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RESEARCH NOTE

Investigating the Effect of Underlying Fabric on the Bagging Behaviour of Denim Fabrics

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ABSTRACT

Underlying fabrics can change the appearance, function and quality of the garment, and also add so much longevity of the garment. Nowadays, with the increasing use of various types of fabrics in the garment industry, their resistance to bagging is of great importance with the aim of determining the effectiveness of textiles under various forces. The current paper investigated the effect of underlying on the bagging behavior of denim fabrics. The experiments carried out on four different denim fabrics as the main components including cotton, polyester and lycra, as well as three types of adhesive interlining and three common lining as the underlying components. The adhesive interlining was added to the fabric by using a fusing machine, and the lining was sewn to the fabric. The bagging behavior was assessed by extraction of the residual bagging height using the image processing method and the bagging fatigue percentage by stress-strain diagram. The results showed that with the addition of adhesive interlining and lining to the fabric, the bagging fatigue percentage increased. The lining sewn to the fabric reduced the residual bagging height. Also, the friction between the face fabric and the lining was an important factor that, the bagging fatigue percentage increased with increasing the friction, regardless of the fabric material.

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1. INTRODUCTION

The bagging is a three dimensional, permanent and irreversible deformation in wearing the garment due to continuous movements of the body and clothing in the use. When the fabric is exposed to cyclic loads, internally tensile forces and externally compressed forces are created during deformation and ultimately lead to plastic deformation. This deformation is attributed to the initial creep and the friction of fiber included in the fabric structure [1] and is observed in the knee and the elbow more than other areas due to cyclic loading. The bagging behavior affects the clothing beauty and effectiveness, and gradually creates an unpleasant appearance during the use and is virtually unusable. Garment bagging behavior is one of the most important issues in the field of the production and consumption of the textiles, which in some industrial textiles, as well as clothing, such as a felt hat, is a necessary factor for production, but it often disrupts consumer comfort by creating an unpleasant appearance. The human body has a certain range of motion and clothing is exposed to the various forces during the use. Often, body movement or expansion causes sliding the fabric on the skin or the elongation of the fabric. But in some cases, various factors prevent the return of the fabric, and clothing cannot restore its original form [2]. These factors include parameters related to the wearer and the clothing parameters such as the fabric, yarn and fiber parameters. The strength of the fiber, yarn, and fabric, the friction between the fabric and the pressurizing agent to create the bagging, yarn elongation, the elongation at break of the fabric, the fabric structure, the texture repeat pattern and the fabric density are the most important parameters that affect the resistance to fabric bagging [1].

Investigatoin on the bagging behavior of the fabric through exposure to the forces, measuring the forces required to create a bagging deformation, the residual height of bagging, and predicting the amount of its bagging in different conditions are the most important stages of the production of the fabrics. There are many researches addressing these issues. Kageyama et al. [3]

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investigated the bagging deformation of the fabric in the knee and suggested that this may be due to bi-axial and shear stress. Kisilak [4] simulated the strain on the knee and the elbow under cyclic loading and studied the fabric behavior under the different weave texture and material type. They concluded that the deformation of a wool fabric was more than a wool-polyester fabric [4]. Zhang et al. [5-11] analyzed a wide range of parameters influencing the bagging behavior of the fabrics. First, the bagging behavior of the fabric was measured using a circular-jaw machine and the mechanism of bagging behavior of the fabric was studied by photography. They tried to describe the physical mechanism of the bagging behavior of the fabric with the development of a formulation including the relationship between fatigue behavior and reducing the internal energy of the fabric. Then, they simulated the bagging behavior using a rheological model including the spring and dashpot, and examined the relative effects of elasticity and viscoelasticity of the fiber on the bagging of the woven wool fabrics [5-11]. Abghari et al. [12] studied the relationship between the in-plane fabric tensile properties and the bagging behavior of the fabric using a new test method to measure the bagging behavior of the woven fabrics by a rectangular jaw. Farahani et al. [1] investigated the effect of the loading cycles on the bagging behavior of the woolen fabrics and they found the relationship between in-plane tensile forces in different directions and the force of the bagging through a new method. The effects of the parameters such as the fabric texture and density, structural properties, the size of the ball and test speed on the bagging behavior of the fabrics were also studied by other researchers [2, 13, 14].

Denim fabrics suffer from the bagging phenomenon. So far, several ways have been developed to prevent their bagging. In current research, the main objective was to provide a novel method to prevent the bagging of pants, especially denims. In order to achieve this goal, the use of lining and interlining was considered. The question raised here is, can it be prevented from bagging by adding a second part (lining and interlining) to jeans? Adhesive interlining and lining fabrics are commonly used in the production of most clothing as the underlying fabrics. Given the basic role of fabric structure and friction in the bagging behavior of the fabric, it is important to study the bagging behavior of the garment with adhesive interlining and lining fabrics. Since no research has ever been done on the begging behavior of the main fabric supported by interlining and lining fabrics in the garment industry, the current paper aimed to investigate the effect of underlying fabric on the bagging behavior of the woven fabrics.

2. MATERIALS AND METHOD

2. 1. Materials

The current paper aimed to investigate the effect of adhesive interlining and lining fabrics added to the main fabric on bagging behavior. Since the bagging behavior of clothing is more often seen in the knee than in other areas, the current experiment carried out on four types of the woven denim fabrics prepared with a combination of different fibers suitable for trousers. Three types of polyester lining and three common types of interlining adhesive available on the market were used to make the layered specimens. Table 1 presents the specifications of the main fabrics, linings and interlinings.

2. 2. Bagging Test

Fabric specimens were cut in 15 * 15 cm^2 and were prepared by using adhesive interlining and lining to test the bagging. Adhesive interlining was added to the fabric by using a fusing machine (NHJ-Q-B0600B) at temprature of 140 ˚C, pressure of 2.5 kg_f/cm^2

TABLE 1. Specifications of the main fabrics, linings and interlinings

Fabric code[a]	Blend type	Weave	End/cm	Pick/cm	Thickness (mm)	Weight (g/m^2)
C	100% C	Twill 1/3	35	22	0.59	369
CL	94% C, 6% L	Twill 1/3	40	22	0.65	385
CP	35% C, 65% P	Twill 1/3	28	22	0.68	380
CPL	32% C, 64% P, 4% L	Twill 1/3	40	22	0.75	394
Lin1	100% P	Twill 1/3	60	30	0.57	46
Lin2	100% P	Twill 1/3	60	37	0.61	58
Lin3	100% P	Twill 1/3	60	33	0.60	50
Int1	100% P	Plain	-	-	0.50	40
Int2	100% P	Plain	-	-	0.52	53
Int3	100% P	Plain	-	-	0.51	43

[a]C=Cotton, P=Polyester, L=Lycra, Lin=Lining, Int=Interlining.

for prcoss duration of 20 s. The lining was sewn to the fabric using Jack industrial lockstitch sewing machine, China, at a speed of 4000 stitches/min. The sample edges were sewn with SPI of 10 as illustrated in Figure 1. The bagging behavior test was performed using a Zwick machine according to ASTM D6797 in 3 cycles of loading and repeated 3 times per specimen. The specimen was placed inside the center of the jaw with an internal diameter of 57 mm.

The bagging test conditions were set as follows: the diameter of the ball 22 mm, the loading speed 20 mm/min, the speed of lifting the load 50 mm/min, and the residual bagging height for cotton fabrics 10 mm and 13 mm for the other fabrics (because the elastic extension region of the cotton samples was slightly shorter than that of other fabrics). The schematic view of the equipment and apparatus used to test the bagging behavior is shown in Figure 2. The paper applied two methods for measuring the bagging parameters in order to evaluate the bagging behavior of fabric; 1. using the image processing method and, 2. using the force-elongation diagram. After each cycle, a 2-minute return period was applied per specimen and the specimen was then taken to a certain position in accordance with Figure 3. Residual bagging height of specimens was photographed using a (Canon IXUS 75) camera with the same settings and conditions for all specimens, and the photos taken were processed using the Digimizer software.

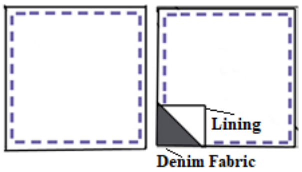

Figure 1. Schematic of lining-main fabric sewn sample

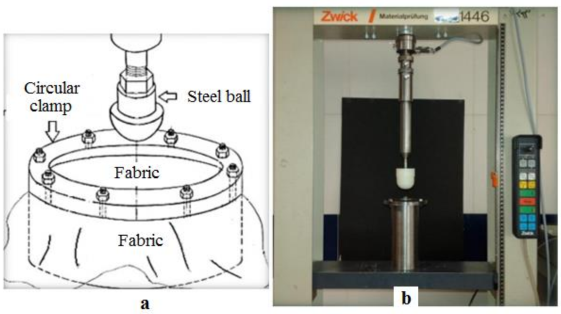

Figure 2. Equipment used to test the bagging behavior of fabric samples: (a) a schematic diagram of the equipment, (b) a view of the test device

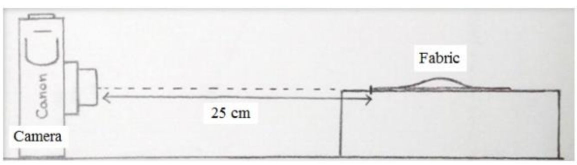

Figure 3. Specimen conditions for shooting

3. RESULTS AND DISCUSSION

By carrying out the bagging test, the bagging photographs as well as the force-elongation diagrams were extracted for each sample. Figures 4 and 5 depict the residual bagging height and a typical force-elongation diagram for three cyclic bagging test, respectively. The residual bagging height was measured in photographs taken from the specimens using the Digimizer software. The bagging fatigue percentage also were calculated from the force-elongation diagrams as follows [13]:

Bagging fatigue = (work of first cycle's loading-work of last cycle's loading)/(work of first cycle's loading) (1)

The average of residual bagging height and the fatigue percentage for specimens without any adhesive interlining and lining as well as specimens with adhesive interlining and lining are reported in Figures 6 and 8. The general comparison of the values of the residual bagging height and the bagging fatigue percentage in all specimens showed that cotton/lycra fabric had the minimum amount of bagging. The residual bagging height values and the fatigue percentage for this specimen were the lowest compared to the other raw specimens. It is clear that the presence of lycra in this

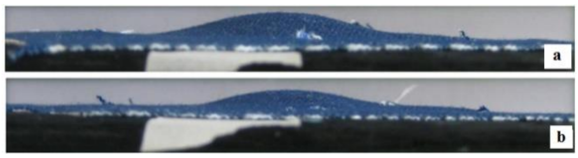

Figure 4. The photograph of residual bagging height of specimens: (a) specimen C, (b) specimen C-lining 1

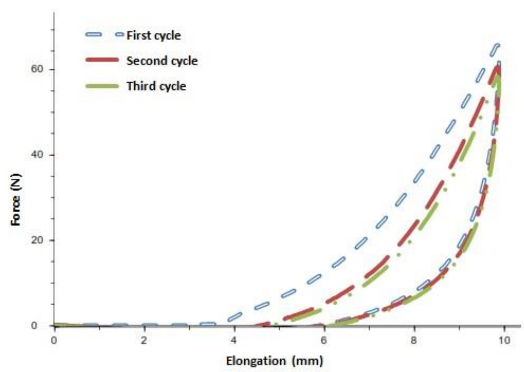

Figure 5. A typical force-elongation diagram for three cyclic bagging

fabric results in less fatigue due to increasing the elasticity. The greater the amount of bagging in a cotton/polyester/lycra fabric compared to cotton/lycra was also due to the effect of the polyester fibers on the fabric bagging behavior. As reported in the previous studies, the bagging fatigue increased with increasing the polyester percentage [15].

3. 1. Analysis the Effect of Adhesive Interlining on Fabric Bagging The findings of the study indicated that the addition of the adhesive interlining to the specimen increased both the residual bagging height and the fatigue percentage (Figure 6). The adhesive interlining layer is added to the fabric through a heat process. Therfore, the adhesive interlining is in complete contact with the fabric so that it does not have any movement on the fabric.

The results showed that the addition of adhesive interlining to the fabric, regardless of its material, greatly affects the fabric recovery to the original shape. In fact, the adhesive interlining, with a negative effect on the elastic and spring-like behavior of the structure, was an obstacle to the return of the fabric to its original state and increased the bagging. Comparison of the residual bagging height values and the fatigue percentage in the adhesive interlining added to specimens showed the lower bagging in the cotton/polyester/lycra fabric. Increasing and decreasing the residual bagging height values and the fatigue percentage are also approximately the same for the various types of lining and adhesive interlining added to the raw material.

3. 2. Analysis the Effect of Lining on Fabric Bagging By sewing lining to the specimens, the residual bagging height dropped compared to the non-lining specimens, while the bagging fatigue percentage increased (Figure 8). Lining is a fabric designed to enhance the strength, beauty and sometimes thermal resistance of the fabric. It is sewn to the internal surface of the fabric and is not in full contact with the fabric, unlike interlining adhesive. As the friction is a very important factor in the bagging behavior of fabrics [1, 16], the role of friction between fabric and lining is important in the bagging analysis of the lining added fabrics. The lining has a slippery surface which helps the garment slide smoothly over the skin. The lining was used to decrease the bagging of main fabric because it slides smoothly over the skin and an individual does not get stuck in the garment. Low friction is preferred between main fabric and lining layer. This helps layered structure easily slide over the skin and therefore, the forces and stresses will decrease on the main fabric. So, in order to get better understand the results in this section, the friction between fabric specimens and 3 types of the used linings was measured and the results were analyzed. Frictional coefficient of fabrics was measured according to ASTM D1894 standard using a tensile tester (Zwick), a wooden sled, a frictionless pulley and an inextensible yarn which was used to provide the connection of the sled to the load cell of the instrument. The instrument measures fabric-to-fabric friction. Fabric samples of 5 * 2.5 cm^2 were prepared and clamped in such a way that the fabric samples lay one over the other with the normal load of 4g/cm^2 placed above them. During friction measurement, back sides of two specimens (main fabric and lining) were tested with a constant speed of 20 mm/min for test duration of 200 s. The kinetic (dynamic) frictional coefficient were determined by using the simple linear equation between the frictional resistance and normal load, as shown below [17]:

$$\mu = F/N \quad (2)$$

Where F is the frictional resistance and N, the normal load. The equipment used for friction tester is shown in Figure 7.

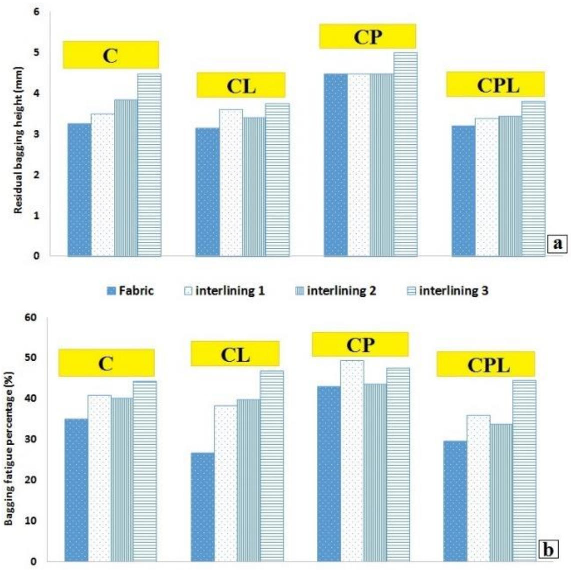

Figure 6. (a) The residual bagging height values and, (b) the fatigue percentage of the adhesive interlining added specimens

3. 3. Analysis the Effect of Friction between Lining and Fabric on Fabric Bagging The results showed that in the case of lining-fabric structures, regardless of

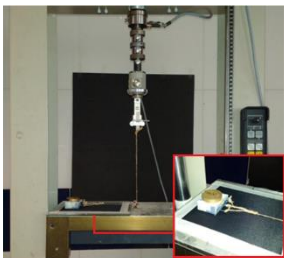

Figure 7. Testing equipment used for the friction between fabric and linig samples

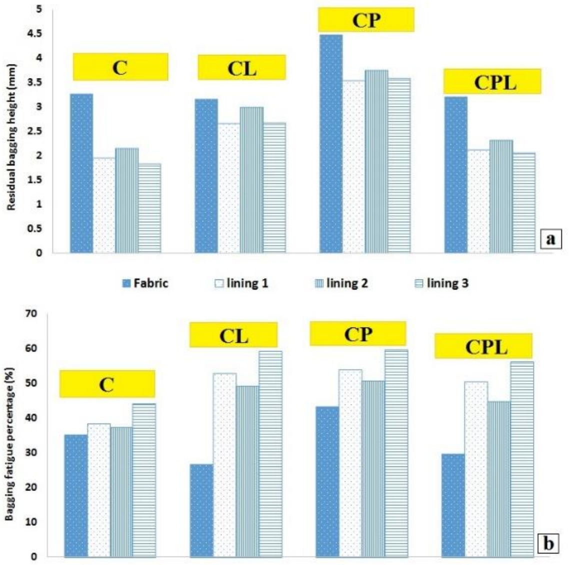

Figure 8. (a) The residual bagging height values and, (b) the fatigue percentage of the lining added specimens

the fabric and lining types, the bagging fatigue percentage increased with increasing the friction coefficient between fabric and lining (Figure 9). Applying the load on lining-fabric structure caused the lining to be influenced at the first and then the fabric. Removing the load, first the fabric and then the lining were released from the load. Therefore, the lowering of the residual bagging height in lining added fabrics than the raw material can be attributed to the later placing of the fabric under the load and the earlier release of the force. The more friction coefficient between fabric and lining caused the easier force transferring from the body to the main fabric. On the other hand, the lining acted as the adhesive interlining by increasing in friction causing the increase of the bagging fatigue.

Figure 9 shows the linear relationship between the coefficient of friction between the fabric and the lining and the bagging fatigue percentage for various fabrics. Using regression analysis in SPSS software, the relation between friction coefficient of fabric and lining, the percentage of cotton fibers in the fabric and the bagging fatigue percentage can be explained by a regression model as follows:

$$\text{Bagging fatigue} = 0.274+0.507F+0.117I_{32}+0.15I_{35}+0.077I_{94} \quad (3)$$

$$I_Z = \begin{cases} 1 & Z = \text{Cotton\%} \\ 0 & \text{Other calsses} \end{cases}$$

where, F is the dynamic coefficient of friction between the fabric and the lining. I_Z is also the coefficient used for the percentage of cotton in the fabric. The percentage of cotton fibers was applied to the model because of being common in all used denim fabrics. Table 2 presents the statistical significance (sig) and coefficients of the regression model (B). The statistical significance determines the meaningful parameters for being present in the model. As seen, all the parameters are meaningful and should be in the model except I_{100}, where the estimated coefficient is 0. For each percentage of cotton, the corresponding coefficient I_Z will be 1 and the others will be 0. For example, if the percentage of cotton is 35, I_{35} = 1, and other I_Z values are zero. In other words, the frictional coefficient determines the slope of the regression model and the intercept is different depending on the percentage of cotton fibers. Figure 10 shows the correlation of the regression curve with experimental results. The correlation coefficient of the model is equal to 0.995 indicating the model's ability to predict the values. Using this regression model, one can predict the bagging behavior of cotton blend denims with lining for unobserved blend ratios and frictional coefficient between fabric and lining.

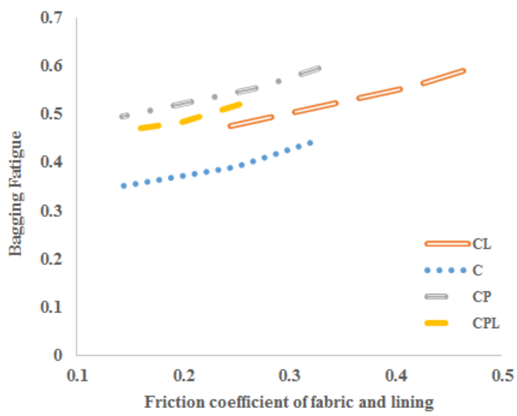

Figure 9. The bagging fatigue percentage diagram according to the friction coefficient between the fabric and the lining

TABLE 2. The regression model and estimated coefficients

Parameter	B	Std. Error	t	Sig.
Intercept	.274	.007	39.996	.000
Friction	.507	.024	20.863	.000
[C=32.00]	.117	.005	21.938	.000
[C=35.00]	.150	.005	28.711	.000
[C=94.00]	.077	.006	12.526	.000
[C=100.00]	0	.	.	.

4. CONCLUSION

Apparel bagging behavior is one of the most important issues affecting the efficiency of clothing in the field of clothing production and consumption. Adhesive interlining and lining fabrics are also two common types

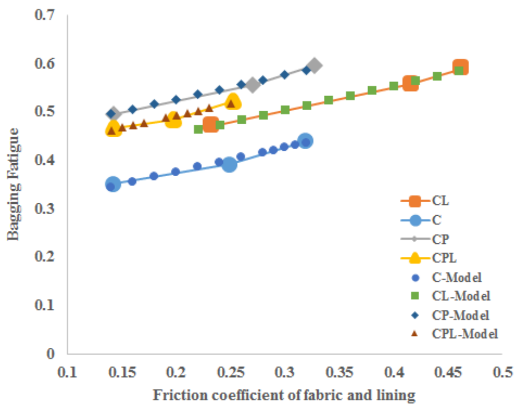

Figure 10. The regression line between the predicted and actual values of the bagging fatigue percentage for lining added fabrics

of fabrics used in the production of most clothing. It is important to study the bagging behavior of fabrics with lining and adhesive interlining due to the essential role of fabric structure and friction on the bagging behavior. The current paper aimed to investigate the effect of adhesive interlining and lining fabrics addition on the fabric bagging behavior. Four different denim fabrics including cotton, polyester and lycra, as well as three types of adhesive interlining and three common lining were tested. The results showed that adding the interlining adhesives to the fabric would increase the amount of bagging fatigue percentage. By lining the fabric, the residual bagging height of the fabric was reduced, while the fatigue percentage increased. Friction between fabric and lining is an important factor that, with its increasing, the bagging fatigue percentage increased regardless of the fabric material.

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چکیده

امروزه با کاربرد روزافزون انواع پارچه‌ها در صنعت پوشاک، بررسی مقاومت آن‌ها به کاسه‌ای شدن با هدف تعیین کارآیی منسوجات تحت نیروهای مختلف از اهمیت بالایی برخوردار است. در این پژوهش تأثیر قرارگیری لایی‌چسب و آستری بر رفتار کاسه‌ای شدن پارچه مورد بررسی قرار گرفته است. چهار نمونه پارچه‌ی جین مختلف با ترکیب الیافی پنبه، پلی‌استر و لایکرا و همچنین سه نوع لایی و سه نوع آستری متداول جهت انجام آزمایشات استفاده شد. لایی‌چسب با استفاده از دستگاه فیوزینگ و آستری نیز با دوخت به پارچه اضافه گردید و کاسه‌ای شدن پارچه با استخراج ارتفاع باقیمانده از کاسه انداختن با روش پردازش تصویر و درصد خستگی کاسه‌ای شدن از نمودار نیرو-ازدیادطول بررسی شد. نتایج نشان می‌دهد که با اضافه شدن لایی و آستری به پارچه، درصد خستگی ناشی از کاسه انداختن پارچه افزایش می‌یابد. دوخت آستری به پارچه سبب کاهش ارتفاع باقیمانده از کاسه انداختن می‌شود و اصطکاک بین پارچه و آستری عامل مهمی است که با افزایش آن، درصد خستگی کاسه‌ای شدن صرف نظر از جنس پارچه افزایش خواهد یافت.

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