Chapter

Compression and Recovery Functional Application for the Sportswear Fabric

Ramratan Guru, Rajeev Kumar Varshney and Rohit Kumar

Abstract

A sportswear fabric should have good stretch and recovery behaviour. This study facilitates an effective design and development of high-stretch sportswear using different knitted structure. Nine types of knitted fabrics were produced by varying the type of fibre and type of structure. An experiment work is done to study the fabric size, stretch and elastic recovery properties. The statistical analysis showed that type of fibre and type of knitted structure significantly influence the fabric stretch. Plain structure fabric showed higher stretch value than rib and interlock-knitted fabric. The high stitch density caused by reduce stretch value in the course- and wale-wise due to yarn floating rather than overlapping influenced the weight and thickness of knitted fabrics. The elastic recovery analysis indicated that the recovery value of plain-knitted structure with polyester-spandex blend is higher among studied fabrics. However, the recovery value decreased over time in comparison with stretch value.

Keywords: sportswear fabric, stretch and recovery performance

1. Introduction

The stretchable knitted structures play an important role in body comfort and fit. The knitted structures allow wearer the freedom of movement with least resistance due to their stretchability and elasticity [1, 2]. Regular physical activity is important to maintain consistency in human health. To achieve comfort and functional support during various activities such as walking, stretching, jogging, athletes and sports persons use sports clothing [3, 4]. Stretch properties represent a significant mechanical property of clothing material that influences clothing pressure. Stretch properties are measured as the percentage of fabric stretch and fabric growth, and recovery [5–7].

Basically, two types of category are normally available in sportswear stretch cloths: First is comfort stretch range of about 20–30% and other power stretch cloth range approximately 30–50%. The basic designs are used for high-active sportswear garments in elasticity and compression cloths.

The power stretch cloths need to have more extensibility and quicker recovery performance [8–12].

The high-compression clothes are more utilized medical compression garments and sportswear cloths sectors. Study on the evaluation of elastic recovery of cotton-knitted fabrics was conducted [13–16]. It is found that length of these cloths is different to a more extent value. As per information, fabric elongation is different from single-structure knit fabric in lengthwise ranging 3–6%, with double cloth knit having lengthwise 3–50%. Elongation in single-structure knit fabric is of widthwise 3–180% and double cloth knit elongation in widthwise of 6–155%. It is elastic recovery different from single-structure knit lengthwise to other structures. According to author, single-knit lengthwise elastic recovery is of range 100–56%, double cloth knit lengthwise elastic recovery is of range 100–57%, and single-structure knit elastic recovery widthwise is found 100–56%, double cloth knit widthwise elasticity recovery is of range 100–30% that is basically found in knit cloths [13–17].

Plain knit had more elongation and growth as compared with double knit. The growth after 30 seconds or relaxation was observed to be 36% and plain knit stretched more under load and after the load was released that exhibited more growth than the double knit. The stretch of knit fabrics is affected more by the cover factor than by the yarn diameter, loop length, loop density or the shape of the loop [18]. Spandex is widely used in sportswear for its superior stretch and recovery properties. Dynamic elastic repossession can assess the immediate apparel response due to body movement; the elastic bare-plaited fabric is found to have higher dynamic elastic recovery than cloth knitted from lycra core spun. The basic phenomena are essential use in stretch and recovery of the cloth to pressure generated by compression apparel. It is found that knitted fabric in normal stretch and recovery performance as compared to compression sportswear garment. Therefore, Lycra is used in knit cloths in blend with other fibres for proper utilization of stretchability and elasticity recovery properties in sportswear garments [19, 20].

The objective of this study was to investigate the effect of the stretch, growth fabric and recovery properties of polyester-spandex-blended, micro-polyester and 100% polyester-knitted fabric. These works could facilitate the design and development of sportswear with the required stretch and recovery properties.

2. Materials and methods

2.1 Materials used

In this study, three different filament yarns—polyester, micro-polyester, blend of polyester-spandex and non-circular cross section were used to prepare samples. The knitted structures—single jersey, interlock and rib fabrics were produced on weft-circular knitting machine (**Table 1**).

2.2 Testing methods

The knitted fabric was conditioned in standard atmospheric condition of 65+/−2% RH and 27+/−2°C temperature and the samples are in condition for 24 hours before testing. The stretch and recovery property tester was using the ASTM D 2594-2004 (2008) standard.

2.2.1 Statistical analysis

One-way ANOVA (Minitab 17 statistics software) tests were used to determine the significant difference between the stretch and elastic recovery properties of fabrics. In order to infer whether the parameters were significant or not, p values were examined. If the 'p' value of a parameter is greater than 0.05 ($p > 0.05$), the parameter was not significant and should not be investigated.

Sample	Fabric structure	Wpcm	Cpcm	Stitch density (loop/cm^2)	Areal density (g/m^2)	Thickness (mm)	Loop length (cm)	Tightness factor (Tex$^{1/2}$/cm)
PET/spandex	Plain	14.17	20.83	295.16	115	0.57	0.39	8.53
	Rib	16.12	24.13	388.97	155	0.65	0.32	10.74
	Interlock	19.31	26.18	527.54	178	0.81	0.26	12.80
Micro-PET	Plain	17.28	15.43	266.63	105	0.50	0.39	8.53
	Rib	16.12	20.14	324.65	144	0.58	0.31	10.74
	Interlock	22.67	17.12	388.11	161	0.68	0.26	12.80
100% PET	Plain	17.12	13.21	226.15	98	0.41	0.39	8.53
	Rib	15.32	20.82	318.91	136	0.52	0.32	10.74
	Interlock	22.15	16.83	372.78	155	0.62	0.26	12.80

**Wpcm—wale per centimetre, Cpcm—course per centimetre, * PET—polyester, * all three fabrics are made from 100 deniers polyester tex 11.11.*

Table 1.
Geometrical properties of knitted fabrics.

2.2.2 Fabric particulars

The fabric details measured were as follows: wales per inch (wpi), course per inch (cpi), linear density of yarn (denier), fabric mass per unit area (g/m^2) and fabric thickness (mm). The wpi and cpi were measured according to the ASTM D-3887 Standard. Yarn linear density and fabric mass per unit area were measured according to ASTM D 1059-01 and ASTM D 3776 M-09a standard respectively by using an electronic weighing balance. Thickness testing was carried out as per BS EN ISO 9073-2 using the electronic thickness tester at 0.25-KPa pressure. For each sample, 30 readings were taken to get the result at 95% confidence level.

2.2.3 Stretch and recovery property tester

ASTM D 2594-2004 (2008) standard test method for stretch properties of knitted fabric was applied under the form-fitting standards as sample size 18.3 cm in wale direction and 21.5 cm in course direction positions and 4.54 kgf weight apply in the Fabric specimen of the lower bench marks were calculated after 60 s and 1 h. Stretch percentage points to test the stretch and elastic recovery of the experimental samples are as shown in **Figures 1** and **2**.

Stretch, growth and recovery percentages were calculated by Eqs. (1)–(3) given below:

$$\text{Fabric stretch\%} = \frac{\mathrm{B} - A}{\mathrm{A}} X100 \tag{1}$$

$$\text{Fabric growth\%} = \frac{\mathrm{C} - A}{\mathrm{A}} X100 \tag{2}$$

$$\text{Fabric recovery\%} = \frac{\mathrm{B} - C}{\mathrm{B} - \mathrm{A}} X100 \tag{3}$$

where A: the distance marked between the upper and bottom parts of the fabric; B: the distance between the marked points after holding the sample for 5 min with 4.54 Kgf load; C: the distance between the marked points after 5-min relaxation.

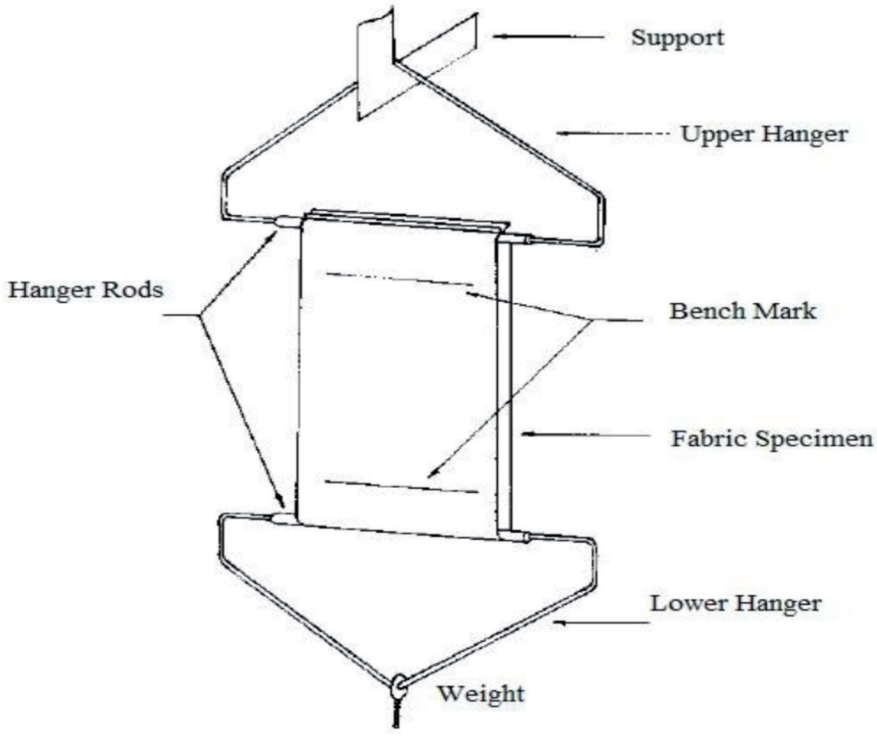

Figure 1.
Stretch and recovery setup assembly.

Figure 2.
Fabric stretch equipment.

3. Results and discussion

Figures 3 and **4** and show knit specimen changes in weight and thickness. The heavier weight of knit specimen was, the thicker its thickness was in descending order 'interlock structure polyester-spandex, micro-polyester and 100% polyester-knitted fabric', 'rib structure polyester-spandex, micro-polyester and 100% polyester-knitted fabric', 'plain structure polyester-spandex, micro-polyester and 100% polyester-knitted fabric'. Thickness and weight of specimen were influenced by density change caused by reducing and increasing fabric size. Thus, high density caused by floating in course-wise causes more knitted fabric weight gain than by loop overlapping.

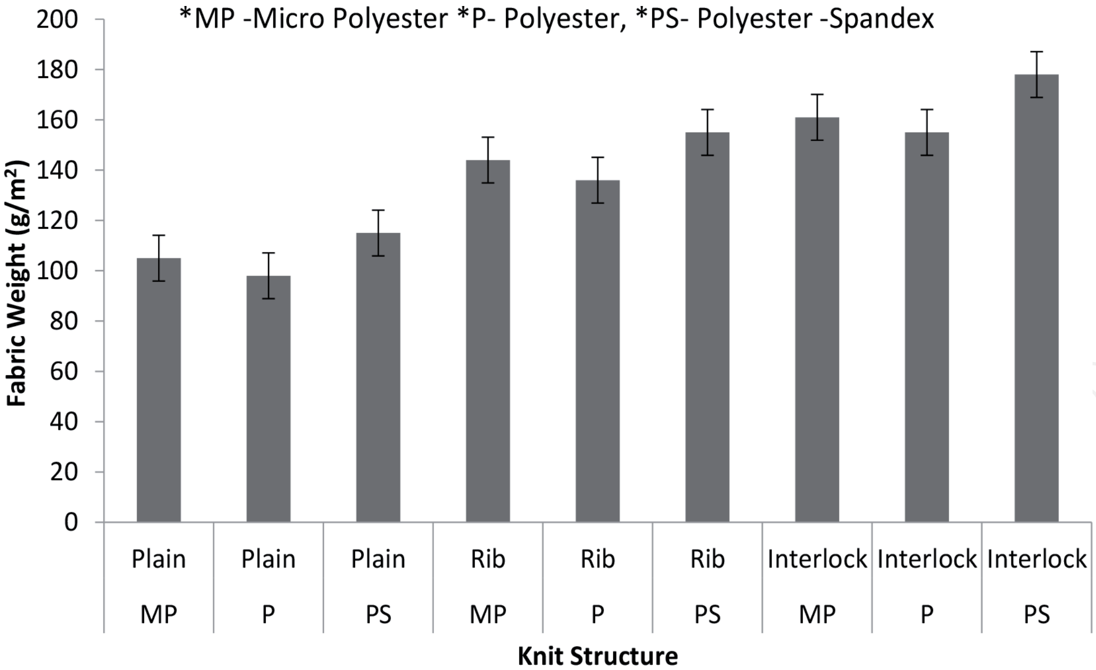

Figure 3.
Fabric weight comparison on knit structure.

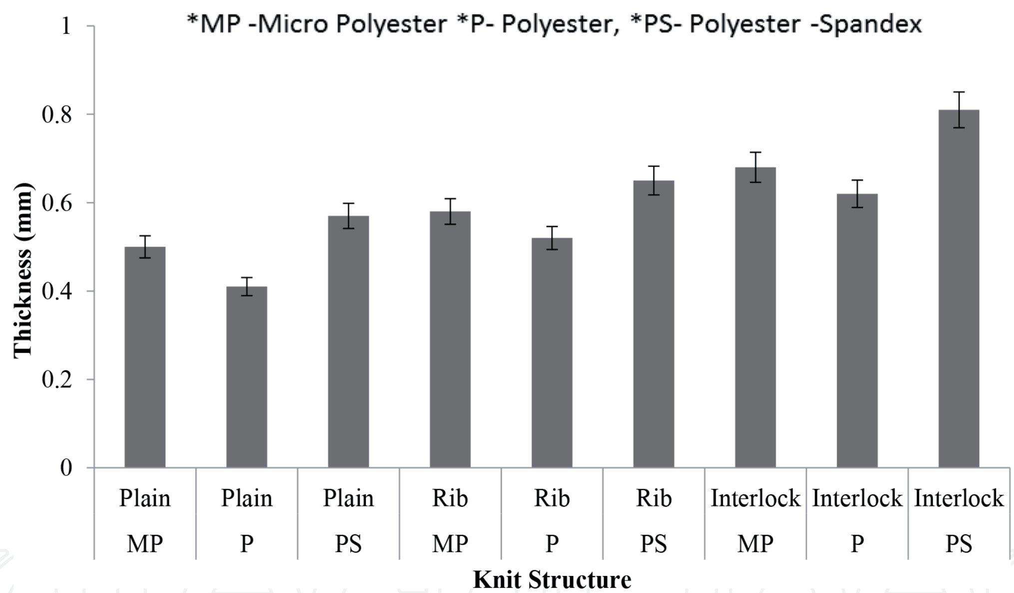

Figure 4.
Fabric thickness comparison on knit structure.

3.1 Stretch properties

Figure 5 and **Tables 2** and **3** indicate that the stretch value decreased in rib and interlock structure-knitted fabrics and direction except for wale-wise and course-wise as compared with plain structure fabrics. The plain structure fabrics have higher-stretch (%) polyester-spandex blend because lycra filament yarn have more stretch properties compared with other polyester and micro-polyester yarn [1].

The interlock structure three-knitted fabric showed a sharp decrease, while rib interlock structure three-knitted fabric had relatively small decrease. It seems that the material effect by stretch properties added to the reducing cause by yarn floating in the fabric structure, which held the loops reduced the stretch value of the fabric. The stretch value in course-wise is influenced by yarn floating rather than loop overlapping, while stretch value in wale-wise is caused by loop overlapping versus yarn floating [10].

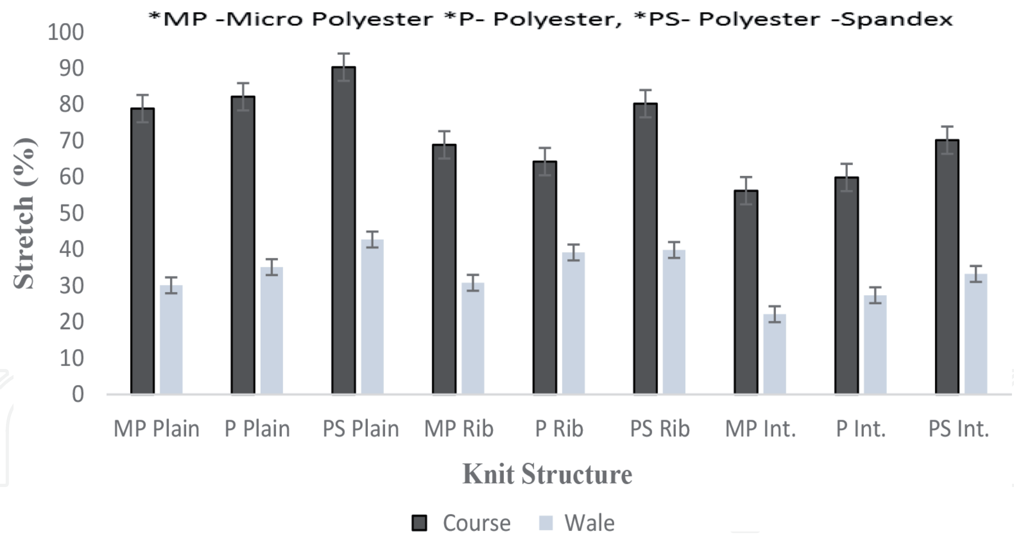

Figure 5.
Stretch comparison on knit structure.

Type of fabric	Structure	Fabric stretch and recovery properties					
		A	B	C	D	E	F
Polyester-spandex blende knitted	Plain	90.28	55.71	64.78	42.71	28.14	34.87
Polyester-spandex blende knitted	Interlock	70.14	29.07	35.85	33.25	19.85	20.11
Polyester-spandex blende knitted	Rib	80.21	38.57	51.21	39.51	22.42	27.31
Micro-polyester knitted	Plain	78.85	45.21	47.85	30.12	16.42	17.91
Micro-polyester knitted	Interlock	56.21	20.22	25.56	22.14	12.34	12.87
Micro-polyester knitted	Rib	64.85	33.28	35.61	30.81	14.78	16.83
100% Polyester knitted	Plain	82.12	52.27	55.22	35.14	20.15	25.12
100% Polyester knitted	Interlock	59.85	25.12	31.09	27.37	13.57	14.85
100% Polyester knitted	Rib	68.24	35.41	39.17	28.15	18.89	22.01

Note: A —*Course-wise stretch percentage,* **B** —*course-wise recovery after 60 sec %,* **C**—*course-wise recovery after 1 hr. %,* **D**—*Wale-wise stretch percentage,* **E**—*wale-wise recovery after 60 sec %,* **F**—*wale-wise recovery after 1 hr. %.*

Table 2.
Mean value of stretch and recovery test results.

Stretch properties	Degree of freedom df	Sum of square value SS	Mean square value MS	F_{actual}	$F_{critical}$	*P* value
A	9	5019.4	557.7	5.413	2.261	0.000
B	9	5728.4	636.4	3.167	2.261	0.006
C	9	6006.0	667.3	2.910	2.261	0.010
D	9	1284.1	385.5	2.813	2.261	0.013
E	9	1082.1	140.33	2.442	2.261	0.040
F	9	2205.2	245.03	5.536	2.261	0.023

Note: A—*Course-wise stretch percentage,* **B**—*course-wise recovery after 60 sec %,* **C**—*course-wise recovery after 1 hr. %,* **D**—*wale-wise stretch percentage,* **E**—*wale-wise recovery after 60 sec %,* **F**—*wale-wise recovery after 1 hr. %.*

Table 3.
One-way ANOVA of stretch and recovery properties of sportswear-knitted fabric structures.

Table 3 shows the ANOVA statistical analysis results at 5% significance level. Stretch and elastic recovery properties of the sportswear-knitted fabrics show significant difference between them (course-wise stretch (%): F_{actual} = 5.432 and wale-wise stretch (%): F_{actual} = 2.813 in comparison with $F_{critical}$ = 2.26) at degree of freedom 9.

3.2 Elastic recovery properties

There was significant value change on knit structure and direction in elastic recovery as shown in **Figures 6** and 7. The recovery value gap among knitted specimen was lower at 1 h than at 60 sec. The stretch loops bent and restricted by the external force loop of stretch take on a form of stability and shape retention in cover time [11–13].

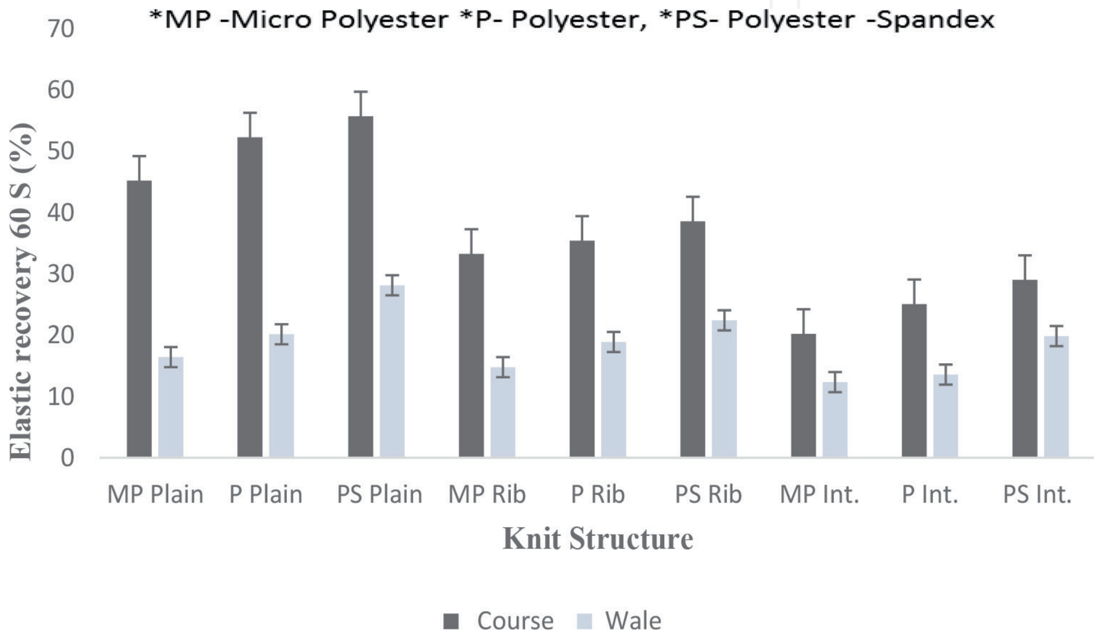

Figure 6.
Elastic recovery 60 sec on knit structure fabric.

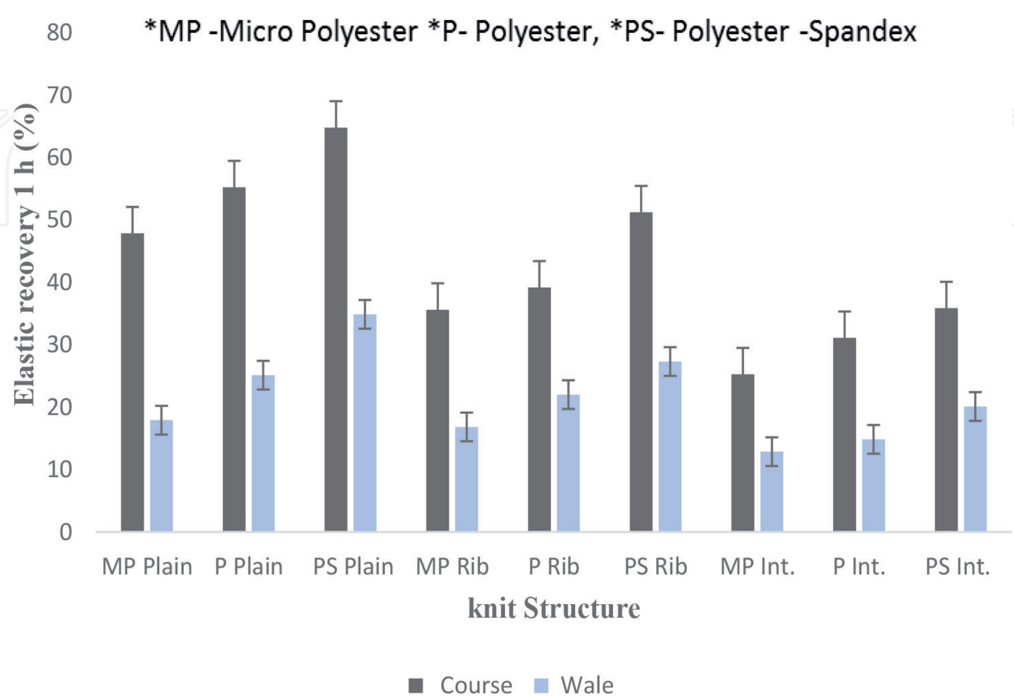

Figure 7.
Elastic recovery 1 h on knit structure fabric.

The ANOVA results show in **Table 3** that with respect to stretch properties after 60 sec %, there is a significant difference between the knitted fabric course-wise recovery after 60 sec %, degree of freedom 9. [$F_{actual} = 3.16 > F_{critical} = 2.26$ ($p < 0.05$)]. And for wale-wise recovery after 60 sec %, there is a significant difference between the structures [$F_{actual} = 2.44 > F_{critical} = 2.26$ ($p < 0.05$)].

It was found from **Table 3**, ANOVA results show that there is a significant difference between the course-wise recovery after 1 h %, value of knitted fabrics [$F_{actual} = 2.91 > F_{critical} = 2.26$ ($p < 0.05$)]. Also, it is noticed that there is a significant difference in wale-wise recovery after 1 h %, between the knitted fabrics [$F_{actual} = 5.53 > F_{critical} = 2.26$ ($p < 0.05$)].

4. Conclusion

The followings conclusions are derived from the above experimental work and given below:

- The elastic and recovery sportswear apparels are basically connected to the fabric material interface with the body, and these basically depend on how material stretch and recovery performance apparel structure perform. In this research study, basically focus should be on for the apparel size, stretch, elasticity of material properties. Apparel cloths have compression-knitted properties with different structures such as plain, interlock and rib and have analysed the correlation with type of materials.

- It is concluded that the plain structure polyester-spandex blend fabric is preferable than micro-polyester and 100% polyester fabric with respect to stretch and elastic recovery characteristics due to its quick recovery, which enhances the power of the performance.

- This chapter proposed an appropriate knit structure and arrangement approach in consideration of fabric size and stretch properties of high-stretch knitted fabric and correlation with type of fibre.

- This chapter provides meaningful market data for the effective development of more diverse garment-related product along with the localization of manufacturing for functional and sports garment.

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