each sample. Three samples were placed simultaneously on an aluminum rod. The rod was fixed and so the upper end of the samples. Another three small rods were selected to put through the lower ends of the samples.

Three sand bags each having total weight of 500 gm including the weight of the rods was prepared. The samples were mounted on the aluminum rod and then placed horizontally on two fixed hooks on the wall. The small rods were inserted through the lower hem, one in each sample. The sand bags were then hung to the small aluminum rods by means of metal wires. The samples were then freely suspended with constant rate of load of 500 gm for 24 hours.Readings were noted from the benchmarks after 24 hours for maximum stretched length. The samples were then unloaded and allowed to
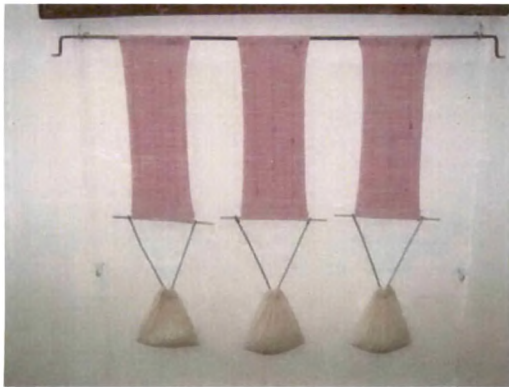
relax for 24 hours. The benchmarks were measured for immediate and delayed elastic recovery behavior. [22][19] (Plate 3.1).
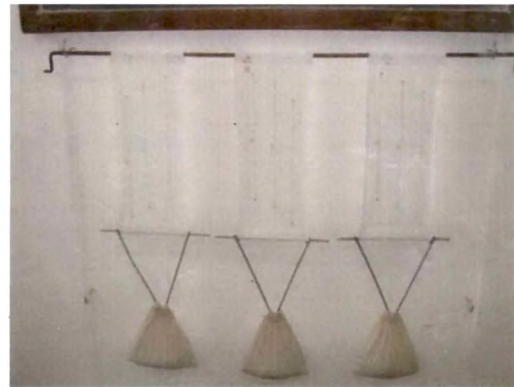

A – Plain (2x2 basket) weave fabric   **B – Twill (2x2) weave fabric**

C – Single jersey knit fabric   **D – Rib knit fabric**

Plate 3.1: Fabric samples under stress for growth and recovery property under constant rate of load

3.2.3   Determination of strength and elongation properties

The tensile strength and elongation of fabrics were determined on Lloyd Tensile Testing Instrument using ASTM D 5034 standard. The instrument was based on the principle of CRE (Constant rate of Extension).
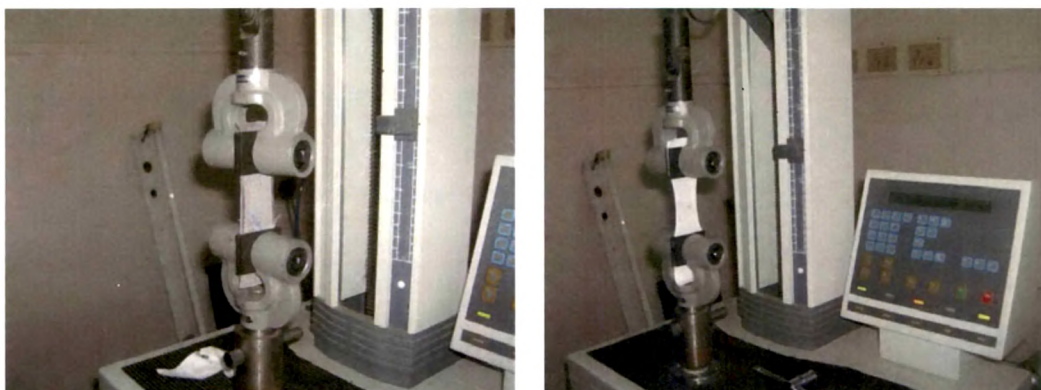
Woven fabric   Knitted fabric

Plate 3.2: Tensile Strength testing of Woven and Knitted fabric samples

Five samples of 7.5 cm x 5 cm from each fabric were cut in lengthwise, widthwise and bias direction. The samples were subjected to elongation with gauge length of 50 mm for 39 mm^2 area with cross head speed of 12 mm/min. (Plate 3.2).

3.2.4   Determination of shrinkage behavior of fabrics

Fabric shrinkage was observed by washing the samples in Launder-o-meter following ASTM D 2724 test method. Three samples of 35 cm x 20 cm size in lengthwise as well as widthwise direction were cut from each fabric. Three datum lines, each one of 20 cm length were marked on every sample with permanent marker. The samples were subjected to three laundry cycles, each one of 45 minutes. Two sets of samples were made, one for water wash and another washed with 5% non-ionic detergent, Teepol. The treatment of washing was given codes as follows:

L1W - Wash cycle I - treatment with only water

L2W - Wash cycle II - treatment with only water

L3W - Wash cycle III - treatment with only water

L1T - Wash cycle I - treatment with 5% detergent solution

L2T - Wash cycle II - treatment with 5% detergent solution

L3T - Wash cycle III - treatment with 5% detergent solution

The samples from all four fabrics with their respective codes were labeled for type of wash, number of wash cycles, and direction of fabric to be measured for shrinkage. In all 24 samples for water and 24 samples for detergent wash were tested.

The samples treated with water were gently pressed between the palms to remove excess of water and dried flat on blotting paper. Teepol treated samples were rinsed with water, pressed between the palms and flat dried on blotting paper. All these samples after drying were ironed gently to remove excess of creases and conditioned in a standard testing atmosphere. The datum lines were measured and noted. Average readings for each direction & wash cycle were noted. Dimensional change (% shrinkage) was calculated using the following formula[6]:

$$Dimensional\ change(\%\ shrinkage) = \frac{100(L_o - L_1)}{L_o}$$

Where L_o is the distance between the datum lines before washing and

L_1 is the distance between the datum lines after washing.

3.2.5   Determination of air permeability of fabrics

Air permeability or porosity is an important property of fabrics used in the clothing industry, principally from view point of comfort. It is the measure of the resistance of fabrics to passage of air through them. The Matefem Air-permeability tester was used to determine the air permeability of fabrics. Average of three readings was taken and reported in $m^3/mt^2/hr$ for fabrics before and after laundry.


Plate 3.3: Matefem Air-permeability Tester

Control samples, without any treatment and laundered samples, treated with water and 5% Teepol solution were subjected to air permeability tests. Five readings from different areas of every sample were taken and reported in $m^3/mt^2/hr$ (Plate 3.3).

3.2.6   Determination of stress-strain behavior under cyclic loading

This test was carried out for the purpose of studying performance of fabric during wear. From the results and graph of tensile strength for each fabric in lengthwise, widthwise and bias direction, standardization of load within limitation of deformation stage was done to achieve maximum recovery of fabric. The basic tensile graphs for every fabric in warp, weft and bias direction were obtained. Yield point for maximum recovery at extension and peak load was marked on tensile graph (3.1). On the basis of yield point samples were tested under cyclic load at yield point, below yield point and above yield point of recovery stage. Fabric extension and recovery characteristic were measured on Lloyd Tensile Testing Instrument in tensile mode using the ASTM standard D 1774 – 94, Vol. 07.01, 1998. The results obtained in mm were represented in cm finally to compare garment stretch and recovery with fabric recovery property.
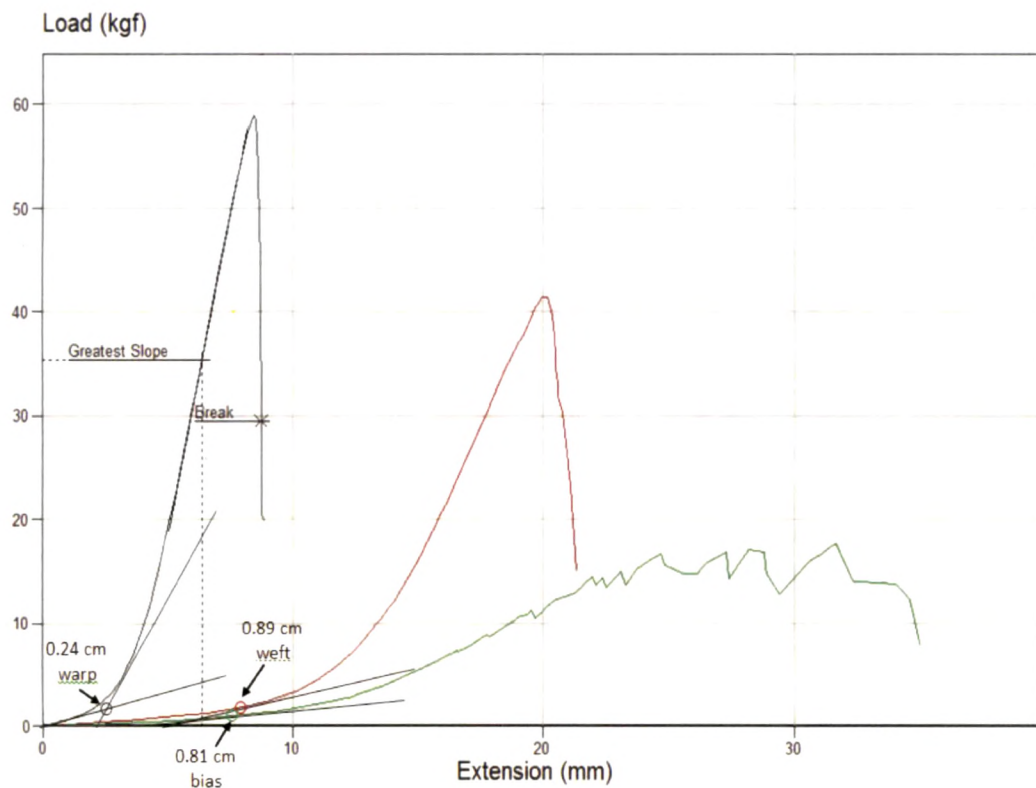
Graph 3.1: Yield points for fabric A in warp, weft and bias direction

3.2.7 Determination of seam strength of fabrics

A fabric tensile test on fabrics containing a seam is a commonly used method to determine seam quality.

The fabrics taken for the research had 3% Lycra yarn incorporated with 97% of cotton. The mill finished fabrics were ready to use, so any preparatory steps like pre-shrinkage was not followed and samples were stitched for seam strength directly. All-purpose polyester sewing thread as suggested by Betzina S. was tested for strength and elongation property. Textured polyester thread was also tested. It was found that textured polyester thread gives better stretch and compatibility with Lycra blends; hence it was used for sewing samples. Two samples of 10 cm x 10 cm in lengthwise, widthwise and bias direction were sewn with textured polyester thread using 75/11 HS stretch needle. The four threads over lock seam was introduced perpendicular to the direction of test to be performed. Five samples for each direction were prepared and tested for seam strength and seam slippage. In all 60 samples, 15 for each fabrics were taken for seam strength property. [53]

3.3 Phase III: Construction of garments

The tested fabrics were used for construction of the upper garment to study stretch, fit and appearance, and recovery behavior of these fabrics.

3.3.1 Development of basic bodice and sleeve block for construction of garments

The basic pattern of garment with specified design details was taken as pilot study and standardized. It was developed on muslin using draping method to check the position of the construction lines and fit of the garment on the dress form. Paper pattern was developed from this draped muslin garment. The design details were princess style from mid armscye to waist, for both front and back, round neck and sleeveless. The length of the garment was till the waist line (Plate 3.4). [39]
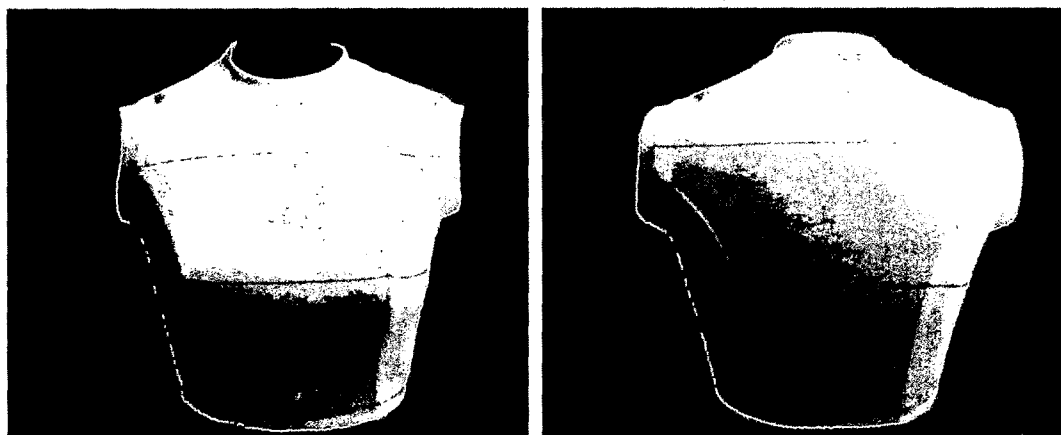
Front View   Back view

Plate 3.4: Basic pattern developed for pilot study

Basic construction lines like shoulder seam and side seam were kept unaltered. The princess style was introduced at the pilot study stage only by converting basic waist and side seam dart into princess line from mid arm hole to waist. Basic bodice pattern with darts with woven Lycra would not give effective fit and with stretch property of Lycra control of fabric fullness through dart would not be suitable. Hence these darts were converted into princess line and pattern of the garment to fit the shape of the body was developed. This would further help to analysed the effect of stretch on garment seams when one size of the garment worn by many larger body sizes. The stretch character of fabric with woven and knitted Lycra maintained the placement of seams or showed any displacement was also observed. [39]

3.3.2   Adaptation of style for final garment construction

The standardized basic bodice block was tried on actual model of the same bust size (81.0 cm). Alteration was done for fit and shape of the garment. The design details were kept the same. The length of the garment was increased by 15 cm making the final length of the garment 55.0 cm. As the final garments were to be made from woven and knitted fabric varieties, centre front opening with zip was facilitated for ease of putting the garment on and taking off. Basic set-in sleeve pattern was also developed and constructed. The adapted style was tried on the model and its paper pattern was then finalized for final garment construction. [36]
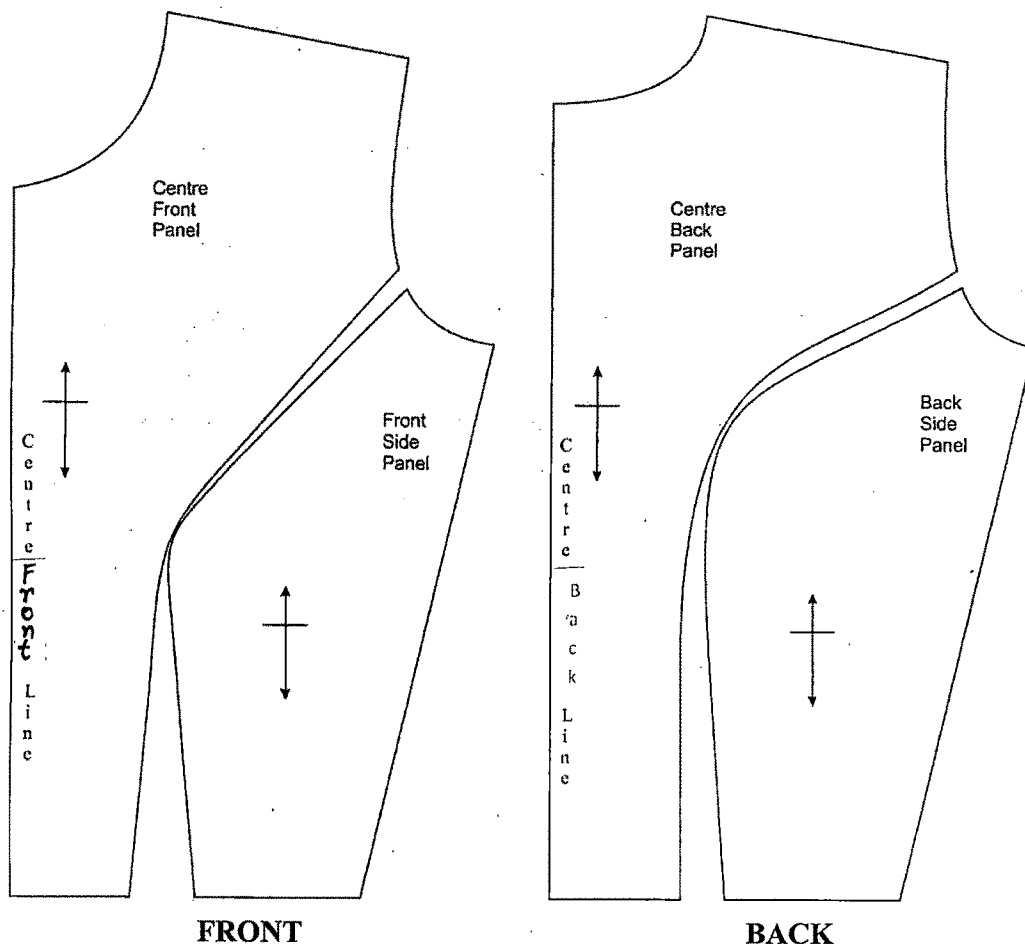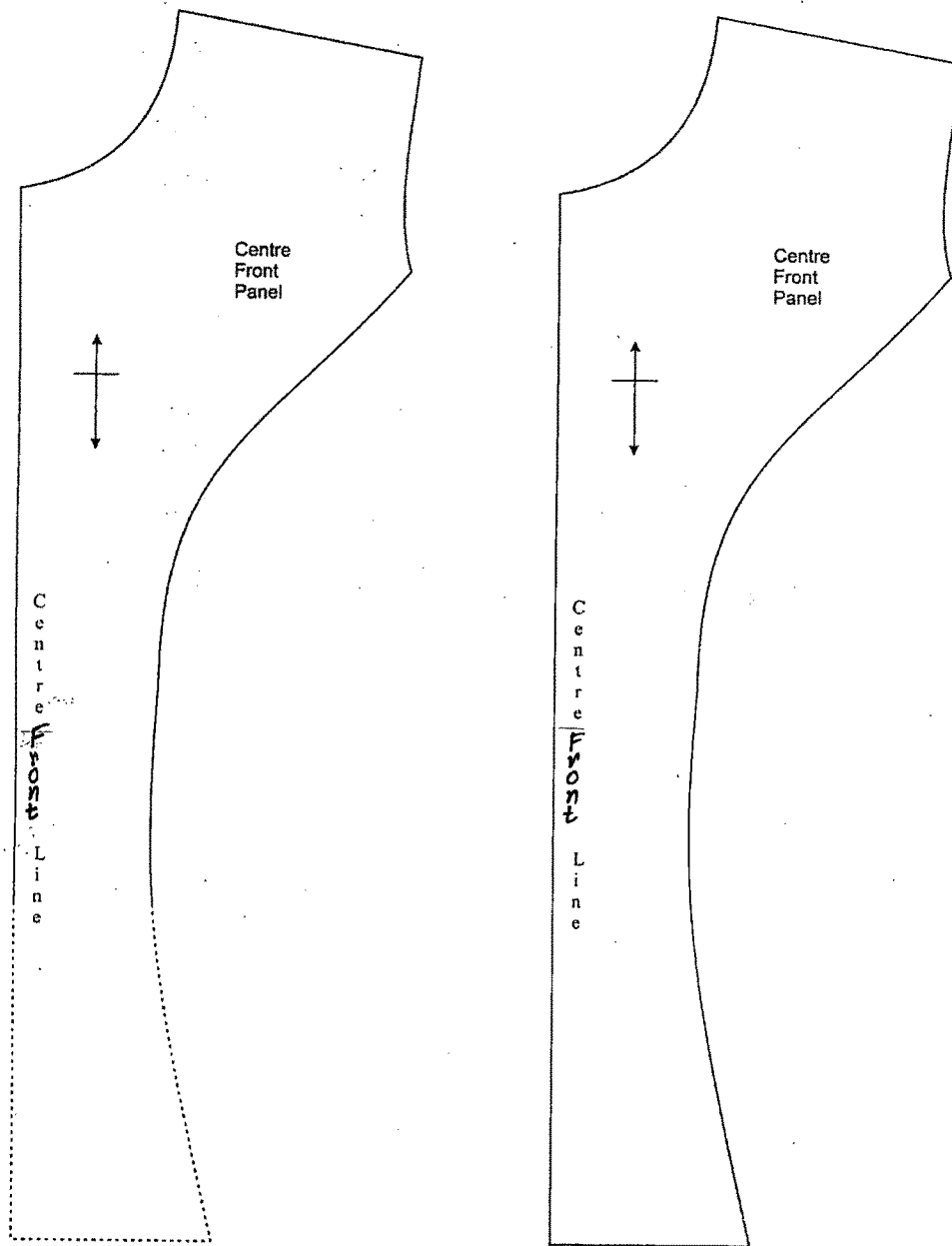
Centre
Front
Panel

C
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Front
Side
Panel

Centre
Back
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C
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Panel

FRONT

BACK

Plate 3.5: Basic patterns developed for the pilot study

Centre
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Centre
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FRONT PATTERN ADAPTATION

FRONT FINAL PATTERN

Plate 3.6: Front pattern adapted for final construction

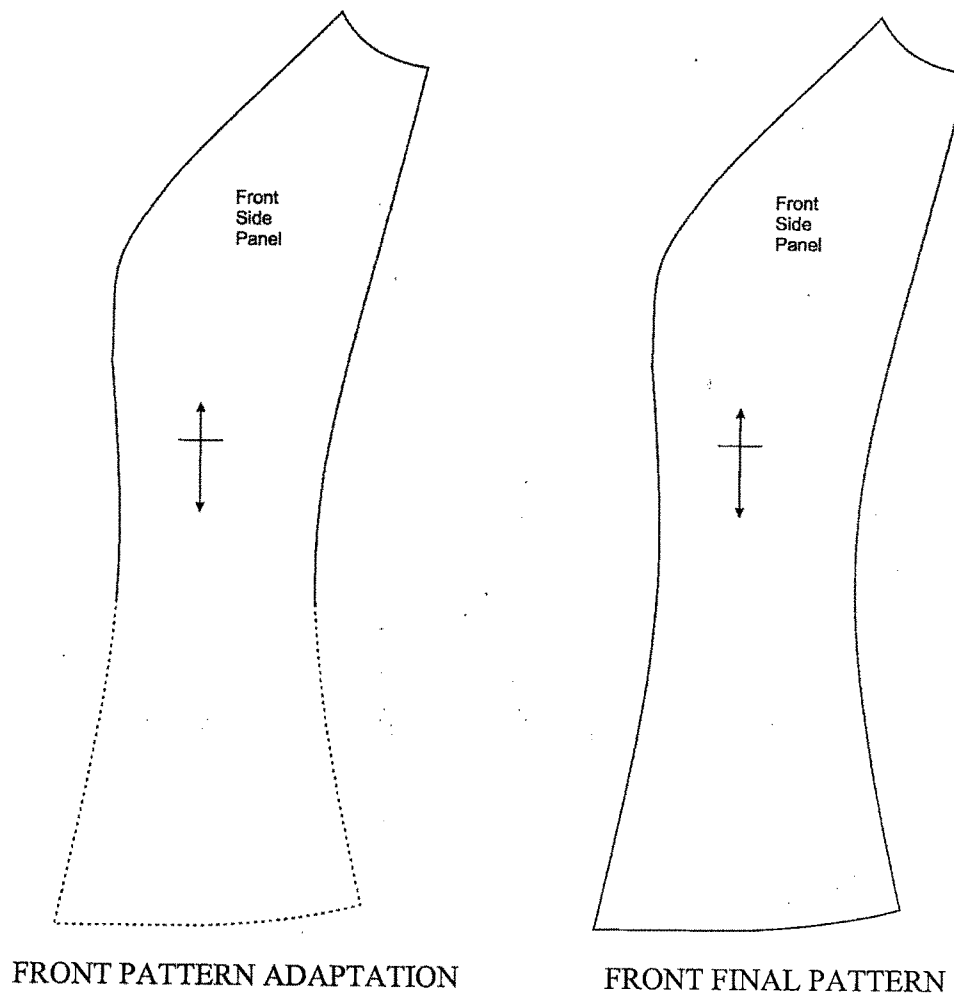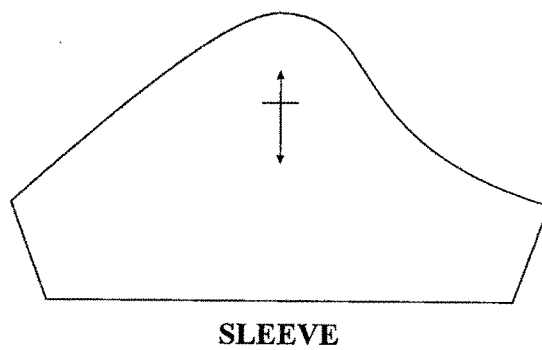FRONT PATTERN ADAPTATION   FRONT FINAL PATTERN

Plate 3.7: Front pattern adapted for final construction

SLEEVE

Plate 3.8: Basic sleeve patterns used for final construction

BACK PATTERN ADAPTATION   BACK FINAL PATTERN

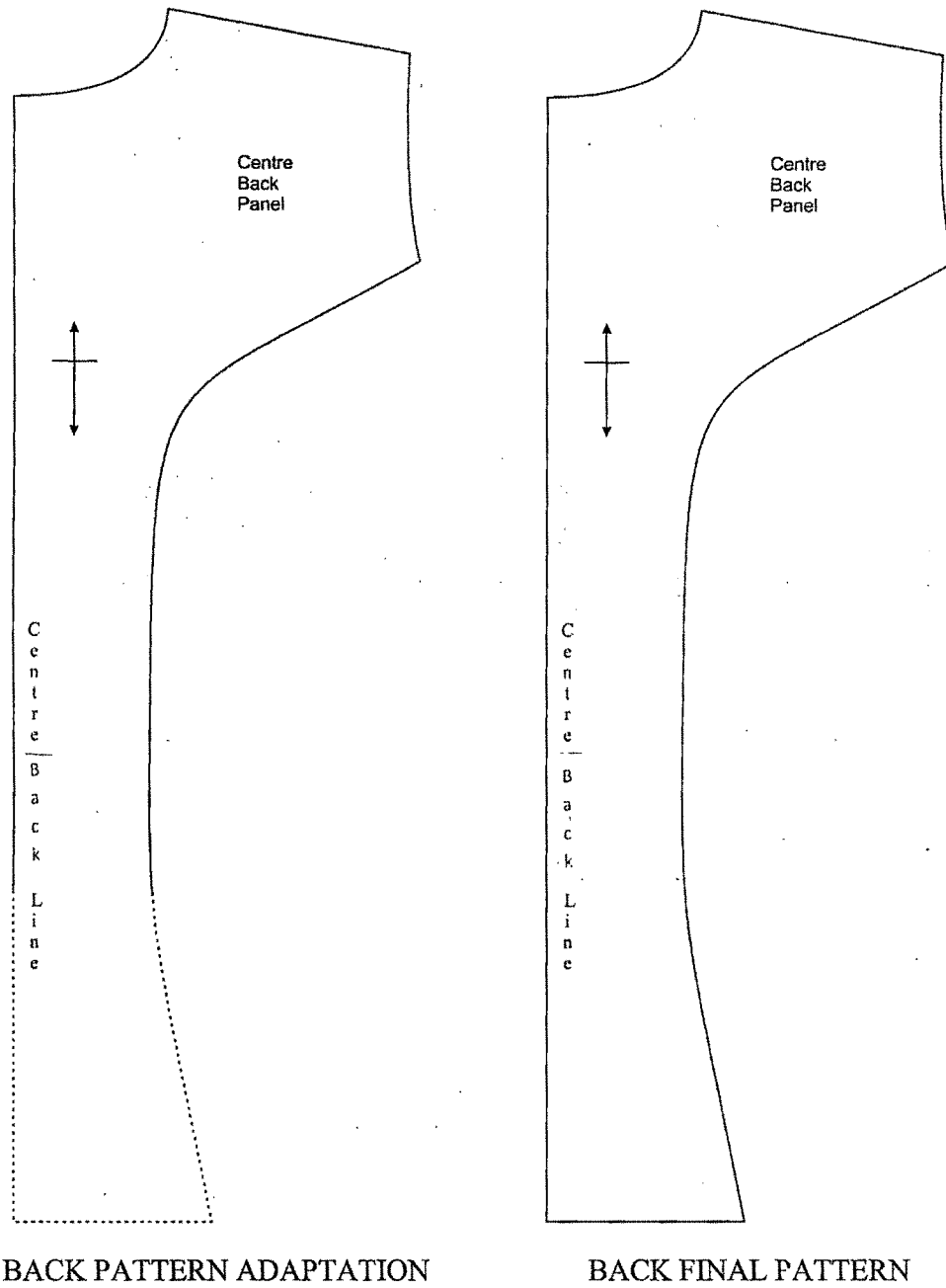**Plate 3.9:** Back pattern adapted for final construction

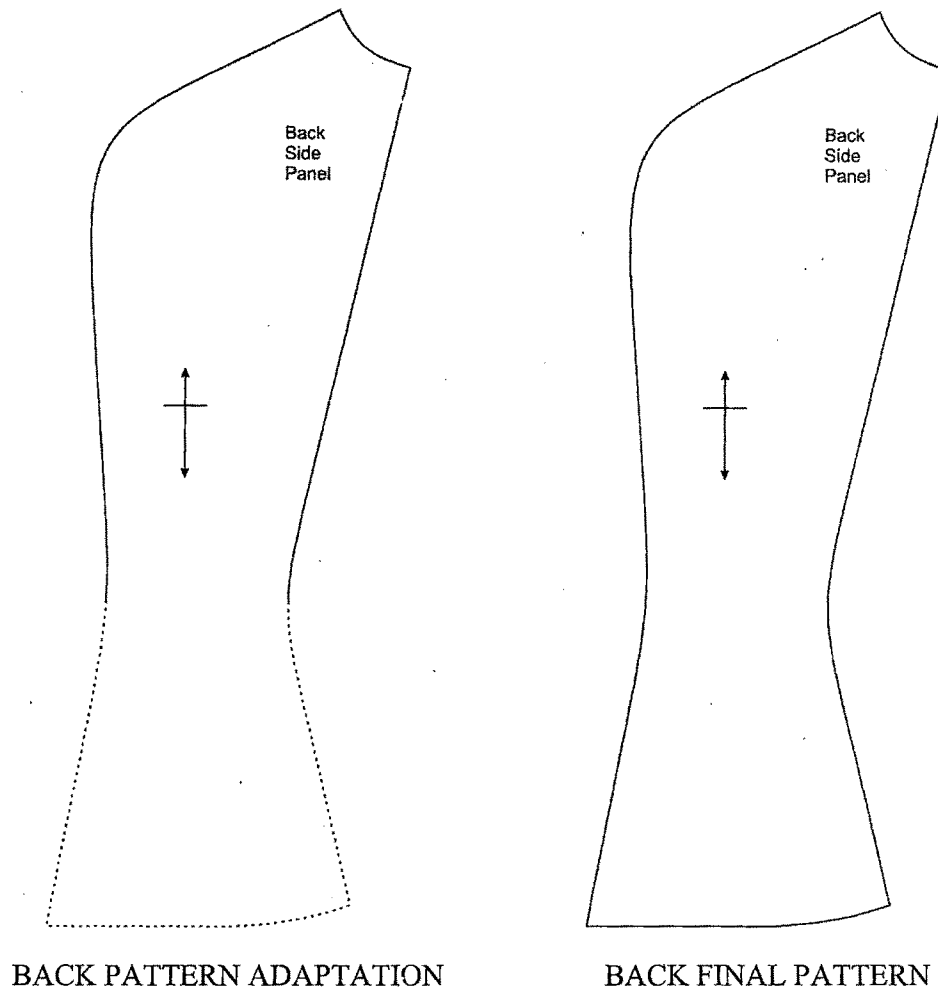BACK PATTERN ADAPTATION   BACK FINAL PATTERN

Plate 3.10: Back pattern adapted for final construction

The body measurements for female models of different bust size had been represented in Table 3.1. Development of basic bodice and sleeve block was done taking 81.0 cm bust round as standard size. The garment with adaptation in style was also constructed with the same size. The test fit of the garment was tried on the model and necessary alternations were done to fit the arm scye and fit at various girth levels.

Table 3.1: Measurement chart of subjects for wear trials (in cm)

Bust Round	81.0	86.0	91.0	96.0
Waist Round	66.0	72.0	74.0	86.0
Hip level	86.0	90.0	94.0	100.0
Bust to bust	18.0	18.0	19.0	19.0
Cage round	68.0	74.0	78.0	86.0
Bust length	26.0	26.0	28.0	28.0
Arm Round	35.0	37.0	38.0	44.0
½ Shoulder	16.0	16.0	16.0	16.0
Sleeve girth	25.0	25.0	26.0	35.0
Sleeve Length	16.0	16.0	16.0	16.0
Full length	55.0	55.0	55.0	55.0

The constructed garments (size 81.0 cm) were studied for extension and recovery behaviour when worn by larger size figures. Hence the effect of stretch at different areas of the body was noted by measuring body landmarks at various length and girth levels. Table 3.2 represents the details of measurements.

Table 3.2: Measurements of front and back body landmarks on standard 81.0 cm bust size garment

	Front (cm)	Back (cm)
a) LENGTH		
i) Full Length	55.0	55.0
ii) Bust Length	26.0	-
iii) Sleeve Length	16.0	-
b) GIRTH		
i) Armpit level	33.0	34.0
ii) Bust level	41.0	40.0
• Centre	18.0	20.0
• Right	11.5	10.0
• Left	11.5	10.0
iii) Waist level	34.0	34.0
• Centre	18.0	18.0
• Right	8.0	8.0
• Left	8.0	8.0
iv) Hip level	42.0	44.0
• Centre	20.0	22.0
• Right	11.0	11.0
• Left	11.0	11.0

3.3.3   Visual assessment of garments for overall appearance

The garments were constructed with standardized pattern details from selected fabrics for the research. Constructed garments were tried on model to assess the garment fit and appearance. Front and back appearance of the garments were recorded photographically. These garments then tried on models of larger bust size of 86.0 cm, 91.0cm and 96.0cm. This helped to visualize the stretch ability of Lycra incorporated fabrics on various body sizes. Appropriateness of garment fit or looseness was also noted to related elastic property with garment design.

3.3.4   Assessment of garment stretch and recovery property after wear trials

The garments stretch and recovery property was worked out in the pilot study. On the basis of that the constructed garments were marked with benchmarks in lengthwise and widthwise direction at various places measured and noted. The garments were then given to subjects to wear for 8 hours duration for their routine activities. Garments were measured while on subjects. After 8 hours of use, the garments were taken off and measured to immediate elastic recovery. Delayed elastic recovery was measured after 24 hours and percent elastic recovery was calculated using the formula below:

$$Percent\ Elastic\ recovery\ =\ \frac{Extended\ Size\ -\ Original\ Size}{Original\ Size}\ \times 100$$

On the basis of the percent elastic recovery, suggestions for garment sizing and styling were drawn.[6][39]

3.3.5   Analysis of fabric and garment properties

Physical properties of fabrics were related to garment properties for final application of fabric for apparel use was statistically analysed. On the basis of strength, elongation and elastic recovery properties of garment were discussed.