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].
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 woven 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 bagging 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 denim 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 cm² 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-QB0600B) at temperature of 140 °C, pressure of 2.5 kg/cm².

<table>
<thead>
<tr>
<th>Fabric code</th>
<th>Blend type</th>
<th>Weave</th>
<th>End/cm</th>
<th>Pick/cm</th>
<th>Thickness (mm)</th>
<th>Weight (g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>100% C</td>
<td>Twill 1/3</td>
<td>35</td>
<td>22</td>
<td>0.59</td>
<td>369</td>
</tr>
<tr>
<td>CL</td>
<td>94% C, 6% L</td>
<td>Twill 1/3</td>
<td>40</td>
<td>22</td>
<td>0.56</td>
<td>385</td>
</tr>
<tr>
<td>CP</td>
<td>35% C, 65% P</td>
<td>Twill 1/3</td>
<td>28</td>
<td>22</td>
<td>0.68</td>
<td>380</td>
</tr>
<tr>
<td>CPL</td>
<td>32% C, 64% P, 4% L</td>
<td>Twill 1/3</td>
<td>40</td>
<td>22</td>
<td>0.75</td>
<td>394</td>
</tr>
<tr>
<td>Lin1</td>
<td>100% P</td>
<td>Twill 1/3</td>
<td>60</td>
<td>30</td>
<td>0.57</td>
<td>46</td>
</tr>
<tr>
<td>Lin2</td>
<td>100% P</td>
<td>Twill 1/3</td>
<td>60</td>
<td>37</td>
<td>0.61</td>
<td>58</td>
</tr>
<tr>
<td>Lin3</td>
<td>100% P</td>
<td>Twill 1/3</td>
<td>60</td>
<td>33</td>
<td>0.60</td>
<td>50</td>
</tr>
<tr>
<td>Int1</td>
<td>100% P</td>
<td>Plain</td>
<td>-</td>
<td>-</td>
<td>0.30</td>
<td>40</td>
</tr>
<tr>
<td>Int2</td>
<td>100% P</td>
<td>Plain</td>
<td>-</td>
<td>-</td>
<td>0.52</td>
<td>53</td>
</tr>
<tr>
<td>Int3</td>
<td>100% P</td>
<td>Plain</td>
<td>-</td>
<td>-</td>
<td>0.51</td>
<td>43</td>
</tr>
</tbody>
</table>

*C=Cotton, P=Polyester, L=Lycra, Lin=Lining, Int=Interlining.
for process 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.

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]:

\[
\text{Bagging fatigue} = \frac{\text{work of first cycle's loading} - \text{work of last cycle's loading}}{\text{work of first cycle's loading}}
\]

(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 1. Schematic of lining-main fabric sewn sample](image1)

![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](image2)

![Figure 3. Specimen conditions for shooting](image3)

![Figure 4. The photograph of residual bagging height of specimens: (a) specimen C, (b) specimen C-lining](image4)

![Figure 5. A typical force-elongation diagram for three cyclic bagging](image5)
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. Therefore, 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-fabric friction. Fabric samples of 5 * 2.5 cm² were prepared and clamped in such a way that the fabric samples lay one over the other with the normal load of 4g/cm² 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]:

$$\mu = \frac{F}{N}$$  \hspace{1cm} (2)

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

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

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

Figure 10. 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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.274</td>
<td>.007</td>
<td>39.996</td>
<td>.000</td>
</tr>
<tr>
<td>Friction</td>
<td>.507</td>
<td>.024</td>
<td>20.863</td>
<td>.000</td>
</tr>
<tr>
<td>[C=32.00]</td>
<td>.117</td>
<td>.005</td>
<td>21.938</td>
<td>.000</td>
</tr>
<tr>
<td>[C=35.00]</td>
<td>.150</td>
<td>.005</td>
<td>28.711</td>
<td>.000</td>
</tr>
<tr>
<td>[C=94.00]</td>
<td>.077</td>
<td>.006</td>
<td>12.526</td>
<td>.000</td>
</tr>
<tr>
<td>[C=100.00]</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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
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 adheres 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.

5. REFERENCES

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

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Paper history:
Received 03 June 2019
Received in revised form 01 July 2019
Accepted 05 July 2019

Keywords:
Underlying Fabric
Interlining
Lining
Bagging Behavior
Denim Jeans

doip: 10.5829/ije.2019.32.09c.02