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JTATM Journal of Textile and Apparel, Technology and Management

Volume 8, Issue 4, Spring2014

Handle and Comfort Characteristics of Cotton Core Spun Lycra and Polyester/ Lycra Fabrics for Application as Blouse

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ABSTRACT

Stretchable plain woven fabrics are developed with 60^s cotton core spun Lycra and polyester Lycra twisted yarn (91D) in weft with cotton, silk and polyester in warp. The influence of fabric specifications on thermal comfort, low stress mechanical properties, primary and total hand value is analyzed. The results indicated that cotton core spun Lycra woven with polyester warp provided higher value of thermal conductivity, air permeability and water vapor permeability. The woven stretch fabrics produced with polyester warp, cotton core spun Lycra and polyester Lycra in weft has excellent aesthetic and drape properties. These fabrics have higher tensile resilience, tensile strain, lower shear rigidity, superior primary hand and a higher total hand value of 4.08 and 3.93 respectively and are best suitable for women's blouse.

Keywords: Cotton core spun Lycra, polyester/Lycra, woven stretch, fabric handle, sari blouse

Introduction

Stretch is often the most important property of textiles that contribute to wearer comfort. The stretch yarn and fabrics are widely used and preferred by the people in the last few years all over the world because of their stretch ability and shape retention properties. Spandex (Lycra) provides stretchable and form fit in garments. Spandex has a high breaking elongation (usually 500% to 800%), a low modulus and a high degree and rate of recovery from stretching [1]. Spandex fibers have good resistance to ultra violet radiation, heat, oxygen, oil and are also resistant to hydrolysis [2]. The work covered in this paper is primarily based on cotton core spun Lycra and polyester/lycra twisted yarn. Several studies have been carried out investigating the physical properties of core spun yarn, cotton/lycra and properties of the fabrics containing different rates of spandex yarns. Core spun cotton/spandex shows high resiliency property than 100% cotton yarns, due to its soft and rubbery isocyanate segments, which has a random coil structure, in the spandex yarn [3]. AL-ansary investigated the effect of spandex ratio on the properties of woven fabrics made of cotton/spandex spun yarn and the results reveal that the ratio of spandex has a significant influence on the physical properties of woven fabrics [4]. The amount of elastane has a considerable effect on dimensional and elastic properties of fabrics [5]. Babaarslan compared different core materials, such as Lycra, textured PES and textured nylon filaments in the production of PES/viscose core yarn, and reported that core yarn with Lycra has the lowest strength and highest elastic recovery compared to core yarns containing textured filaments [6].

To produce woven stretchable garments that can adhere to the shape of the body better with comfortable fit, this study aimed to develop woven stretch fabrics with three different fibers namely cotton, silk and polyester yarns in warp with cotton core spun Lycra and polyester/Lycra twisted yarn in weft and analyze the thermal comfort and handle of these fabrics for women's sari blouse. Two sets of fabrics were produced , one set with cotton, silk and polyester in warp and 60^s cotton core spun Lycra in weft and another set with cotton, silk and polyester in warp and polyester Lycra twisted yarn (91D) in weft. A total of six woven stretch fabrics, cotton/cotton core spun Lycra, silk/ cotton core spun Lycra, polyester/ cotton core spun Lycra, cotton/polyester Lycra, silk/polyester Lycra and polyester/polyester Lycra fabrics have been studied. The influence of fabric specifications on thermal comfort and total hand value of cotton core spun Lycra and polyester twisted Lycra fabrics were studied.

Experimental

Materials

Cotton core spun Lycra yarn of 60^s Ne is used with Lycra in the core and cotton forming the sheath, and polyester Lycra twisted yarn (91D) were used as filling yarn. Six different (1×1) plain woven fabrics were produced using cotton, silk and polyester in warp with cotton core spun Lycra in weft, and cotton, silk and polyester in warp with polyester Lycra twisted yarn in weft. The details of fabric construction and physical properties are described in Table 1.

Table1. Fabric constructional parameters and characteristics

Fabric code	Warp yarn	Weft yarn	Yarn count warp* weft (Denier)	Finished fabric Set/Inch warp* weft	Lycra count (Denier)	Cover factor	Weight g/m^2	Thick ness, mm	Lycra % in weft yarn	Lycra % in fabric
T_1	Cotton	Cotton core spun Lycra	89 *89	110* 76	40	19.03	129.56	0.77	8.20	5.07
T_2	Polyester		21 * 89	132*72	40	14.9	100	0.90	8.20	6.95
T_3	silk		31 * 89	154*88	40	18.3	125	0.99	8.20	6.37
T_4	Cotton	Polyester Lycra twisted	89 * 91	152*72	40	21.8	134.75	0.67	10.20	5.44
T_5	Polyester		21 * 91	224 *82	40	19.4	105.39	0.71	10.20	7.44
T_6	Silk		31 * 91	232 * 76	40	21.42	127.44	1.07	10.20	7.40

Methods

Thermal comfort properties

Air permeability test

The air permeability of the woven stretch fabrics was obtained by KES-F8-AP-1 air permeability tester. This test method covers the measurement of the air permeability--the rate of air flow passing perpendicularly through a known area under a prescribed air pressure differential between the two surfaces of a material of textile fabrics. The result of air permeability expressed as air resistance (R) was recorded in term of kPa s/m in which a larger value of air resistance (R) indicates poorer air permeability of the fabric and vice versa [7].

Thermal conductivity test

The thermal property was studied by using Lee's disc apparatus. This test is used to measure the speed at which the heat travels through a material through conduction. The transmission of heat occurs both by conduction through the fiber and the entrapped air and by radiation. The Figure 1 represents the simple form of Lee's disc which has been used for determining the thermal conductivity of woven stretch fabrics. The sample is placed in between a steam chamber N and a brass disc M. The thermometers T_1 and T_2 are inserted into the holes in N and M to record the temperatures on the two sides of the sample. The heater is switch on to heat the brass disc and the temperatures of all disc increases in nonlinear relationships and at different rates with the time according to its position from the heat source. And the temperatures were recorded every (5 minutes) until reach to the equilibrium temperature of all disks. To find the rate at which heat is radiated by the disc M, it is brought directly into contact with the steam chamber after removing the fabric sample and its temperature T raise about 10^0C above the steady temperature T_2. With a stop clock, the time is recorded for every one degree fall of temperature as it cools from (T_2+5) ^{0}C to $(T_2-5)^0$C. Similar calculations are made with the other readings and the average value of the rate fall of temperature R at $T_2{}^0$C is found.

Heat Conducted by the specimen = $K A (T_1 - T_2) / d$. (1)

Heat lost by the disc = $MSR (2h+r) / (2h+2r)$ (2)

At the steady state $K A (T_1 - T_2)/d = MSR (2h+r) (2h+2r)$ (3)

Thermal conductivity of the sample $K = MSR.d (2h+r)/A (T_1 - T_2) (2h+2r)$ (4)

where M-mass of the disk , S-specific heat capacity of the brass , d-thickness of the sample, R-rate of fall temperature due to heat, h-thickness of the brass disc, r-radius of the brass disc and A-surface area of the sample.

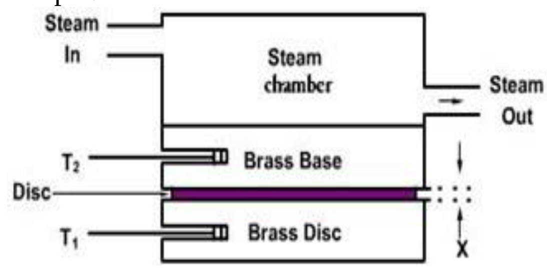


Figure 1. Lee's Disc

Water vapor permeability test

The water vapor permeability of the samples was studied with the SDL, Atlas M261, water vapor permeability tester. The evaporation cup method was used to measure the resistance of fabric to moisture vapor as per BS 7209:1990. The fabric was sealed over cylindrical distilled water and the rate of evaporation was measured under standard atmospheric conditions. The moisture vapor resistance was calculated in grams of water passing through the square meter of fabric in 24 hours.

Fabric hand evaluation

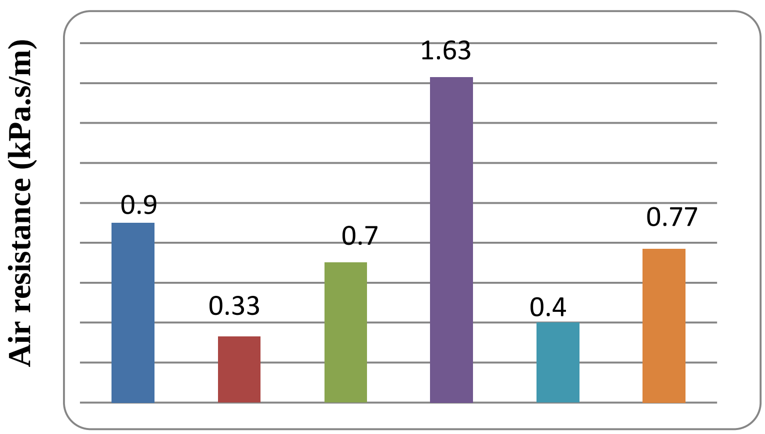
The KES-F (Kawabata Evaluation System) was used for measuring low-stress mechanical properties of woven stretch fabrics [8]. The tensile and shear properties were studied on KES-FB1. The tensile properties were measured by plotting the force extension curve between 0 and a maximum force of 500gf/cm and the recovery curve. Shear properties were measured by shearing a fabric sample parallel to its long axis, keeping a constant tension of 10g/cm the clamp. Bending property was measured on KES-FB2 by bending the fabric sample between the curvatures ±2.5 / cm. Compression properties were tested on the KES-FB3 (compression tester) by placing the sample between two plates and increasing the pressure while continuously monitoring the sample thickness to a maximum pressure of 50 gf/cm^2. The surface roughness and coefficient of friction are measured using KES-FB4 (surface tester). All the fabrics were conditioned at 65 ±2% and 22± 1^0C before the measurement. Primary hand values (HV), Koshi (stiffness), Numeri (smoothness) and Fukurami (fullness and softness), required for determination of total hand value of woven stretch fabrics were evaluated on a scale of 0-5 by Kawabata hand evaluation equations using computer software.

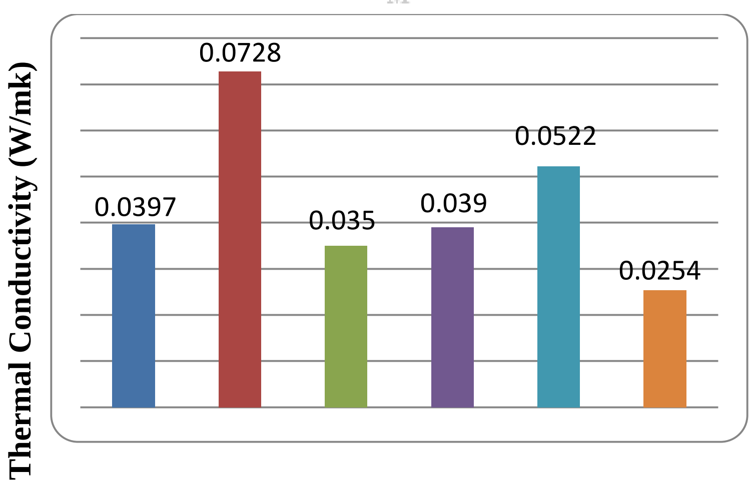
Results and Discussion

Thermal comfort properties

Air permeability

The air resistance (*R*) of cotton core spun Lycra and polyester/Lycra fabrics are shown in Figure 2. The air permeability of a fabric determines its resistance to wind penetration during stormy weather which affects the thermal insulation of the fabric and is closely related to the construction characteristics of the yarns it is made of, in which large volumes are occupied by air. In this study, it is observed that polyester/cotton core spun Lycra and polyester/polyester Lycra have lower air resistance value than other fabrics. This is due to the fact that these fabrics are made of finer yarns, lower cover factor that allows air to flow through the fabric, thus resulting in higher air permeability value than other fabrics. It is also observed that the fabric of cotton core spun Lycra (weft) and polyester Lycra (weft) with cotton warp (T_1 and T_4) have higher air resistance value than the other fabrics. This is due to the compact structure of the fabric having higher warp denier and fabric cover that reduces inter-yarn spacing and hence lesser number of pores of lower cross-sectional area available for air passage. The higher air resistance value thus implies a superior cover and hence gives improved fabric warmth.





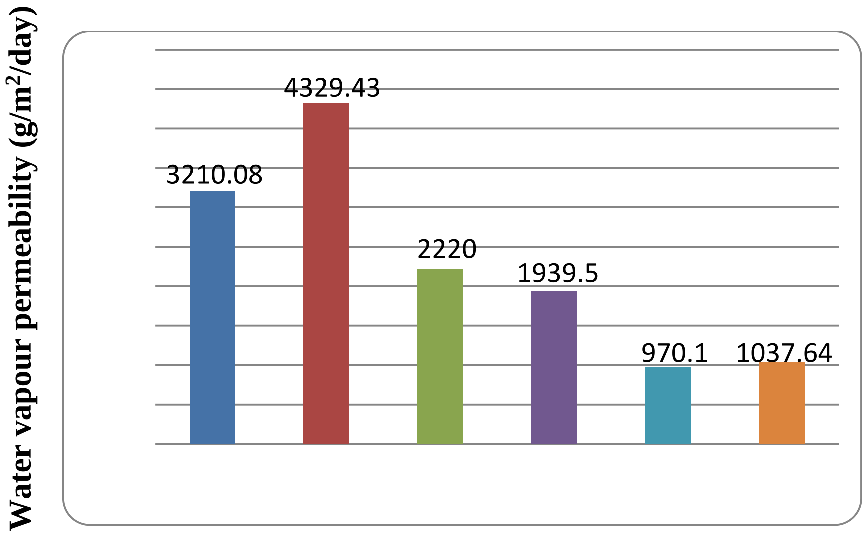


Figure 2. Thermal comfort of cotton core spun Lycra and polyester Lycra fabrics

Thermal conductivity

The maintenance of thermal balance is probably the most important physical comfort attribute of clothing. A higher value of thermal conductivity indicates a faster heat transfer from the skin to the fabric surface. This is usually associated with cooler feeling. The results of the thermal transport data for the fabrics are reported in Figure 2. It is observed that cotton warp and silk warp with cotton core spun Lycra and polyester Lycra (T_1, T_3, T_4, & T_6) shows lower thermal conductivity than their respective polyester warp samples. An increase in air permeability of the fabric means that more air will be able to penetrate through the fabric, which will enhance heat and vapor transfer from the guarded hot plate surface. Higher the air permeability, higher is the thermal conductivity value (T_2 & T_5). Polyester warp with cotton core spun Lycra (weft) and polyester Lycra (weft) (T_2 & T_5) samples have higher thermal conductivity value. This is attributed to the lower fabric cover that allows more air gaps in their fabric structure and thus improves the resultant thermal conductivity through the fabric. The higher air permeability value implies a more open structure, which will give a cooler perception to the wearer in comparison to a less permeable one.

Water vapor permeability

Water vapor permeability is the ability to transmit vapor from the body. The water vapor permeability of clothing materials is noted to be a critical property of textiles which contribute to comfort under hot and cold weather conditions. The results of the moisture transport data for the fabrics are reported in Figure 4. Cotton core spun Lycra fabrics (T_1, T_2 & T_3) shows good water vapor transmission results because of relatively better hygroscopicity of cotton. It can be observed that fabric composed of polyester/cotton core spun Lycra (T_2) exhibit higher water vapor permeability as this fabric is made of finer yarns with low fabric cover that gives higher porosity and thereby increasing the total air space within the fabric. Amongst all fabrics, polyester/polyester Lycra fabric (T_5) shows lowest water vapor permeability value, which is attributed to the hydrophobic nature of polyester that results in a relatively low level of comfort, as moisture is not absorbed nor drawn away from the skin. Amongst all fabrics developed, polyester/cotton core spun Lycra (T_2) has better air permeability, thermal conductivity and water vapor permeability.

Tactile comfort properties (Low stress mechanical properties)

Tensile Properties

The low stress tensile properties of cotton core spun Lycra and polyester Lycra fabrics are given in Table 2. EMT gives the tensile strain value under strip biaxial extension. It is the factor affecting tailorability and seam slippage. The higher the extensibility, the better is the fabric quality from the point of view of handle. According to Behara and Sardana, higher the EMT value, the greater will be the wearing comfort [9]. From the results, it is observed that polyester Lycra fabrics (T_4, T_5 & T_6) are having higher EMT value as compared to cotton core spun Lycra fabrics (T_1, T_2 & T_3). Polyester/polyester Lycra fabric (T_5) has highest value for EMT. This is because of finer denier in both warp and weft direction. Fabric woven with finer yarn count has good extensibility. The linearity of tensile property (LT) is indicative of wearing comfort. According to Behara, lower values of LT give higher fabric extensibility in initial strain range, and this gives comfort in wearing the cloth [10]. In addition, the higher value of LT means more elastic recovery of a fabric at a particular load and increases the dimensional stability of the fabric [11]. It is observed that there is no significant difference noted in linearity of tensile property curve (LT) between cotton core spun Lycra and polyester Lycra fabrics. Tensile energy (WT) is defined as the energy required for extending the fabric which reflects the ability of the fabric to withstand external stress during extension .The larger value of WT implicates a better tensile strength of the fabric [7]. In all the fabrics WT is higher in weft way than warp way. This is because of the stretch in weft way withstanding the stress during extension. Higher WT is observed in silk/polyester Lycra fabric (T_6) and in general polyester Lycra fabrics (T_4, T_5 & T_6) show higher value for tensile energy than cotton core spun Lycra fabrics (T_1, T_2 &T_3). This shows the toughness of polyester Lycra fabrics. The tensile resilience (RT) refers to the ability of fabric recovery after applying the tensile stress. The higher the tensile resilience of a fabric makes the fabric more elastic and improves better its fabric handle. It has been observed that RT values are higher for polyester/polyester Lycra fabric (T_5). This is due to finer denier of warp and weft yarn that gives better recovery. It was observed that fabrics woven from yarns of finer denier were observed to be easily stretchable when subjected to tensile deformation as can be observed from the values of tensile strain (EMT). This is also replicated in the higher values for tensile energy (WT) and tensile resiliency (RT).

Table 2. Tensile properties

Sample		LT	WT gf.cm/cm^2	RT %	EMT %
T_1	Warp	0.915	0.84	58.11	4.47
	Weft	1.103	8.51	66.43	25.65
	Avg	1.009	4.67	62.27	15.06
T_2	Warp	0.805	0.35	65.92	3.65
	Weft	1.035	8.41	63.87	30.85
	Avg	0.920	4.38	64.89	17.25
T_3	Warp	0.981	1.10	55.41	1.74
	Weft	1.081	6.93	67.75	32.50
	Avg	1.031	4.01	61.58	17.12
T_4	Warp	0.927	0.31	54.24	2.55
	Weft	1.095	15.05	83.36	54.60
	Avg	1.011	7.68	68.80	28.58
T_5	Warp	0.842	0.59	71.43	1.84
	Weft	1.067	14.95	77.76	79.20
	Avg	0.955	7.77	74.60	40.52
T_6	Warp	0.848	0.39	48.75	1.47
	Weft	0.999	19.75	70.12	56.50
	Avg	0.923	10.07	59.44	28.99
EMT- Tensile strain, LT-Linearity of tensile property, WT-Tensile energy and RT-Tensile resilience					

Shear Properties

The shear rigidity of a fabric depends on the mobility of warp and weft threads at the intersection point, which depends on weave, yarn diameter and the surface characteristics of both fiber and yarn. From the point of view of handle, the lower the shear rigidity, the better the fabric handle. Shear rigidity (G) and hysteresis of shear force at 0.5 degree (2HG) and 5 degrees (2HG5) for cotton core spun Lycra and polyester Lycra fabrics are shown in Table 3. Polyester/cotton core spun Lycra (T_2) and Polyester/polyester Lycra fabric (T_5) has the lowest value for shear and shear hysteresis properties. This may be attributed to the finer denier of polyester in warp. The higher value of shear rigidity causes difficulty in tailoring and discomfort during wearing. The lowest value of shear rigidity for the polyester/polyester Lycra fabric (T_5) suggests that this fabric will adjust to three dimensional shape easily in response to shearing deformation force. Silk fabrics (T_3 & T_6) exhibit a higher value of shear rigidity and shear hysteresis. This is due to high coefficient of friction (MIU) of the fabric surface that prevents the movement of yarn in the body of the fabric during the application of shear force.

Table 3. Shear properties

Sample		G gf/cm.deg	2HG gf/cm	2HG5 gf/cm
T_1	Warp	1.54	4.39	3.40
	Weft	1.28	2.14	3.25
	Avg	1.41	3.26	3.33
T_2	Warp	1.49	4.26	3.11
	Weft	1.01	2.23	3.06
	Avg	1.25	3.24	3.09
T_3	Warp	1.63	5.34	3.74
	Weft	1.24	3.51	3.93
	Avg	1.43	4.43	3.83
T_4	Warp	1.08	3.28	3.01
	Weft	0.71	2.18	2.09
	Avg	0.90	2.72	2.55
T_5	Warp	0.92	2.47	2.50
	Weft	0.62	1.50	1.61
	Avg	0.77	1.99	2.06
T_6	Warp	1.42	3.74	3.30
	Weft	0.85	1.81	2.06
	Avg	1.14	2.78	2.68
G-Shear rigidity,2HG-Hysteresis of shear force at 0.50, 2HG5-Hysteresis of shear force at 5^0				

Bending Properties

Bending rigidity (B) gives an idea of the textile drapeability that is the tendency of a fabric to bend by the influence of its own weight. The fabric's bending rigidity basically depends on the bending rigidity of constituent yarns from which the fabric is manufactured, the fabric construction and mobility of threads within the fabric. Bending rigidity is the important mechanical property influencing the tailor ability of the fabrics. The lower the value of bending rigidity, the easier for the fabric to bend. 2HB represents the hysteresis of bending moment which is a measure of recovery from bending deformation. The results for bending properties are shown in Table 4. It is observed that there is no significant difference noted in bending rigidity (B) and hysteresis of bending movement (2HB) between cotton core spun Lycra and polyester Lycra fabrics. Silk/polyester Lycra fabric (T_6) shows the highest bending rigidity and hysteresis of bending movement. This is due to higher ends per inch (EPI) and thickness that made the fabric more rigid. From Table 4, it is also observed that B and 2HB values are higher in warp direction than in weft direction. This is due to higher warp density.

Table 4. Bending properties

Sample		B gf.cm^2/cm	2HB (gf.cm/cm)
T_1	Warp	0.0561	0.0513
	Weft	0.0203	0.0364
	Avg	0.0382	0.0438
T_2	Warp	0.0349	0.0540
	Weft	0.0339	0.0256
	Avg	0.0344	0.0398
T_3	Warp	0.0488	0.0815
	Weft	0.0287	0.0511
	Avg	0.0387	0.0663
T_4	Warp	0.0789	0.0897
	Weft	0.0067	0.0249
	Avg	0.0428	0.0573
T_5	Warp	0.0665	0.0552
	Weft	0.0134	0.0104
	Avg	0.0400	0.0328
T_6	Warp	0.1064	0.2059
	Weft	0.0078	0.0234
	Avg	0.0571	0.1146

B-Bending rigidity, 2HB-Hysteresis of bending movement

Surface Properties

The surface characteristics are one of the most important parameters contributing to the smoothness of the fabric. Yarn and fabric construction parameters influence the surface features of the fabric. The surface properties in terms of coefficient of friction (MIU), mean deviation of MIU (MMD) and geometrical roughness of cotton core spun Lycra and polyester Lycra fabrics are shown in Table 5. Higher value of MMD corresponds to larger variation of friction. It is observed from Table 5, that there is no significant difference noted in coefficient of friction (MIU) and mean deviation of MIU (MMD) between cotton core spun Lycra and polyester Lycra fabrics. The geometrical roughness (SMD) determines the surface properties of friction (drag) and surface contour (roughness). The higher the geometrical roughness value, the rougher the fabric surface Silk /cotton core spun Lycra and silk/polyester Lycra fabrics (T_3 & T_6) shows highest geometrical roughness (SMD) value and thereby makes the fabric surface less smooth and rougher. This is because of higher warp density and thickness that increases the area of contact and thus reduces the evenness of the fabric surface and results in crinkled effect. Cotton/cotton core spun Lycra and cotton/polyester Lycra fabrics (T_1 & T_4) has lower geometric roughness value and thus indicates that the fabric has a smooth surface. This is because of lower warp density and thickness that prevents altering the surface property and cause evenness in the fabric surface and makes it smoother.

Table 5. Surface properties

Sample		MIU	MMD	SMD (μm)
T_1	Warp	0.187	0.0170	5.32
	Weft	0.192	0.0136	3.67
	Avg	0.190	0.0153	4.49
T_2	Warp	0.194	0.0169	4.84
	Weft	0.218	0.0168	5.66
	Avg	0.206	0.0169	5.25
T_3	Warp	0.209	0.0171	4.74
	Weft	0.222	0.0221	7.55
	Avg	0.216	0.0196	6.14
T_4	Warp	0.228	0.0140	4.05
	Weft	0.254	0.0155	3.24
	Avg	0.241	0.0147	3.65
T_5	Warp	0.301	0.0189	4.20
	Weft	0.299	0.0183	5.76
	Avg	0.300	0.0186	4.98
T_6	Warp	0.336	0.0274	5.99
	Weft	0.358	0.0280	8.26
	Avg	0.347	0.0277	7.13
MIU-Coefficient of friction, MMD-mean deviation of MIU, SMD-Geometrical roughness				

Compression Properties

The compressibility of a fabric mainly depends on the yarn packing density and yarn spacing in the fabric. Compressibility provides a feeling of bulkiness and spongy property in the fabric. Compression has correlation with the thickness of the fabric. The fabric compression properties, linearity of load thickness curve (LC), compression energy (WC) and compression resiliency (RC) values of cotton core spun Lycra and polyester Lycra fabrics are shown in Table 6. The linearity of compression mainly depends on the fabric thickness and compression characteristics of the yarn. Results show that silk/polyester Lycra fabrics (T_6) have the highest LC value. This is because of higher fabric thickness. The higher the thickness value, the higher the compressibility. The Compression energy (WC) value implies the fluffy feeling of the fabric. When the values of WC are increased, the fabric will appear fluffier [12]. Compression energy (WC) depends on LC and amount of compression. Silk/cotton core spun Lycra and silk/polyester Lycra (T_3 & T_6) has the highest value of WC. This is so because, silk in warp with cotton core spun Lycra and polyester/Lycra in weft, when woven into fabric, due to its thickness increases the contact area between yarns and as a result, the inter yarn frictional force will increase that would in turn make the fabric more difficult to compress. Compression resilience (RC) determines the percentage of reduction in fabric thickness, when a compression load is increased. The higher the compression resilience values, the higher the thickness reduction and greater the fabric foaminess. A higher percentage indicates better recovery property. The results indicate that fabrics with cotton, polyester and silk in warp woven with polyester Lycra (T_4, T_5 & T_6) recover better than cotton core spun Lycra samples (T_1, T_2 & T_3). This is attributed to the resilient nature of polyester Lycra yarn that makes the fabric to recover better. It was also observed that cotton/polyester Lycra (T_4) has the highest compression resilience value. This was attributed to the higher fabric cover and weight leading to compact structure and higher surface area resulting in better interlocking of the structure and shows lower compressibility and higher recovery.

Table 6. Compression properties

Sample	LC	WC (g.cm/ cm^2)	RC %
T_1	0.496	0.075	60.54
T_2	0.514	0.100	60.74
T_3	0.588	0.109	60.89
T_4	0.520	0.041	76.49
T_5	0.612	0.049	72.03
T_6	0.673	0.066	70.69
LC-Linearity of Compression, WC-Compressional energy and RC-Compressional resilience.			

Fabric Hand Value

The three primary hand values, namely *Koshi*, *Numeri*, *Fukurami* and Total Hand Value (THV) of the fabric was calculated to characterize these cotton core spun Lycra and polyester Lycra (stretchable) fabrics for women's thin dress. Table 7 shows the primary hand value and total hand value of cotton core spun Lycra and polyester Lycra fabrics. The Primary hands used to characterize women's thin dress were *koshi* (stiffness), *Numeri* (smoothness), and *Fukurami* (fullness and softness). The Primary hands are rated numerically on a scale from 0 (weak) to 10 (strong) and the Total Hand Value is rated from 1(poor) to 5(excellent). Primary hand and Total hand values of the cotton core spun Lycra and polyester Lycra fabric samples for women's thin dress reveals that all the fabrics were rated above 5 for *Koshi* (stiffness) indicating that these fabrics are medium to strongly stiffer. Higher value of *Koshi* was observed in cotton warp woven with cotton core spun Lycra and polyester Lycra fabrics (T_1& T_4).This is because of the inherent characteristic of cotton yarn that makes it stiffer than other yarns. The *Numeri* (smoothness) value of fabric is a function of surface characteristics of fibers and yarns used for fabric manufacturing. Polyester/cotton core spun Lycra (T_2) has the highest *Numeri* value. This is because finer denier of polyester warp and cotton core spun Lycra weft provides smoother surface. The *Fukurami* value is a measure of fullness and softness of a fabric and it mainly depends on compressional properties of fabrics. Polyester/cotton core spun Lycra and polyester/polyester Lycra (T_2 & T_5) has the highest *Fukurami* values among the cotton core spun Lycra and polyester Lycra fabrics. The rated values were above 7 for *Fukurami* revealing that the cotton core spun Lycra and polyester Lycra fabrics are medium to strong in fullness and softness. The Total Hand Value (THV) of the fabric is estimated with the help of primary hand values using the Kawabata system of equations. The results show that THV value is higher for Polyester/cotton core spun Lycra (T_2- 4.08) thus proving that this fabric is excellent for women's thin dress. The Total Hand Value (THV) were above 3 for rest of the cotton core spun Lycra and polyester Lycra fabrics revealing that these fabrics are moderately suitable for women's thin dress and specifically for blouse.

Table 7. Primary and Total hand value of cotton core spun Lycra and polyester Lycra fabrics

Sample	Koshi	Numeri	Fukurami	THV
T_1	6.10	6.18	7.81	3.99
T_2	5.79	6.28	8.29	4.08
T_3	5.72	5.64	7.69	3.76
T_4	5.99	5.24	7.29	3.56
T_5	5.82	6.17	7.66	3.93
T_6	5.50	4.36	7.09	3.30

Conclusions

The study investigates the handle and thermal comfort analysis of developed cotton core spun Lycra and polyester Lycra fabrics and studied the influence of fiber properties, fabric specification on thermal comfort and handle. The study performed a quantitative investigation of primary and total hand value of cotton core spun Lycra and polyester Lycra fabrics. The outcomes of the study explicitly revealed that polyester/cotton core spun Lycra fabric shows higher air permeability, thermal conductivity and water vapor permeability. Finer denier of polyester in warp with cotton core spun Lycra and polyester Lycra in weft were seen to have higher softness, smoothness (increased *Numeri* and *Fukurami*) and highest total hand value, thereby giving a higher rating for sample 2 (T_2- Polyester warp with 60 Ne cotton core spun Lycra as filling yarn) and sample 5 (T_5- polyester warp with 91D polyester Lycra as filling yarn) making it best suitable for women's blouse.

The woven stretch fabrics developed for blouse using cotton core spun Lycra and polyester Lycra yarn makes it more comfortable to wear by allowing the fabric to stretch well, prevents shrinking and helps blouse to maintain their original shape, and also lessens the wrinkled appearance in blouse. The polyester/cotton core spun Lycra and polyester/polyester Lycra fabrics developed for blouse gives a lustrous appearance. The study will help the manufacturers in developing a new stretchable cotton core spun Lycra fabric with exacting fabric characteristics that would give much softer and smoother feel with good drapeability and tailorability for women's wear. The study further helps the manufacturers to enhance the fabric quality in respect of soft feel comfort.

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