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Changes of Dimensional Stabilities for Viscose, Polyester and Spandex Constituents: A Study on Knit Fabric Stage versus Garments Stage

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Abstract: Dimensional stability is one of the fundamental issues from customer point of view due to after use changes of length and width of garments hinder the proper use ability of garments. The paper is to investigate the change of dimensional stabilities and their association and difference with different selective synthetic fibres constituents. Fabrics and their adjacent garments samples are washed with detergent and the changes of length and width are measured in respect of previous dimensions. A sample of 50 repeated measures was conducted to measure the dimension change. Then the data was processed using software – Statistical Package for Social Science (SPSS) to determine the association and difference. It is revealed that there is significant association with viscose fibre composition and change of length after 1st and 3rd wash as well as change of width after 3rd wash at fabric stage. However, at garments stage, there is significant association with viscose fibre composition and change of length after 1st wash as well as with change of width at 3rd wash. 1st wash of fabric and garments significantly differ with its 3rd wash, however, there is no significant difference between fabric and garments after the same wash.

Keywords: *Fabric, Garments; Wash, Change of Length, Change of Width.*

1. INTRODUCTION

The dimensional stability of fabric and garments determines whether the fabric and garments can retain its original shape and remain stable when applied over a substrate, and its suitability for specific use. So it is one of the vital phenomenon of fabric as well as garments which needs to be confirmed of dyed fabric and finished garments as per the requirements of buyer. When customers buy garment according to size and after wash it becomes small or large than requirements, it is shocking for the customer. The fabric with proper dimensional stability is worn and washed for many times, which rarely affect the user experience. The fabric with poor dimensional stability is usually shown as shrinkage which can be in sewing, ironing, washing and so on, from them, wash shrink is the problem that consumer pays close consideration. There are numbers of parameters which can affect dimensional stabilities. Like for woven fabric weave types with high number of interfacings and lower crimp values even in case of higher number of interfacings have better dimensional stabilities [1], on the other hand in case of pique knit fabric compared to single jersey fabric stitch density, stitch type and wash type has a significant similar effect on shrinkage whereas sewing thread type have no role as well as shrinkage value is less for pique than jersey [2]. Again shrinkage of yarn in contributed little to the dimensional change of knitted fabric while the wale and course spacing before laundering followed a parabolic relationship similar to that of the laundered fabrics exhibited the least change in dimensions [3] whereas for non-scoured yarn dyed knitted fabric degree of distortion off the knitting machine have significant effects on shrinkage even 3% shrinkage can be achieved if there is careful yarn selection with controlled knitting and finishing process [4]. A test method is developed to assess fused system twisting characteristic after shrinkage [5].After washing eyelet knitted Vincel and Courtelle fabric shows certain amount length shrinkage whereas slack fabrics shows considerable width extensions [6]. On the other hand for 1 x 1 rib knitted fabric composing 100 % cotton and 93 % cotton with 7 % spandex shows further shrinkage after relaxation in which higher length, area shrinkage and lower width shrinkage found for spandex oriented fabric [7]. But for tumble drying level of length and width shrinkage in plain single jersey and lacoste is increased rapidly as their moisture content fall below 20 % with or without heat [8]. Knit fabric of acrylic fibre have no significant relaxation shrinkage until exceeding transition temperature but width relaxation shrinkage is rapid than length [9]. Apart from this large linear shrinkage is found after dry cleaning for cotton Punto-di-Roma double jersey knit fabric which is prominent in earlier cycle than later one [10]. Due to washing of plain knit blended fabric area shrinkage is reduced for Terylene, Tricel and Courtelle composition whereas decrease in shrinkage for wool and nylon blends and vice versa for all wool blends with fibro and fibrolane yarns [11]. Other factors; such as knit type, fabric tightness, types of yarn and fibre percentage have significant impact on shrinkage while length shrinkage is higher than width for pique but for plain and fleecy knit it is completely opposite as well as 50/50 cotton/polyester shrinks less than 100 % cotton [12] but single-knit structures made of viscose fibre are subject to extreme shrinkage, mainly in terms of length, because of its difference in crystalline and amorphous structure than that of cotton fibre [13]. Besides, a set of prediction equations are proposed by regression analysis for different types of fabric and finishing route where it has been found that finishing process, yarn count and stitch length of knit fabric affect length and width [14] whereas increase in yarn twist reduce shrinkage [15]. On the other hand line drying is better than tumble and higher lycra percentage in composition shows better result for shrinkage as well for knit fabric [16]. Again, shrinkage of different knit fabrics followed upon ten cycles of different relaxation methods where in the length direction there are gradual progressive shrinkage but in the width direction it has found opposite senses [17] but it is significantly reduced but not in a liner way by increasing the resin concentration and curing time resulting a severe loss in the fabric bursting strength which can be improved by increasing softener concentration including loss in shrinkage control [18]. Presently various treatment are used to stabilize dimensional stability in which resin treatment is one of them. For resin finish increase the set of yarn which reduce dimensional change after wash and tumble drying [19] while mercerization is used to improve the dimensional stability of cotton knits [20] and compacting is similar successful method for improving dimensional stability but may not last more than 4−5 washes [21]. Apart from this to predict the shrinkage there are several methods are studied among them a feasible shrinkage prediction method for plain knitted fabric is presented based on deformable curve [22] and similar study is carried out to predict dimensional changes for circular knitted cotton fabrics by controlling manufacturing and processing variables [23]. Besides, fuzzy model has been developed for predicting mechanical properties of the viscose/lycra plain knitted where it has been found that yarn tenacity has the greatest and main effects on the fabric bursting strength than that of yarn count and knitting stitch length [24]. Therefore, previous studies show the

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effects of different factors like washing, drying, weave type, fibre composition, fabric types, fabric design, knitting stiffness, relaxation, yarn twist and degree of distortion on dimensional changes that is on shrinkage for knit and woven fabric as well. Besides there are few studies on the application of treatment to stabilize dimensional changes as well as for the prediction of shrinkage there are few methods are examined and assessed. By considering the facts this study is to reveal the difference of dimensional changes of knit fabric and its corresponding garments due to 1st and 3rd wash by investigating the association between fibre (viscose, polyester, spandex) composition and dimensional changes of knit fabric with its adjacent garments are studied for 1st and 3rd wash.

2. METHODOLOGY

A. Materials

Wascator washing machine (Front loading horizontal rotating drum type), Stability template and percentage ruler, Balance/scales, Over lock sewing machine, Standard makeweights, Tumble dryer, Non-rusting mesh trays for drying/relaxing, Metal ruler with mm graduations, knit fabric and adjacent same garments comprising of different fibres constituents like cotton, polyester and spandex.

B. Methods

i) Sample Preparation

The method of sample preparation is done according to buyer Mark & Spencer PLC test method originally derived from ISO 3759:1994 (E) method [Chapter 6.2 and 6.3 of ISO 3759] originated from ISO 3759 Textiles-Preparation, marking and measuring of fabric specimen and garments in test for determination of dimensional change. Overall procedure of marking is same, only template containing slots and holes is used for precise measurement for facilitating easy and convenient test procedure. Furthermore ISO 5077 Textile-Determination of dimensional change in washing and drying indicates the same measurement procedure like ISO 3759 method. According to figure 1 marking is done by template maintaining 1 to 12 slots and holes. Actually measurement in length and width taken in three position and overall length and width is calculated from the average of three measurements. It may be mentioned that according to Mark and Spencer & ISO 3759 one sample is taken for this procedure rather than multiple samples.

Fabric: Fabric specimens are taken after 50mm of the fabric end. Then place and mark the specimen the fabric as shown in Figure 1. The template consists of 12 slots (positions 1 to 12 on the diagram) and 8 holes (positions 1 to 6, 9 and 10). The distance between each pair of slots/holes is 350mm. After marking the specimen in the numerical sequence indicated in the diagrams draw a line around the template and cut along this line without rounding off the corners to provide a 500 mm square specimen for testing.

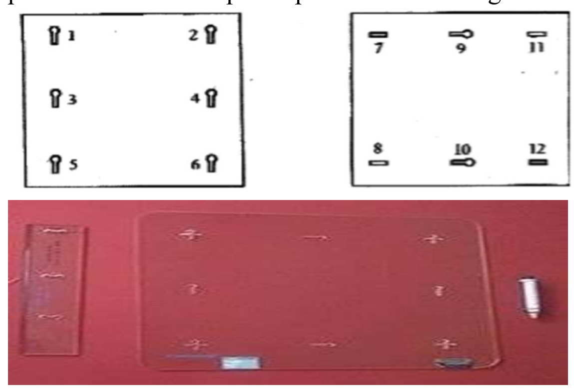

Figure 1. Sample marking for measuring dimensional changes and template

After that to get double thickness folded the fabric end to end by positioning the template parallel to the end and sewed by over lock sewing machine. Finally by a texpen mark through the holes onto one side of the double thickness of fabric.

Garments: Marked two lengths and two widths approximately 25mm in from the side seams and the top or bottom of the garment. Measured by using a metric rule; recorded these measurements to the nearest millimetres by turning the garments inside out before marking and also for measuring. Here length measurement is taken on wale direction and width measurement is taken on course direction.

ii) Process

One sample from a fabric using template measurements in three positions for both course and wale and the recoded value for dimensional change is actually the average of those three measurements in three positions then the following process is carried out for further course of action.

Wash Load: Test specimens is weighed and the load up to 2kg by the addition of makeweights.

Detergent: 20 'g' non-phosphate powder detergent containing optical brightening agent in 0.5 litters of warm water.

Wash Method: BS EN ISO 6330-2012

Washing:

i. Placed the wash load (5N) in the Wascator by ensuring that test specimens are not folded and then close the door.
ii. Set the temperature of 50˚C with 100% Polyester having 2 kg total load.
iii. Started the machine and added the prepared detergent mix by pouring it through the dispenser.
iv. At the end of the wash program, removed the specimens, taken care not to distort them.

Tumble Dry and Relaxation: According to methods of Mark and Spencer samples having nylon polyester and spandex are tumble dried for 45 min considering main constituents; on the other hand for viscose the specimen are tumble dried for 90 minute considering the blends and generic type of constituents. Finally lay the specimens individually on the mesh trays for 4 hours before measuring.

a) Fabric: Hold the percentage ruler at an angle of approximately 45˚ to fabric with the percentage scale against the specimen. Then recorded the change in dimension (average of the 3 lengths and widths as percentage) between the three length marks and the three width marks.

b) Garments: The washed dimension with change of each length and width as a percentage is reported by calculating the percentage change of garments dimensions by using the following formula:

$$\frac{Original\ measure - after\ wash\ measure}{original\ measure} \times 100 = \%\ Change \qquad (1)$$

Analytical tools

Random samples of knit fabric specimens comprising of different fibres constituents like cotton, polyester and spandex are taken then they are washed and measured the dimensional changes. After that same garments of same fabric constituents are washed and measured the dimensional changes. In both stages dimensional changes are measured for after 1st and 3rd wash. Then calculated data of dimensional changes of fabric and garments is input in SPSS and based on the viscose, polyester and spandex constituents descriptive statistics are analysed first and then to analyse association between dimensional changes and fibre constituents Chi-square test done. Finally paired samples T-Test is done to differentiate the dimensional changes of fabric versus fabric and fabric versus garments after 1st and 3rd wash.

3. RESULT AND DISCUSSION

A. Association between fibre composition (viscose, polyester, spandex) and dimensional changes of knit fabric with its adjacent garments

During analysis of 50 fabric specimens and their adjacent garments all fibres that is viscose, polyester and spandex constituents are classified into three classes that is <11%, 11-35%, >35 %; <30%, 30-80 %, >80% and 0%, >5%, 1-5% respectively. Besides, dimensional changes are also classified into three categories that is no, >2.5% and <2.5%.

Table I shows the association between viscose fibre composition and length, width changes after 1st and 3rd wash of fabric and its adjacent garments where it has been found that, no changes are found in length for 5 fabric samples and for 9 garments samples after 1st wash which is significant but in case of 3rd wash 70% and 57.7% samples have no changes respectively for fabric and garments having below 11% viscose whereas 19 fabric samples and 17 garments samples are changed in length about below 2.5% after 1st wash but after 3rd wash 9 samples of fabric and 5 of garments are changed below 2.5% having below 11% viscose. Again among 11 samples of 11-35% viscose most of the cases length changes above 2.5% in 34.6% and 33.3% samples of fabric and garments after 1st wash but after 3rd wash there is no changes for 30% and 23.1% samples respectively and rest are changed above 2.5% but there is no samples are changed below 2.5%. But above 35% viscose composition of 13 samples, 11 fabric samples and 10 garments samples are changed in length about above 2.5% whereas 52.4% fabric and 31.6 % garments are changed in length above 2.5% after 3rd wash. On the other hand, for width in maximum cases viscose containing below 11% causes mostly no changes, above and below 2.5%

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changes whereas below 2.5% width changes are found for maximum samples of fabric and garments.

Table II shows the association between polyester fibre composition and length, width changes after 1st and 3rd wash of fabric and its adjacent garments where it has been found that, no changes are found in length for all fabric samples and for 60% garments samples after 1st wash which is significant for below 30% polyester composition but after 3rd wash no changes in length are found mostly having 30-80% polyester for fabric but below 30% polyester for garments. Again after 1st wash length changes below 2.5% is found mostly for above 80% polyester compositional fabric and garments of 90% and 80 % samples respectively which is also significant whereas after 3rd wash 50 % fabric samples and 66.67 % garments samples are changed in length having polyester of above 80%. Furthermore in case of length changes of above 2.5%, below 30% polyester oriented fabric and garments are changed in length more that is 50.5% and 57.1% respectively after 1st wash which is significant whereas the percentage is also more after 3rd wash. On the other hand, in terms of width after 1st and 3rd wash no changes are found maximum for having polyester fibre of 30-80% both for fabric and garments stage but which is different in terms of width changes below 2.5% because it is more in fabric and garments having polyester fibre above 80%. Again width changes of above 2.5% after 1st and 3rd wash is maximum in the fabric and garments having polyester of below 30%.

Table III shows the association between spandex fibre composition and length, width changes after 1st and 3rd wash of fabric and its adjacent garments where it has been observed that, after 1st wash length is not changed for 5 samples of fabric having no spandex whereas in garments the no. of sample is 6 but where 36.36% garments sample having above 5% viscose have no changes in length which is significant whereas after 3rd wash no changes has been found for 45% and 53.8% respectively which are for above 5% viscose composition. Again below 2.5% length changes are found mostly for spandex composition off 1 to above 5% spandex composition for 1st wash which is significant but slightly different after 3rd wash that is more for fabric and garments having no spandex. Furthermore for above 5% spandex composition fabric and garments, length changes above 2.5% mostly. On the other hand for width after 1st wash 50% fabric are not changed having spandex of 1-5% whereas 62.5% garments have not changed having spandex above 5% but after 3rd wash in both stage the changes is maximum for composition of above 5%. Again fabric and garments having spandex above 5% have been changed below and above 2.5% mostly after 1st and 3rd wash.

TABLE I. CROSS TABULATION BETWEEN FABRIC, ITS ADJACENT GARMENTS LENGTH, WIDTH CHANGE FOR VISCOSE FIBER (%) COMPOSITION (AFTER 1ST AND 3RD WASH)

Dimensional Changes	**Changes Status**	**Fabric Stage**				**Garments Stage**			
		Viscose Fiber Composition (%)			**Chi-Square**	**Viscose Fiber Composition (%)**			**Chi-Square**
		<11%	11%-35%	>35%		<11%	11%-35%	>35%	
Length Change (1st Wash)	No	5 (71.43)	1 (14.29)	1 (14.29)	30.769***	9 (81.82)	1 (9.09)	1 (9.09)	26.353***
	<2.5%	19 (90.48)	1 (4.76)	1 (4.76)		17 (85)	2 (10)	1 (5)	
	>2.5%	6 (23.1)	9 (34.6)	11 (42.3)		4 (19)	7 (33.3)	10 (47.6)	

Width Change (1st Wash)	No	3 (60)	1 (20)	1 (20)	4.597	5 (71.4)	1 (14.3)	1 (14.3)	4.256
	<2.5%	20 (64.5)	6 (19.4)	5 (16.1)		18 (64.3)	6 (21.4)	4 (14.3)	
	>2.5%	7 (46.7)	2 (13.3)	6 (40)		7 (46.7)	2 (13.3)	6 (40)	
Length Change (3rd Wash)	No	14 (70)	6 (30)	0 (0)	23.794***	15 (57.7)	6 (23.1)	5 (19.2)	4.835
	<2.5%	8 (80)	1 (10)	1 (10)		5 (71.43)	1 (14.29)	1 (14.29)	
	>2.5%	7 (33.3)	3 (14.3)	11 (52.4)		10 (52.6)	3 (15.8)	6 (31.6)	
Width Change (3rd Wash)	No	10 (58.8)	6 (35.3)	1 (5.9)	12.267**	10 (47.6)	6 (28.6)	5 (23.8)	8.030*
	<2.5%	13 (72.22)	1 (5.55)	4 (22.2)		15 (78.95)	1 (5.26)	3 (15.79)	
	>2.5%	6 (40)	3 (20)	6 (40)		5 (45.5)	3 (27.3)	3 (27.3)	

*p<0.1, **p<0.05, ***p<0.01

TABLE II. CROSS TABULATION BETWEEN FABRIC, ITS ADJACENT GARMENTS LENGTH, WIDTH CHANGE FOR POLYESTER FIBER (%) COMPOSITION (AFTER 1ST AND 3RD WASH)

Dimensional Changes	Changes Status	Fabric Stage				Garments Stage			
		Polyester Fiber Composition (%)			Chi-Square	Polyester Fiber Composition (%)			Chi-Square
		<30%	30-80%	>80%		<30%	30-80%	>80%	
Length Change (1st Wash)	No	5 (71.43)	1 (14.29)	1 (14.29)	44.571***	6 (60)	2 (20)	2 (20)	27.571***
	<2.5%	1 (5)	1 (5)	18 (90)		1 (5)	3 (15)	16 (80)	
	>2.5%	13 (50.5)	11 (42.3)	2 (7.7)		12 (57.1)	7 (33.3)	2 (9.5)	
Width Change (1st Wash)	No	1 (25)	2 (50)	1 (25)	3.616	2 (28.6)	3 (42.9)	2 (28.6)	4.233
	<2.5%	10 (32.3)	6 (19.4)	15 (48.4)		8 (28.6)	7 (25.0)	13 (46.4)	
	>2.5%	7 (46.7)	4 (26.7)	4 (26.7)		8 (53.3)	2 (13.3)	5 (33.3)	
Length Change (3rd Wash)	No	2 (11.8)	8 (47.1)	7 (41.2)	11.922**	10 (38.5)	8 (30.8)	8 (30.8)	5.679
	<2.5%	8 (44.4)	1 (5.6)	9 (50.0)		1 (16.67)	1 (16.67)	4 (66.67)	
	>2.5%	8 (53.3)	3 (20)	4 (26.7)		8 (42.1)	3 (15.8)	8 (42.1)	
Width Change (3rd Wash)	No	5 (25)	8 (40)	7 (35)	18.288***	6 (28.6)	8 (38.1)	7 (33.3)	6.743
	<2.5%	1 (10)	1 (10)	8 (80)		7 (38.9)	1 (5.6)	10 (55.6)	
	>2.5%	13 (61.9)	3 (14.3)	5 (23.8)		5 (45.5)	3 (27.3)	3 (27.3)	

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**p<0.05, ***p<0.01

TABLE III. CROSS TABULATION BETWEEN FABRIC, ITS ADJACENT GARMENTS LENGTH, WIDTH CHANGE FOR SPANDEX FIBER (%) COMPOSITION (AFTER 1ST AND 3RD WASH)

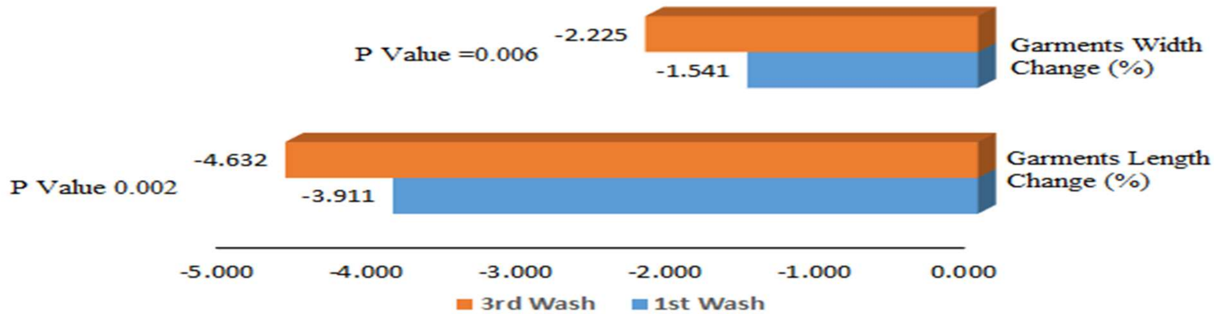
Dimensional Changes	Changes Status	Fabric Stage				Garments Stage			
		Spandex Fiber Composition (%)			Chi-Square	Spandex Fiber Composition (%)			Chi-Square
		0%	>5%	1-5%		0%	>5%	1-5%	
Length Change (1st Wash)	No	5 (71.43)	1 (14.29)	1 (14.29)	26.654***	6 (54.55)	4 (36.36)	1 (9.09)	14.991***
	<2.5%	6 (31.6)	6 (31.6)	7 (36.8)		5 (26.3)	7 (36.8)	7 (36.8)	
	>2.5%	2 (7.7)	21 (80.8)	3 (11.5)		2 (9.5)	16 (76.2)	3 (14.3)	
Width Change (1st Wash)	No	1 (25)	1 (25)	2 (50)	2.871	2 (25)	5 (62.5)	1 (12.5)	3.793
	<2.5%	8 (25.8)	17 (54.8)	6 (19.4)		6 (21.4)	14 (50)	8 (28.6)	
	>2.5%	4 (26.7)	9 (60)	2 (13.3)		5 (33.3)	8 (53.3)	2 (13.3)	
Length Change (3rd Wash)	No	6 (30)	9 (45)	5 (25)	8.148*	7 (26.9)	14 (53.8)	5 (19.2)	0.817
	<2.5%	5 (55.6)	3 (33.3)	1 (11.1)		2 (40.0)	2 (40)	1 (20)	
	>2.5%	2 (9.5)	15 (71.4)	4 (19)		4 (21.1)	11 (57.9)	4 (21.1)	
Width Change (3rd Wash)	No	2 (11.8)	10 (58.8)	5 (29.4)	5.830	2 (9.5)	14 (66.7)	5 (23.8)	6.786
	<2.5%	8 (44.4)	8 (44.4)	2 (11.1)		8 (44.4)	8 (44.4)	2 (11.1)	
	>2.5%	3 (20)	9 (60)	3 (20)		3 (27.3)	5 (45.5)	3 (27.3)	

*p<0.1, ***p<0.01

B. Comparison among length and width changes of fabric and garments for 1st & 3rd wash

There are differences among length and width changes of fabric and garments for 1st and 3rd time washing where Figure 1 and 2 shows that in case of length and width changes of fabric and garments after 1st and 3rd wash there are significant differences of length and width both for fabric and garments after first and third washes. Furthermore, it has been found that in all cases changes in length and width after 1st wash is always more than dimensional changes after 3rd wash.

(a)



(b)

Figure 2. Mean change (%) in (a) fabric and (b) garments length and width after 1st and 3rd wash

Figure 3. Mean change (%) in fabric and garments according to length and width

On the other hand, in terms of dimensional changes of fabric and with its adjacent garments after 1st and 3rd wash Figure 2 shows there are no significant differences so the changes of length and width of fabric is not dependent on dimensional changes of garments whereas the dimensional changes of fabric is always higher then changes of garments. Besides, Table IV shows length and width change of fabric and garments in 1st versus 3rd wash vary significantly whereas length and width change after 1st and 3rd wash in fabric versus garments does not vary significantly.

TABLE IV. COMPARISON AMONG FABRIC AND GARMENTS DIMENSIONAL CHANGES

	Comparison	P Value from paired t test
Width change of Fabric	1st wash Vs 3rd wash	<0.01
Length change of Fabric	1st wash Vs 3rd wash	<0.01
Width change of Garments	1st wash Vs 3rd wash	0.006
Length change of Garments	1st wash Vs 3rd wash	0.002
Width change after 1st wash	Fabric Vs Garments	0.674
Width change after 3rd wash	Fabric Vs Garments	0.614
Length change after 1st wash	Fabric Vs Garments	0.317
Length change after 3rd wash	Fabric Vs Garments	0.834

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4. CONCLUSION

Dimensional changes of fabric and its adjacent garments have a spectaculars impact on the performance of end products to end users where fibre composition directly affects the changes and the changes can be varied due to quantity of fibre composition and types of fibre have been used in the particular product. This study reveals that-

a) Viscose containing below 11% of fabric and garments changes in dimension mostly. Most length and width changes after 1st wash are below 2.5% and width after 3rd wash as well but no change is mostly after 3rd wash of length.

b) Polyester containing above 80% and below 30% of fabric and garments changes in dimension mostly. Most length and width changes after 1st and 3rd wash are below 2.5%, for above 80% polyester.

c) Spandex containing above 5 % of fabric and garments changes in dimension mostly. Most length change after 1st and 3rd wash above 2.5% for above 5% spandex (only different after 3rd wash of garments) and width changes after 1st wash below 2.5% of above 5% viscose and after 3rd wash there are no changes prominently having above 5% spandex.

d) Every case dimensional changes after 1st wash is more significant than 3rd time wash sometimes there is no changes of repeated wash.

e) There are significant differences of length and width changes both for fabric and garments after first and third washes.

f) The changes of length and width of fabric is not dependent on dimensional changes of garments.

Further study on different composition of different fibers can be studied based on the impact of different factors like yarn type, fabric type, fabric weight, garments type on dimensional change.

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