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Relationship between jacket comfort and stiffness of adhesive interlining

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Abstract: We investigated the effects of adhesive interlining on wearing and moving comfort and garment pressure exerted on the body. Scheffe's paired comparison test was performed for sensory evaluation of four jackets of the same pattern: one without interlining and three with different adhesive interlinings (soft, normal, hard). The bonded fabrics have different shear and bending rigidities. Nineteen subjects performed a series of postures and movements while wearing the jackets: (1) standing, (2) moving arms forward, (3) raising arms overhead, and (4) moving arms horizontally to the side. They compared wearing and moving comfort, and the feeling of garment pressure on designated parts of the body on a seven-point scale. Analysis of variance revealed significant differences in preference scores between jacket types. A jacket with lower stiffness was evaluated as more comfortable and as placing less pressure on the body. There were significant differences in wearing comfort between jackets even when subjects were standing. We conclude that adhesive interlinings affect wearing and moving comfort of jackets and the pressure exerted by a jacket on the body, especially in the shoulder, back, forearm, under the arm and bust areas. The use of lower-rigidity interlining, especially for the shoulder, back, under the arm and bust, will result in a more comfortable jacket, although the interlining must be sufficiently rigid to maintain the desired shape and appearance of the jacket.

Keywords: Jacket, Comfort, Stiffness, Adhesive, Interlining

1. INTRODUCTION

Adhesive interlining is generally used in parts such as the front, side, upper shoulder and

hemline of jackets to increase textile rigidity. Studies have investigated the changes in bending rigidity and shear stiffness associated with bonding adhesive interlining [Kim K. et al, 2011-2013]. The effect of adhesive interlining on jacket appearance was investigated by Kim et al. [2013], who found that the surface smoothness and waist line and thus the appearance of a jacket were affected by bonding adhesive interlining.

Although the effects of adhesive interlining on garment appearance have been investigated, the effect on clothing comfort has not. Along with garment appearance, wearing comfort is considered as an important factor of clothing. Changes to bending rigidity and shear stiffness could affect jacket comfort. There are many studies on the relationship between pressure and garment comfort of tight fit garment giving high pressure such as underwear, socks and stockings [Jeong, Y. et al. 2006 Liu, H. et al. 2013, Ishimaru, S. et al. 2011]. However, researches on the effect of compression on the outer garment such as a jacket are less.

There are some studies on the jacket comfort taking account with garment pressure caused by different both patterns and materials [Kanai, H. et al 2007]. Satoh and Ikeda et al. [1994, 1995] investigated the wearing comfort of several commercial jackets on market considering garment pressure. Chen et al. [2003] investigated the relationship between clothing pressure and the textile mechanical properties of a men's jacket employing grey incidence analysis theory. Even though, they showed that tensile and compression properties, shear stiffness and weight per unit area are related to the above clothing pressure of a men's jacket, the influence of partially different rigidity of a jacket on wearing comfort has not been investigated. In practice, the stiffness of clothing material is controlled by bonding interlinings. Sometimes, depending on the jacket parts, interlinings of different rigidities are used for the appearance. Even jackets made with the same face fabric, the comfort will be different depending on the interlining kinds. The partially different rigidity will affect comfort of the entire and part of jacket. Thus, the comfort changes caused by bonding interlining need to be investigated.

Using the jacket that was made using different interlining with varied rigidity, we investigated the effects of adhesive interlining on wearing and moving comfort and on garment pressure exerted on the body. We also considered the different comfort depending on different movement of different body parts.

2. EXPERIMENTAL

We carried out sensory tests to investigate the effects of adhesive interlining on wearing and moving comfort and on garment pressure exerted on the body. Scheffe's paired comparison test (Nakaya variation, which neglects sample order) was used for the sensory evaluation.

Four jackets of the same pattern and material (100% wool) without a lining were made for this evaluation. Figure 1 shows the jacket pattern and the interlining parts. The jacket size is JIS (Japanese Industrial Standards) 9AR (height 158 cm, bust 83 cm and hip 91 cm). One (no interlining) was made without interlining and the others were made with three different adhesive interlinings (soft, normal and hard) having different shear and bending rigidities. Pictures of jacket samples are shown in Figure 2. The masses of the jackets and the shear stiffnesses and bending rigidities of the fabric bonded by interlining measured with a KES-FB system [Kawabata, 1980] are given in Table 1. The mass of jacket, shear stiffness and bending rigidity of fabric bonded interlining used in jacket samples increased in the order of no, soft, normal and hard interlining.

Nineteen subjects, whose fitting sizes were 9AR, volunteered to participate in the test. Subjects

wore the same T-shirt and skirt for the test. They performed a series of postures and movements while wearing the jackets: (1) standing, (2) moving arms forward, (3) raising arms overhead, and (4) moving arms horizontally to the side as shown in Figure 3. They compared the feeling of weight, feeling of hardness, wearing comfort, moving comfort, and feeling of garment pressure on designated parts (neck, shoulder, bust, front of the upper arm under the arm, part around the bust and button, back, back of the upper arm, front side and back side) of the body for the entire jacket as shown in Figure 4. They scored the results on a seven-point scale. The test was carried out in a chamber with standard conditions of 20 ± 1 °C and 65% ± 5% relative humidity.

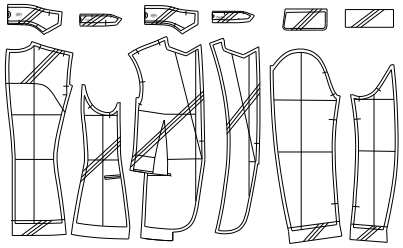


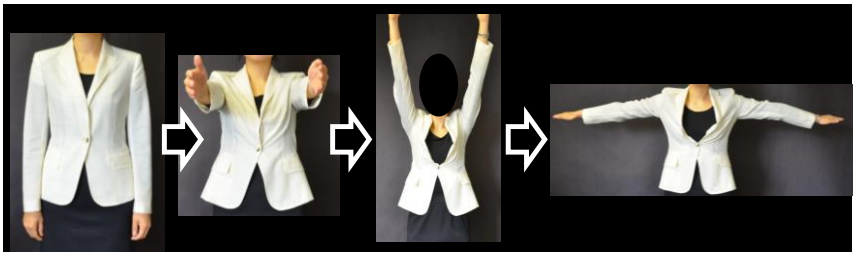
Figure 1: Jacket pattern with interlining parts (diagonal lines)

(a) no interlining (b) soft interlining (c) normal interlining (d) hard interlining

Figure 2: Jacket samples with different interlining

Table 1: Mass, shear stiffness and bending rigidity of fabric bonded by interlining

Property \ Fabric bonded by interlining	No interlining		Soft interlining		Normal interlining		Hard interlining	
	warp	weft	warp	weft	warp	weft	warp	weft
Mass (g)	201.6		212.3		234.8		263.7	
Shear stiffness ($gf \cdot cm^{-1} \cdot degree^{-1}$)	0.668	0.664	0.886	0.834	2.256	2.204	5.934	6.082
Bending rigidity ($gf \cdot cm^{2} \cdot cm^{-1}$)	0.062	0.050	0.108	0.101	0.214	0.208	0.453	0.456



(1) (2) (3) (4)

Figure 3: Movement in the sensory test; (1) standing; (2) moving arms forward; (3) raising arms overhead; and (4) moving arms horizontally to the side

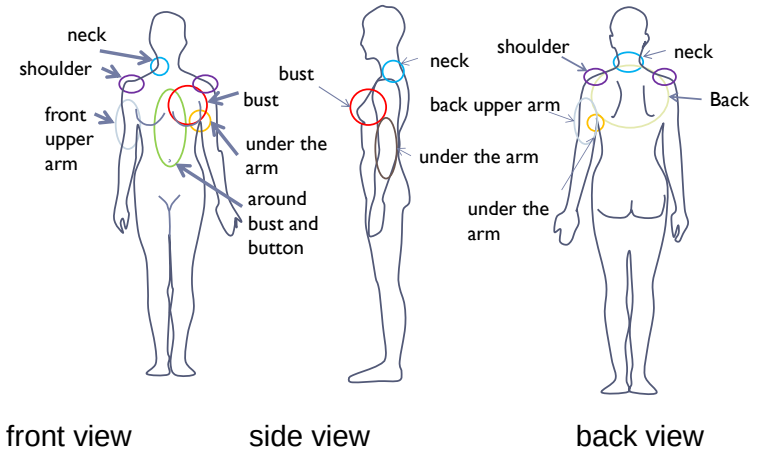


Figure 4: Designated body parts in the sensory test

3. RESULTS AND DISCUSSION

Significant differences in preference scores between jacket types were revealed using analysis of variance. Table 2 shows the significant differences between sample pairs in terms of feeling of weight, feeling of hardness and feeling of pressure for each movement. There were significant differences in feeling of weight between all samples except between the jackets with no interlining and soft interlining. It was thus revealed that the subjects felt differences in jacket weight.

There were significant differences between all sample pairs in the evaluation of the feeling of hardness for the entire jacket. Even when standing, subjects felt the difference in the feeling of hardness. For all movements, subjects felt differences on the neck, bust and under the arm between the two jackets of all sample pairs except for the pair having no interlining and soft interlining. This means that the differences in weight, bending rigidity and shear stiffness between the jackets having no interlining and soft interlining were too small for subjects to feel. The results reveal that the subject felt the weight and hardness of jackets differently for different interlinings except in the comparison of jackets with no interlining and soft interlining.

Table 2: Significant differences between jackets of sample pairs in feeling of weight, feeling of hardness and feeling of pressure for each movement (*: 5% significant difference, **: 1% significant difference)

Evaluation condition / Jacket sample pair		no interlining –soft interlining	no interlining –normal interlining	no interlining –hard interlining	soft interlining –normal interlining	soft interlining –hard interlining	normal interlining –hard interlining
Standing	Feeling of weight		**	**	**	**	**
	Feeling of hardness—entire	**	**	**	**	**	**
	Feeling of hardness—neck		**	**	*	**	**
	Feeling of hardness —bust		**	**	**	**	**
	Feeling of hardness—under the arm		**	**		**	**
	Feeling of pressure—entire		**	**	**	**	**
Front	Feeling of hardness —entire		**	**	**	**	**
Horizontal	Feeling of hardness —entire	*	**	**	**	**	**
Up	Feeling of hardness—entire		**	**	**	**	**

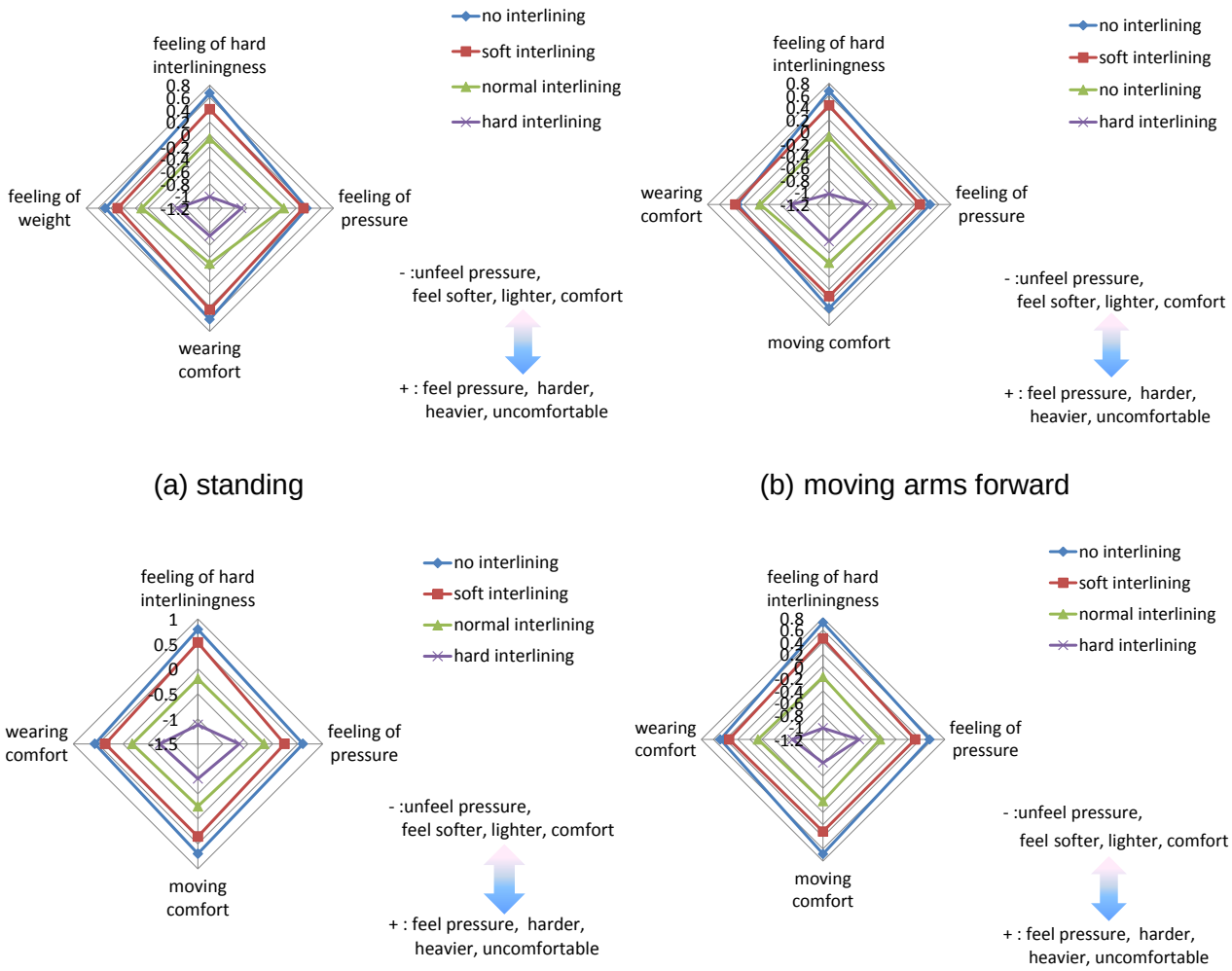
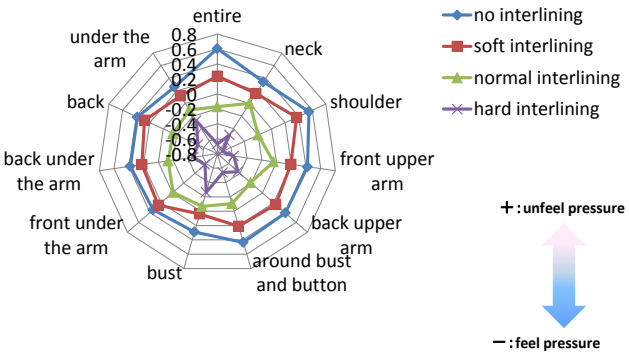


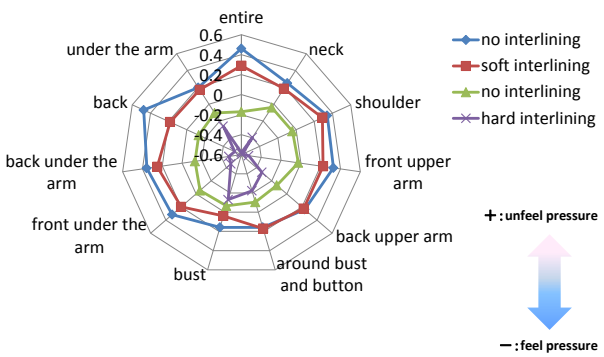
Figure 5: Preference scores for feeling of hardness, feeling of weight, wearing comfort, feeling of pressure, and moving comfort of the entire jacket in each movement

Preference scores of feeling of hardness, feeling of weight, wearing comfort, feeling of pressure, and moving comfort of entire jacket for each movement are shown in Figure 5. The jacket without interlining was evaluated as the softest and lightest. The subjects evaluated the jackets as being increasingly harder and heavier in the order of jacket with no, soft, normal and hard interlining. In terms of moving comfort, feeling of pressure and wearing comfort for the entire jackets, subjects again evaluated jacket without interlining is the most comfortable, the easiest to move in and having the lowest pressure for the entire jacket. The results were the same as the results for the feeling of hardness.

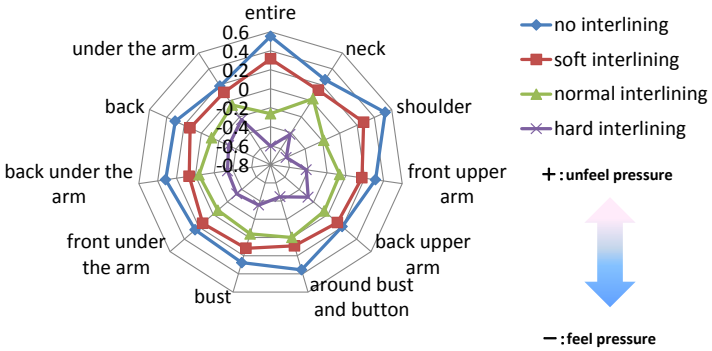
Preference scores of feeling of pressure for each part and each movement are shown in Figure 6. The feeling of pressure increased in the order of no, soft, normal and hard interlining. This was the same order as for bending rigidity and shear stiffness of the bonded fabric. However, the areas where subjects felt pressure varied depending on movement. There were significant differences between the two jackets of most sample pairs except for the pair of jackets having no and soft interlining. This result is the same as that for feelings of hardness and weight. However, there were significant differences for the back, under the arm during horizontal arm movement, and bust during upward arm movement for all sample pairs. It was thus found that subjects largely felt differences in pressure for the back, under the arm and bust in those movements. This is explained



(a) raising arms overhead

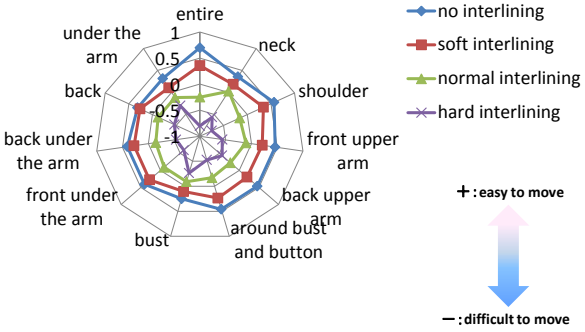


(b) moving arms forward

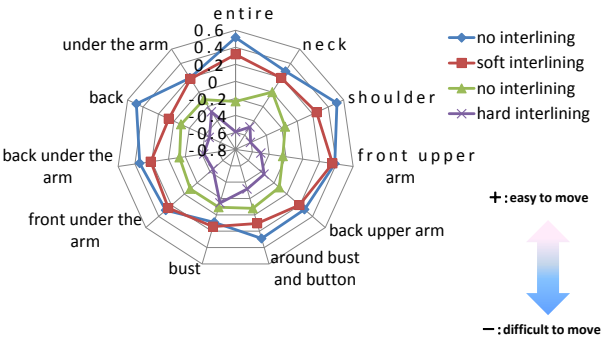


(c) moving arms horizontally to the side

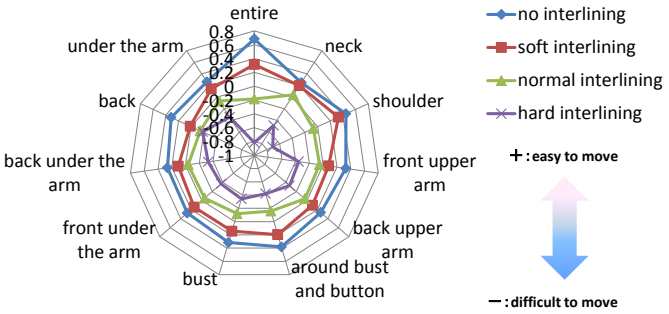
Figure 6: Preference scores of feeling of pressure in each area for each movement



(a) raising arms overhead



(b) moving arms forward



(c) moving arms horizontally to the side

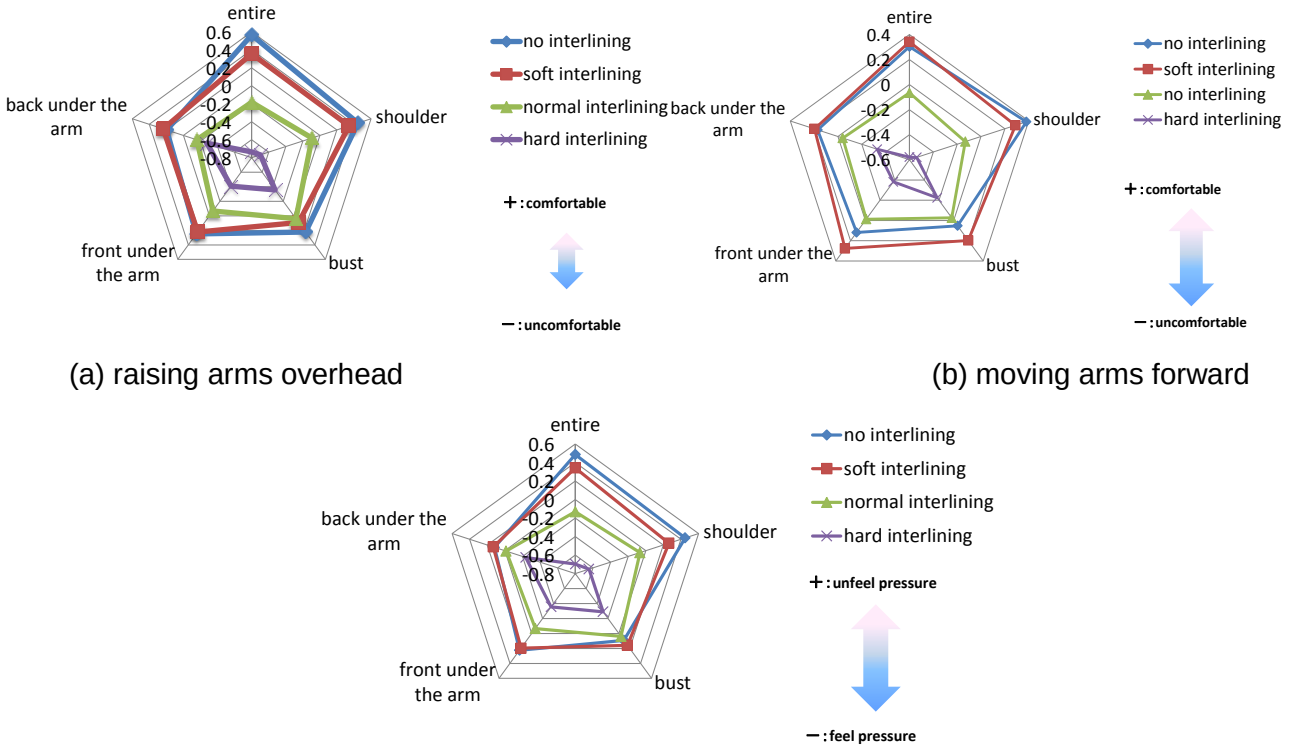
Figure 7: Preference scores of moving comfort in each area for each arm movement

by the large difference in pressures. The pressures were generated by the restriction of fabric deformation on the body parts in the movements that require large deformations of fabric.

Preference scores of moving comfort in each area for each movement are shown in Figure 7. In terms of moving comfort, the jacket without interlining, followed by the jackets with soft, normal and hard interlining, was evaluated as the easiest to move in. There were significant differences between the two jackets of almost all sample pairs except for some areas for the jackets with no and soft interlining. There were significant differences between jackets with no and soft interlining in the shoulder and back for the forward arm movement, in the front of the forearm and back for the horizontal arm movement, and in the front and back of the forearm and under the arm for the upward arm movement. It was thus found that subjects felt moving comfort at the shoulder, back, front and back of the forearm, and under the arm more strongly. The reason is the same as that explaining the results for the feeling of pressure. However, subjects felt the differences in moving comfort more sensitively than those in the feeling of pressure.

Subjects particularly felt pressure and moving comfort in the forearm, where interlining was not used. The reason was that the deformation of clothing was affected by other connected parts. Forearm parts of sleeves were drawn out with the side and shoulder parts where interlining was used. It was thus found that interlining affected parts where interlining was not used.

Preference scores of wearing comfort in each area for each movement are shown in Figure 8. There were significant differences in wearing comfort between the two jackets of almost all jacket pairs for the standing posture and other movements except for the pair of jackets with no and soft interlining. The jackets with no and soft interlining were evaluated as being comfortable, the jacket with normal interlining as having medium comfort, and the jacket with hard interlining as being the most uncomfortable.



(a) raising arms overhead

(b) moving arms forward

(c) moving arms horizontally to the side

Figure 8: Preference scores of wearing comfort in each area for each arm movement

The above results reveal that the jackets felt different to the subjects because of their different stiffnesses of fabric due to different bonding interlining. Preferences of feeling of weight, feeling of hardness, feeling of pressure, moving comfort and wearing comfort had the same tendency. Softness, comfort and absence of pressure were judged to decrease in the order of the jackets with no, soft, normal and hard interlining. It was thus revealed that the different stiffness of bonded fabric resulting from the interlining affected the wearing comfort of the jackets.

4. CONCLUSION

A jacket with lower stiffness of fabric was evaluated as more comfortable and as placing less pressure on the body. We conclude that the stiffness of bonded fabric affects the wearing comfort of jackets and the moving comfort and pressure exerted by a jacket on the body, especially in the shoulder, back, forearm, under the arm and bust areas. This is due to the restriction of fabric deformation in areas that require large deformations of fabric during movements. These areas are the shoulder, back, under the arm and bust. A lower stiffness of bonded fabric with interlining in these areas will result in a more comfortable jacket, although the interlining must give sufficient stiffness to maintain the desired shape and appearance of the jacket. In this study, it was found that the effect of the fabric rigidity on the jacket comfort taking into account the arm movements and jacket parts. The quantitative evaluation will be our next subject.

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