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International Journal of Textile Science and Engineering

Review Article

Chowdhary U. Int J Text Sci Eng 3: 125.
DOI: 10.29011/IJTSE-125/100025

Impact of Interfacings and Lining on Breaking Strength, Elongation and Duration of the Test for Knitted Wool

Usha Chowdhary*

Department of Human Environmental Studies Fashion Merchandising and Design, Central Michigan University, Mount Pleasant, Michigan, USA

***Corresponding author:** Usha Chowdhary, Department of Human Environmental Studies Fashion Merchandising and Design, Central Michigan University, Mount Pleasant, Michigan, USA. Email: chowd1u@cmich.edu

Citation: Chowdhary U (2019) Impact of Interfacings and Lining on Breaking Strength, Elongation and Duration of the Test for Knitted Wool. Int J Text Sci Eng 3: 125. DOI: 10.29011/IJTSE-125/100025

Received Date: March 5, 2019; **Accepted Date:** March 20, 2019; **Published Date:** March 29, 2019

Abstract

The study examined breaking strength, elongation and time at break for 100% medium weight knitted wool with interfacings and lining. Several ASTM standards were used to measure structural and performance attributes. Fabric strength, elongation, and time taken to rupture for fabric exclusively and with interfacings and lining attached were measured for eight relationships. Hypotheses were tested using T-test analysis. Confidence level was established at 95%. Results revealed that majority of the hypotheses were accepted. Results for fusible and non-fusible interfacings varied. Adding fusible interfacing did not enhance strength in the lengthwise direction. Fusible and non-fusible interfacings did not differ for elongation. It took longer for fabric to break in lengthwise than the crosswise direction. Future research is needed to confirm the findings of this study for various fabrics, seam types, stitch types, fabric construction and fiber contents.

Introduction

For decades, textile and apparel industry have conducted research in a parallel fashion where apparel was made based on conventional practices rather than testing fabric in the apparel product development process. With advancement of technology and its increased integration in academia, industry professionals do textile testing before to insure quality in produced apparel more than ever before. Even though it has been common practice T use wool and acetate together, none of the prior work examined their compatibility with each other for durability determined by breaking strength. Industry practice has also used interfacings/interlining and linings to provide professional look to the garments. However, they did not specifically determine their contributions to the strength and elongation of the fabric.

Even though, wool and acetate have been used for lined jackets and coats for decades, none of the previous work researchers tested their compatibility with each other. Acetate is an excellent material for lining because of its slipperiness that allows for easy putting on and taking off the garment. However, it is not clear from previous research if it is equally strong and has compatible elongation also. Therefore, the reported study examined the impact of lining and interfacing on breaking strength and elongation of the interlock knit in 100% wool.

Consumer looks for durability and comfort in the textile used for everyday wear. With comfort and stretch of knits, they have gained popularity over the woven fabrics. Professional garments require use of support fabrics such as interlinings and linings as quality indicators of an apparel item. They provide smooth appearance [1]. Wool was chosen because it is used for professional apparel. Layering of fabrics with interfacings/interlinings and linings provides it professional look. The purpose of the paper was to compare breaking strength, elongation and time at break for 100% medium weight knitted wool with interfacings and lining.

Literature Review

The literature review is organized in three sections: Breaking Strength and Elongation, Seam Strength and Efficiency, and Structural Attributes.

Annual book of ASTM standards was used to define breaking strength and elongation using (ASTM D 4850-2013) [2]. Breaking strength refers to the ability of the 9 stretched and original length represented in percentage. Ahmed and Slater reported that low breaking strength of wool made the fabric to abrade more and become soft [3]. Chen, Spola, Gisbert, and Sellabona reported that angle0interlock structures allow higher extension in the weft direction and strength in the warp direction [4]. Chiweshe and Crews found that wet softeners reduced breaking strength more than the dry softeners [5]. Kang and Kim also found that wool is softened by use of softeners and silicone treatment reduces the breaking strength of wool [6]. Chowdhary annotated several research articles that focused on breaking strength and elongation [7]. Kwak, Lee, Lee, and Jeon reported that stretch breaking process used by them resulted in lower elongation and higher breaking strength [8]. The authors compared bursting strength for three types of knits. Jersey and pique knits differed for fabric count, thickness and weight. However, it did not hold true for the interlock knits. Chowdhary, Adnan, and Cheng examined bursting strength and elongation of seven jersey knits and found that the strength was highest for Polyester/Spandex (96/4%) and lowest for the Rayon/Wool/Lycra blend (76/20/4%) [9]. Chowdhary found that stretch was highest in polyester/cotton (60/40%) interlock knit in the crosswise direction [10]. However, it was higher in rayon/nylon/spandex (65/30/5%) blend than polyester/cotton blend. A recent study reported that addition of lining enhanced breaking strength of woven fabrics in woven fabrics [11]. However, results were mixed for elongation and addition of interfacing. Researchers emphasized the need for repeating research for other structural attributes.

Seam Strength and Efficiency

The test standard ASTM D-1683/D1683M -17 measures seam strength with force that is applied at 90 degrees angle for woven fabrics [12]. It works in conjunction with ASTM D5034. Interfacings and linings are joined with seams to the fabric, therefore it was deemed necessary to review literature in this are for inclusion. Seam strength and efficiency are important concepts in apparel construction. Seam efficiency is the ration between seam strength and fabric strength represented in percentage Chowdhary emphasized the importance of examining seam strength and efficiency because it can enhance the quality of the apparel product [13]. Chowdhary and Poynor found that seam efficiency was the highest for seam with 10-12 stitches per inch but the lowest for 6-8 stitches per inch [14]. Chowdhary reported that the unserged seams in the warp direction had higher seam strength than the serged warp seam [15]. However, in filling direction serged seam was stronger than the unserged seam. Elongation was higher for warp in both direction and seam forms. The scholar also noted that seam efficiency can be enhanced by changing seam types, stitches per inch or stitch density, stitch types, and sewing threads [15]. The author recommended to have at least 65% seam efficiency. Of course, it should be higher for better quality apparel where durability is also important. Breaking strength refers to the breaking force required before the seam ruptures.

Addition of interfacing improved this medium weight fabric. Sew-on type interfacing had higher elongation than the fusible type [15]. Two polyesters had higher seam efficiency than two cottons and flannels. The test and previous research focused only on woven fabrics. As evidenced by the preceding information, very limited work has been reported on the role of interfacings and linings even though they have been used for quality apparel as support fabrics for centuries. Therefore, there is need to explore this work further.

Structural Attributes

Previous research reports that structural attributes influence fabric quality and performance. Therefore, it is important to include them while examining performance attributes [15-17]. Some of the important structural attributes are fiber content, fabric construction, fabric count, fabric thickness and fabric weight. For the purposes of the reported study selected structural attributes were defined as follows (ASTM D 4850-2013). Fabric count refers to the number of wales and courses in one inch. Fabric thickness is defined as the distance between two planes of the fabric. Fabric weight was measured as mass per unit area and computed in ounces per square yard. Some of the studies below demonstrate the influence of structural attributes on performance attributes.

Chen, et al. asserted that more layers made fabrics structurally stable [4]. Omerglu and Ulku found that tensile strength can be function of the process of making yarns [18]. Uttam and Sethi found that increased shrinkage resulted in higher cover factor as well as heavier and thicker fabric than the unwashed form [19]. Chowdhary reported that both fabric count and thickness increased from 5th to the 25th wash for two of the three brands of knitted t-shirts an increase in stitch length increased the width [20]. Additionally, finer yarns resulted in less wide materials than the coarser yarns. significantly. Crouh tested influences modal/cotton blend after 10 washing and drying cycles and concluded that laundering air permeability, bursting strength and fabric weight [17]. Haque and Alam found that finer yarns made less wide fabric than the coarser yarns [16]. Additionally, cover factor was also influenced by repeated laundering.

Overall, literature review revealed the importance of examining the relationship between structural and performance attributes for enhanced quality. One study addressed the role of support fabrics for woven fabrics [11]. However, the previous researcher does not provide any research on the role of support fabrics such as lining and interlining for knitted fabrics. Therefore, this study was deemed relevant.

Based on the literature review, following five hypotheses were developed.

- Hypothesis I: Adding interfacing to the fashion fabric will enhance fabric strength in the lengthwise direction.
- Hypothesis II: Adding lining to the fashion fabric will enhance fabric strength in the lengthwise direction.

- Hypothesis III: Fabric with fusible interfacing in wales will differ in strength from the course direction.
- Hypothesis IV: Adding interfacing and lining to the fabric to the fashion fabric will increase breaking time in the lengthwise direction.
- Hypothesis V: Fabric and fusible interfacing in lengthwise direction will take longer than the crosswise direction.to break.
- Hypothesis VI: Adding lining to the fashion fabric will reduce elongation in the lengthwise direction.
- Hypothesis VII: Fabric with fusible interfacing will have lower elongation than the non-fusible interfacing.
- Methodology

ASTM standards were used to measure three structural and three performance attributes. Three structural attributes were fabric count, thickness and weight; and three performance attributes were breaking strength, elongation, and time taken for the fabric to break They were measured and tabulated using standardized tests, mentioned in (Table 1). INSTRON 5544 machine was used to measure three performance attributes. All seams where used had ½ inch seam allowance with 12 stitches per inch. Yarn size of the sewing thread was 29.7 Text with standard deviation of .675. Fusible interfacing was ironed on following manufacturer's instructions. Except for the fusible interfacing only lengthwise breaking strength was tested because machine did not allow for additional stretch.

Attribute	Standard
Breaking Strength	ASTM D5034 09(2013)
Fabric count	ASTM D8007-2015
Fabric Thickness	ASTM D1777 – 96 (2015)
Fabric Weight	ASTM D3776/D3776M -09a (Reapproved 2017)
Seam Strength	ASTM D1683.D1683M - 2017
Conditioning	ASTM D 1776.D1776M - 16

Table 1: Standards used for tests used in the study.

Results and Discussion

Fabric Description

Knitted fabric used for the investigation was made from 100% wool, low fabric count, and medium weight. Its thickness was from medium to high (Table 2). Fabric construction of the chosen wool was interlock knit that looks same on both sides. Wool is most commonly used fabric for professional suits. Traditionally, acetate was the commonly used item for jackets. However, it has now been replaced with polyester because polyester is stronger than acetate and is more compatible for durability than acetate. Therefore, polyester lining was used as a comparison fabric for wool. Interfacings chosen represented woven and nonwoven as well as fusible and non-fusible interfacings.

Fabric Attribute	Mean	Standard Deviation
Fabric Count	46.2	.447
Wales	23.8	.548
Courses	22.4	.447
Fabric Thickness (mm)	1.148	.045
Fabric Weight (ozs./yd^2)	7.1830	.105

Table 2: Mean and Standard Deviation for Fabric Count, Thickness and Weight of Wool (n=5).

Hypotheses Testing

Hypothesis I: Adding interfacing to the fashion fabric will enhance fabric strength in the lengthwise direction

The t-values revealed that strength of the fabric dropped with addition of both fusible and non-fusible facings. However, it was significantly lower for non-fusible than fusible interfacing. Differences were not significant when fusible interfacing was used with the fashion fabric (Table 3). Hypothesis I for fusible interfacing was rejected but non-fusible interfacing was accepted. None of the previous studies examined this relationship. Therefore, no comparisons cold be made with the existing literature review. It was interesting to note that breaking strength was higher for fusible interfacing than the non-fusible interfacing even though sewing thread was used to make the seam. Probably fusing provide stronger bonding and fewer air spaces. Addition of interlining simply provided support for professional look but did not strengthen the collective unit. It was worth noting that strength with fusible interfacing differed for warp and weft directions. In one of the previous studies, addition of interfacing in filling direction of the woven wool did not make significant increase in strength [11].

Performance Attribute	Mean (Pounds/inch^2)	Standard Deviation	t-value
Breaking Strength Lengthwise			
Fabric	73.510	6.249	
Fabrics plus fusible interfacing	58.987	17.793	0.487 ns
Fabrics plus non- fusible knitted interfacing	24.132	5.766	4.251*
Fabric Plus Polyester Lining	248.009	38.16	-2.553*

Breaking Strength Crosswise with fusible interfacing	45.217	7.868	5.632*
Table value: 1.860 for 8 degrees of freedom for alternate hypothesis and 2.206 for the null hypothesis ns = Not Significant *p<.05			

Table 3: Means, Standard Deviation, and t-test Values for Breaking Strength of different combinations of interfacing and polyester lining. (n=5).

Hypothesis II: Adding lining to the fashion fabric will enhance fabric strength in the lengthwise direction.

Adding polyester lining to the woolen fabric significantly increased the strength (- 2.553, p<.05) of the lined garment (Table 3) Fashion fabric by itself and the breaking strength of 73.51 pounds per square inch (psi). Fashion fabric with lining had the breaking strength of 248.009 pounds per square inch. Hypothesis II was accepted. Polyester is a strong fiber. Chowdhary et al. found that polyester blend had higher bursting strength than the rayon/wool/spandex blend [9]. Adding strong fabric like polyester significantly improved the strength of the garment. The findings are consistent with Chowdhary and Wentela who found that breaking strength of woven wool with polyester lining increased significantly [11].

Hypothesis III: Fabric with fusible interfacing in wales will differ in strength from the course direction.

Findings revealed that fabric was stronger (t8= 5.632, p<.05) in lengthwise (M= 58.98 psi) than the crosswise direction for fabric M= 545.21 psi) with fusible interfacing. Hypothesis III was accepted (Table 3). Several scholars have reported that fabrics are stronger in lengthwise than crosswise [15,21,22]. This finding supports contention of previous scholars.

Hypothesis IV: Adding interfacing and lining to the fabric to the fashion fabric will increase breaking time in the lengthwise direction.

Results from the t-test revealed that time reduced significantly for fabric with fusible knit interfacing than the non-fusible knitted interfacing and lining (Table 4). Time increased significantly higher for the non-fusible interfacing and lining. Hypothesis IV was partially accepted. It took longest for fashion fabric and lining followed by fabric with non-fusible knit interfacing, fabric by itself, and fabric with fusible interfacing for lengthwise direction. Lowest time was recorded to break fabric with fusible interfacing in the crosswise direction. In the previous study with woven wool, the fabric took the longest with all three fabrics, followed by fabric with lining, fabric, and fabric with interfacing [11]. For woven wool, addition of interfacing reduced the time taken for fabric to break.

Performance Attribute	**Seconds**	**Standard Deviation**	**t-value**
Time Taken to Break Lengthwise			
Fabric	8.996	0.669	
Fabrics plus fusible interfacing	5.505	3.085	2.211*
Fabrics plus non- fusible knitted interfacing	14.238	0.443	13.072*
Fabric Plus Polyester Lining	14.432	0.497	13.036*
Time Taken to Break Crosswise with fusible interfacing	3.873	0.232	40.984*
Table value: 1.860 for 8 degrees of freedom for alternate hypothesis and 2.206 for the null hypothesis ns= Not Significant *p<.05.			

Table 4: Means, Standard Deviation, and t-test Values for Time taken to Break different combinations of interfacing and polyester lining (n=5).

Hypothesis V: Fabric and fusible interfacing in lengthwise direction will take longer than the crosswise direction.to break.

Mean value in the lengthwise direction was 5.505 seconds and it was 3.873 for the crosswise direction (Table 4) The differences were significant at the 95% level of confidence. Hypothesis V was accepted. IT makes sense based on the assumption that fabrics are stronger in lengthwise than crosswise direction. It is consistent with Chowdhary [14].

Hypothesis VI: Adding interfacing to the fashion fabric will reduce elongation in the lengthwise direction.

Addition of both fusible and non-fusible interfacings to fashion fabric reduced Elongation percentage significantly (Table 5). Hypothesis VI was accepted. Sewing or fusing interfacing create resistance for stretch. Therefore, this finding makes sense.

Performance Attribute	%	Standard Deviation	t-value
Elongation Lengthwise			
Fabric	64.18	5.231	
Fabrics plus fusible interfacing	27.171	10.382	6.367*
Fabrics plus non- fusible knitted interfacing	32.96	6.106	7.766*
Fabric Plus Polyester Lining	38.16	3.517	8.225*
Elongation Crosswise with fusible interfacing	40.23	5.539	1.988*
Table value: 1.860 for 8 degrees of freedom for alternate hypothesis and 2.206 for the null hypothesis ns = Not Significant *p<.05			

Table 5: Means, Standard Deviation, and t-test Values for Elongation of different combinations of interfacing and polyester lining (n=5).

Hypothesis VII: Adding lining to the fashion fabric will reduce elongation in the lengthwise direction.

Adding polyester lining (38.16%) reduced elongation of fashion fabric (64.18%) Significantly (t_8 = 8.225, p<.05). Hypothesis was accepted. These findings are incongruent with the previous study for woven wool. In that study, elongation increased with adding of polyester lining [11].

Hypothesis VIII: Fabric with fusible interfacing will have lower elongation than the non-fusible interfacing.

Means displayed in Table 5 revealed that elongation mean with fusible interfacing was 27.17% and that with non-fusible interfacing was 32.96%. t-test revealed that differences were not significant (t_8 = -.961, p>.05) between fusible and non-fusible interfacing. Hypothesis VII was rejected. It appears that fusion material of fusible interfacing created similar effect to sewn on interfacing for elongation in the reported study. None of the previous studies examined it. Therefore, no comparison could be made.

Hypothesis #	Hypothesis	Accepted/Rejected
I:	Adding interfacing to the fashion fabric will enhance fabric strength in the lengthwise direction.	Rejected
II:	Adding lining to the fashion fabric will enhance fabric strength in the lengthwise direction	Accepted
III:	Fabric with fusible interfacing in wales will differ in strength from the course direction.	Accepted
IV:	Adding interfacing and lining to the fabric to the to the fabric to the fashion fabric will increase breaking time in the lengthwise direction.	Rejected
V:	Fabric and fusible interfacing in lengthwise direction will take longer than the crosswise direction.to break.	Accepted
VI:	Adding interfacing to the fashion fabric will reduce elongation in the lengthwise direction.	Accepted
VII:	Adding lining to the fashion fabric will reduce elongation in the lengthwise direction.	Accepted
VIII:	Fabric with fusible interfacing will have lower elongation than the non-fusible interfacing.	Rejected

Table 6: Outcome of Hypotheses Testing.

Summary and Conclusions

The reported study explored the under-researched area. Several relationships were established and tested for adding support fabrics for lined garments. Several useful findings were revealed. For example, Addition of interfacing did not always increase the strength and reduce the elongation. Differences were found between fusible and non-fusible interfacings. Adding lining increased strength but reduced elongation. It is a viable area to conduct additional research with other fiber contents for fashion fabric, interfacing, and lining. Findings confirmed some of the existing knowledge and challenged to re-think in some other areas. Interfacing did not enhance strength, but lining did. It is important to extend this exploratory study to comprehensively understand the relationship between fashion fabric and constructed garment for several textile attributes that contribute toward aesthetics, care, comfort and durability. This study is just a beginning in the suggested direction. It is an attempt to bring textile and apparel manufacturing areas for matching research findings with enhanced construction quality by using optimally compatible support fabrics. The study may be extended to answer the following questions.

- Do woven and knitted fabrics act similarly for breaking strength and elongation?
- Should comparisons be made between and among several types of interfacings and linings to determine their durability?
- Can such studies through repetition or modified ways contribute to better understanding of relationships between fabric and garment attributes than known now?
- How do lab and industry garments compare for selected performance and structural attributes?
- Will comparison between acetate and polyester lining help with better decision making by apparel manufacturers?
- How can these findings be used advantageously by apparel manufacturer, retailers and consumers alike?

Acknowledgments

The author expresses gratitude to Ariel Anouthai, Kathryn Beck, Krista Franzese, Sara Findsen, Winnie Killewald, Alona Lysa, Anelise Merchant, Brittany Schooley, Makaia Smith, and Jenna Sturdevant for sharing their data for inter-operator comparison.

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