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Effects of the Lining on Comfort and Configuration of Semi-Flared Skirt

Hiroko KAWABATA, Ayumi MATSUMOTO* and Chisa YOSHIZAWA**

Faculty of Education, Saitama University, Saitama 338-8570, Japan
***R & D Laboratory for Applied Product, Asahi Kasei Fibers Co., Ltd., Osaka 569-0096, Japan*

The effects of the lining on semi-flared skirts were investigated for wearing evaluation and observation of the hemline. We tested six skirts with two different types of lining cutting patterns combined with three kinds of conventional lining fabrics (cupro, special polyester with a characteristic softness, and regular polyester). The first pattern was a flared pattern having the same contour as the outer fabric (*i.e.* flared pattern), and the second was of a straight contour with slits on each side (*i.e.* straight pattern). Thirteen female university students tested and evaluated the comfort of each skirt. The test results showed that skirts with the flared pattern were more comfortable than those with the straight pattern, especially in terms of easiness of body movement. Also, cupro lining ranked higher than other linings in the tactile sensation on the skin. Using the motion analysis method, we observed the hemlines of the outer fabrics and the lining fabrics of the skirts worn on a mannequin, in static and dynamic states. The hemline area of skirts in static state was larger and symmetric in flared linings. The hemline area and hemline travel distance were larger, while space between outer and lining fabrics was smaller in dynamic state in skirts with flared linings than with straight linings. The two fabrics were found to move together in skirts with flared linings, the fact that can be suggested as the reason for more functional mobility. Cupro linings covered smaller hemline areas, but exhibited the most travel ditance and movement with great dynamism. We consider this to be related to the bending and shearing properties of the linings. These results imply that both lining patterns and physical properties of the lining fabrics influence the silhouette as well as comfort.

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INTRODUCTION

The lining, as the innermost part of a garment, is a silent but important partner to the outer fabric. Its many functions include maintaining and enhancing the drape, form, and flow of the garment, facilitating smooth dressing and removal, and shielding the outer fabric from deposits, yellowing, and other degradation or soiling.

However, there have been observed quite a few garments without liner for reducing cost and operations. And moreover, consumers tend to take relatively little notice of the lining when they purchase a garment but may later express dissatisfaction or discomfort related to it. In previous studies, we found that lining fabric affects the tactile sensation, form, and functional mobility of tight skirt,[1)2)] and that lining smoothness and stretch properties are important for the design of comfortable garment.[3)] In the present study, we focus on the effects of linings when used in semi-flared skirts made of thin chiffon fabric ("*chiffon* skirts"), in which they are necessary to prevent a "see-through" appearance, maintain the skirt configuration, and protect the chiffon fabric. In preliminary surveys, we found that various lining fabrics and patterns have been used in ready-made chiffon skirts, and their selection has been generally based simply on experience as scientifically based information has been apparently lacking. We have been not able to find reports of studies on the influence of linings on chiffon skirt conformation and silhouettes.

For this study, we made six skirts using two different lining cutting patterns and three different lining fabrics. We then conducted a subjective test in which the wearers rated the skirts for comfort, functional

* Present address: People Co., Ltd., Higashi-Nihonbashi, Tokyo 103-0004, Japan

mobility, and other properties, and evaluated the results to determine the effects of the lining fabrics and patterns. We next performed a motion analysis test, in which we investigated the configuration and movement of the skirt hemlines when mounted on stationary and moving mannequins. All results are applied to elucidating the importance and the basis for selection of appropriate lining fabrics and patterns for comfort, drape, form, and flow in chiffon skirts.

MATERIALS AND METHODS

Fabrics

The surface of the skirt and lining fabrics was shown in Fig. 1. The surface of the fabrics was observed by the digital microscope of 100 magnification (BS-D 8000 Ⅱ, Sonic Co., Ltd.). The characteristics of the fabrics were listed in Table 1. Drape coefficient was measured by JIS-L-1096.[4] Frictional coefficient, bending, shearing, and tensile property were tested by KES-F2 under sensitive condition.[5] Dynamic vibration properties of the fabrics were applied by using the expression shown by Matsudaira.[6]

The outer fabric of the skirt was thin plain weave *chiffon*, with high-twist yarns made of polyester filament. The fabric had a soft hand and good drape characteristics, and needed lining to reduce the "see-through" appearance and to support the configuration.

The lining fabrics were cupro (CU), special polyester (ES1), and regular polyester (ES2), all of the type conventionally used for linings. All the lining fabrics were woven by straight fibers without crimp, with the same finesses, and with circular cross section. Three of the lining fabrics were fine plain weaves called Taffeta and the differences were not seen from observation of the surface as shown in Fig. 1. CU is a Cuprammonium rayon fiber, a kind of man-made cellulose fiber made of cotton linter. The two linings, ES1 and ES2, are made of polyester fibers. The ES1 was composed of electroconductive yarns preventing fabric cling and had been processed with sodium hydroxide for reduced weight. The sodium hydroxide treatments make space between fibers and improve softness, as indicated in bending and shear properties shown in Table 1. The ES2 is unprocessed and woven with fibers of the same finesses as the ES1.

Skirt

Figure 2 illustrated the pattern of the semi-flared skirts in this study. The size of the skirts was 9AR (waist=63 cm, hip=92 cm), with 68 cm length and 130 cm hem circumference. The skirt hem was rolled by lock-stitch machine. The lining patterns were based on conventional patterns found on the market. One was a flared pattern having the same contour as the outer fabric (thus, the liners in skirts CU(1), ES1(1), and ES2(1), and the other was a straight pattern with slits of 17 cm on each side for functional mobility (thus, the liners in skirts CU(2), ES1(2), and ES2(2). Both lining patterns were 4 cm shorter than the skirt. The liner was attached to the outer fabric at the waist and zipper but not at the side seams. The lining hem was folded up twice into widths of 1 cm. Six skirts were thus made in all, each with a different combination of the above lining fabrics and patterns.

Wearing test and evaluation

Thirteen female university students participated as subjects in wearing tests performed in October 2004 in a laboratory room with a mean temperature and humidity of 31℃ and 63%. The experiment was conducted under a high temperature and high humidity environment to evaluate comfort of garments in summer seasons. Each subject wore the six skirts in random order without stockings or pantyhose and answered a ten-statement questionnaire on ease of putting on and taking off the skirt ("donning" and "doffing"), A1, functional mobility, B1 to B4, tactile sensation/cool feeling, C1 to C4, and overall comfort, D1, as indicated in Fig. 4. The subjects rated each

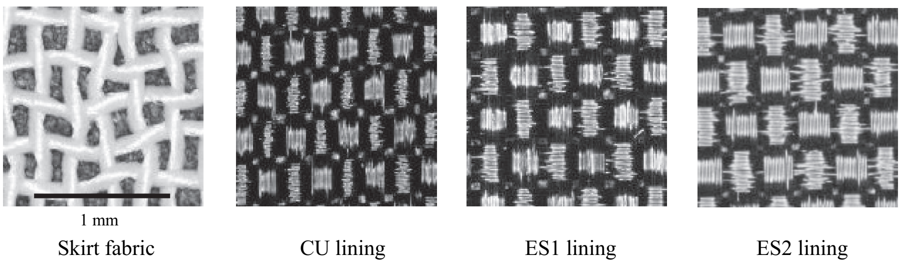


Fig. 1. Skirt and lining surface

Table 1. Properties of skirt and lining fabrics

Fabric		Skirt	Lining		
			CU	ES1	ES2
Fabric fibers		Polyester	Cupro	Polyester	Polyester
Fineness (dtex)	warp×weft	84×84	56×84	56×84	56×84
Density (count/cm)	warp×weft	51×45	53×34	44×33	41×33
Weaves		Plain	Plain	Plain	Plain
Thickness (mm)		0.19	0.08	0.07	0.07
Weight (g/m^2)		73	59	52	52
Drape coefficient	% (node count)	15 (6)	45 (5)	55 (5)	57 (4)
Standard moisture regain (%)		0.4	11.0	0.4	0.4
Surface frictional coeficient	MIU	0.211	0.212	0.291	0.232
	MMD	0.020	0.012	0.018	0.034
	SMD (μm)	3.305	3.196	3.340	3.326
Bending	B (N·m^2/m)	8.83×10^{-7}	1.86×10^{-6}	1.39×10^{-6}	1.74×10^{-6}
	2HB (N·m/m)	2.65×10^{-5}	8.04×10^{-5}	7.16×10^{-5}	12.10×10^{-5}
Shear	G (N/m·rad)	17.42	17.42	21.91	34.27
	2HG (N/m)	0.35	0.13	0.63	1.43
	2HG5 (N/m)	0.72	0.72	1.35	2.67
Dynamic vibration properties	2HG/G$^{0.5}$	0.085	0.031	0.134	0.245

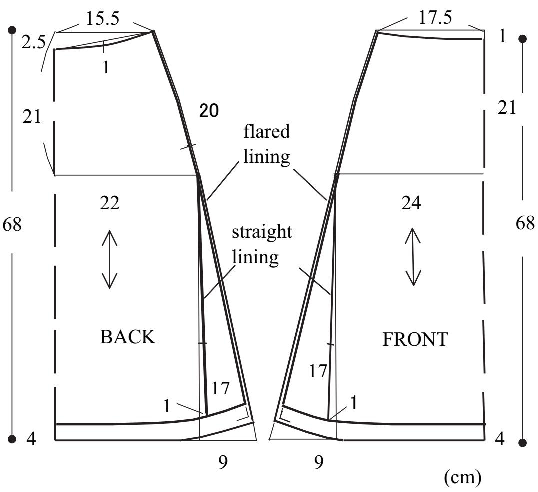


Fig. 2. Skirt and lining patterns

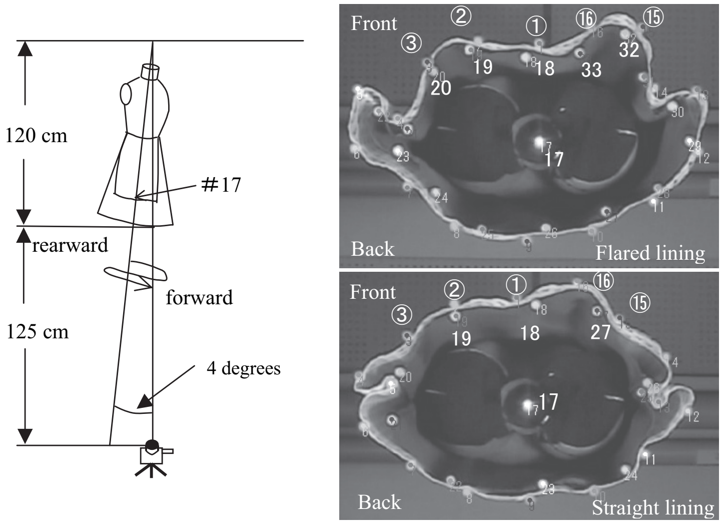
skirt on the following seven-point semantic-differential scale: ±3 (strongly agree), ±2 (agree), ±1 (slightly agree), 0 (neutral), with positive values indicating comfort or favorable impression.

Test-stand observation

The apparatus of the test-stand observation was illustrated in Fig. 3. The skirt was mounted on a mannequin suspended from the ceiling, and videotaped from directly below the skirt, first in the stationary state and then in the dynamic state for 4.8 s intervals during pendulum swings by the mannequin tipped 4 degrees rearward. The angle of the inclination was decided on the degree at which observation of the skirt hem movement could be made without the skirt being entangled with the mannequin.

Marking points on the skirt were shown in Fig. 3. To determine the differences among the skirts in form and flow, the outer fabric of each skirt was marked 16 points (① to ⑯), and the liner of each skirt respectively was marked 16 points (#18 to #33; on the flared lining pattern) or 10 points (#18 to #27; on the straight lining pattern) along their hemlines. The point of #17 was marked on the center at the bottom of the mannequin torso to make sure of its regular movement.

The video images in the videotaped intervals were analyzed to determine (a) the variation in hemline area (area circumscribed by hemline; approximated as area of polygon formed by the marked points), (b) the hemline travel (cumulative distance of hemline movement), and (c) the variation in interfabric area (area between outer fabric and liner at hemline).



#17:center at the bottom of mannequin torso

Fig. 3. Illustration of monitoring system and marking points

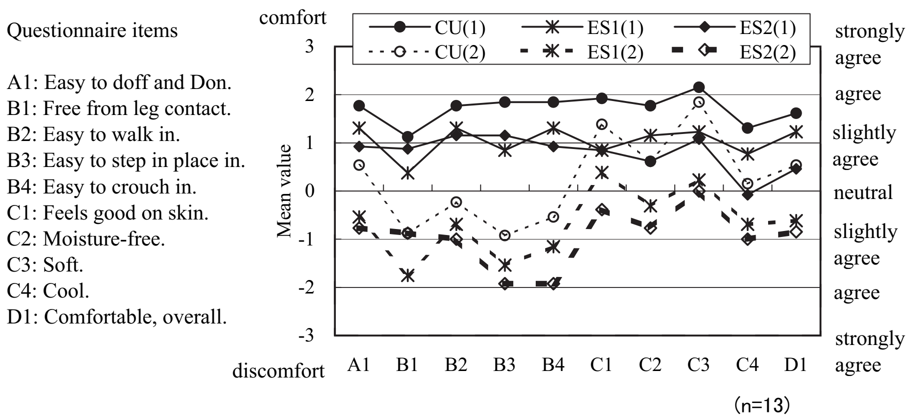


Fig. 4. Questionnaire items and evaluation results of wearing test

RESULTS AND DISCUSSION

Wearing test and evaluation

Figure 4 showed the ten statements in the questionnaire and the mean value of the responses to each statement. To discuss the results, one-way analysis of variance procedure and multiple comparisons were used.

In answer to the question "donning and doffing (A1)" and functional mobility (B1 to B4), the significance level for lining pattern was 1%. The skirts lined with the flared pattern were more comfortable during movement. And a significance level of 5% was found for lining fabric in donning and doffing (A1) and in ease of crouching (B4). In relation to functional mobility, these results indicated that the lining pattern have had a strong influence on comfort during movement. The order of the three lining fabrics in terms of the mean values of the responses, from high to low, could follow CU, ES1 and ES2. From these results, the smoothness of the lining imparts a feeling of freedom and gentleness on the skin.

In answer to the question in tactile sensation, lining fabric was significant at the 1% level for the responses to C1 and C3, and at the 5% level for those to C2 and C4. Lining pattern was significant at the 5%

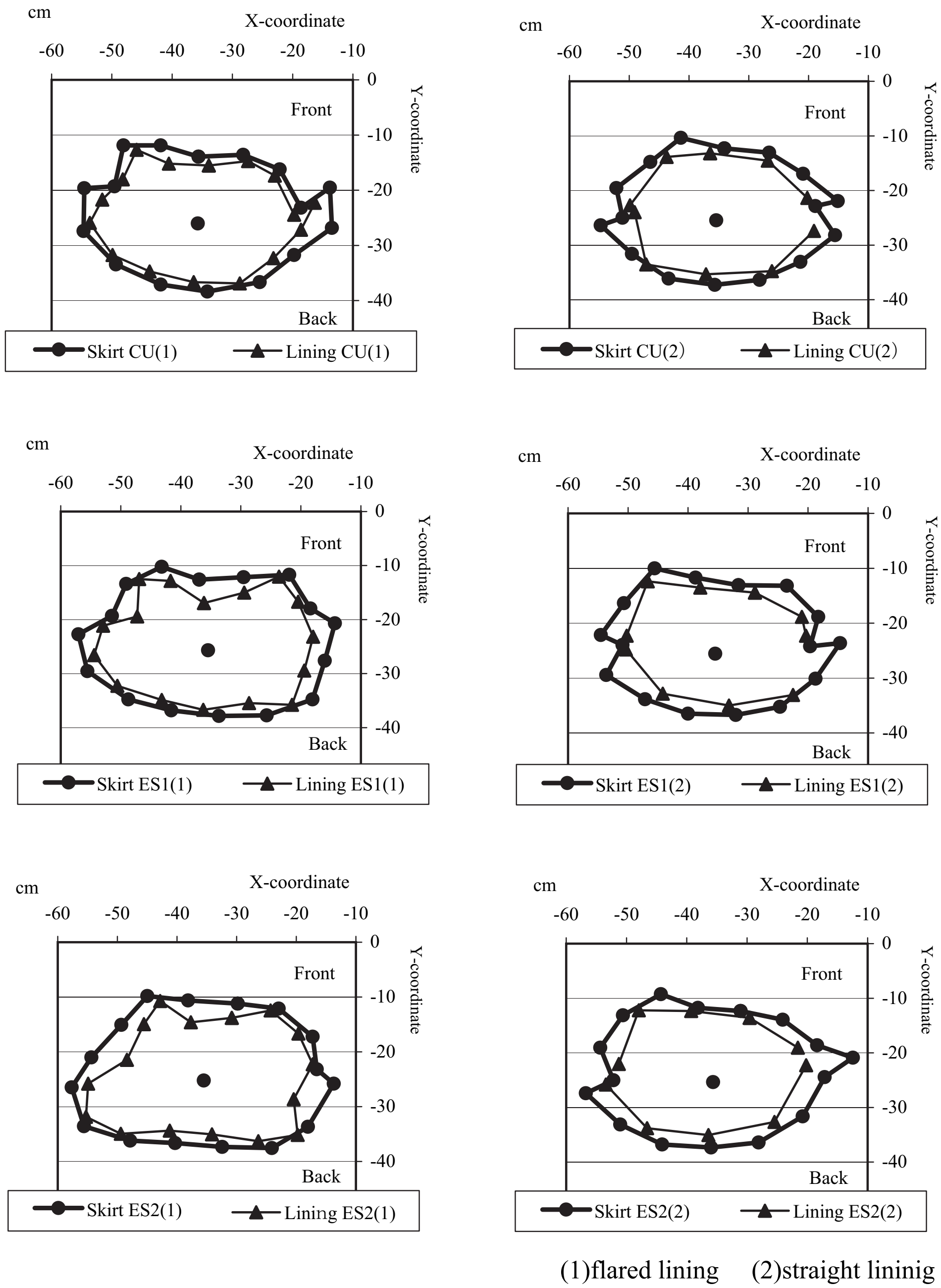


Fig. 5. Skirt and lining hemlines

level for all the answers according to feeling on the skin. Tactile sensation was related to mechanical characteristics such as bending and shear, and moisture and thermal comfort which were related to the moisture regain of the fiber itself (Table 1). In the responses concerning sensory comfort, however, the mean values for CU(2) were not significantly higher than those for ES2(1) and ES1(1), which suggested that flared patterns have been able to improve sensorial comfort and freedom from contact with the skin.

Test-stand evaluation—static

The shapes formed by the marked points along the outer fabric and lining hemline, were shown in Fig. 5. The skirt lined with CU(1) had smaller area and more complicated shape than that of ES2(1). With the skirt side, all the flared lining patterns were symmetric and convex. However, the skirt with CU(2) lining was concaved and the skirt with ES2(2) was not right-left symmetrical because the straight lining could not hold the outer fabrics at the skirt side. This result indicated that a flared pattern could maintain outer shape and silhouette more effectively than the straight pattern.

As shown in Fig. 6 in terms of the areas of the polyhedrons, the skirts with the flared lining pattern covered larger hemline areas than those with the straight lining pattern, thus indicating a wider skirt configuration at the base for flared liners. Comparing the three lining fabrics, the hemline area of ES2 was largest, that of ES1 was intermediate, and that of CU was smallest. The trend has related to drape property of the lining fabric. As all three lining fabrics had a higher stiffness than the outer fabric, the hemline area was strongly influenced by the lining fabric with the flared liners. With the straight liners, though the ES2 skirt hemline area was the largest, the differences between that of CU and ES1 were not enough to be significant.

All of these results indicate that both the lining pattern and the fabric have not a little influence to the shape and silhouette of the skirts, and show the importance of selecting the appropriate lining pattern and lining fabric to obtain an attractive and graceful skirt design.

Test-stand evaluation—dynamic

1. Variation in hemline area

The variation of the area circumscribed by skirt hemline with time was shown in Fig. 7, which was the partial for three seconds. The oscillations curve on the right axis indicated the movement of the #17 point. The hemline area on the left axis generally peaked each time the mannequin torso reversed its direction of swing and then rapidly decreased from that maximum. The hemline area was thus greatest when the mannequin was at its forwardmost or rearwardmost points of travel, and smallest when the mannequin was at the midpoint of its swing.

The hemline areas of the skirt with the flared lining pattern tended to be larger than those with the straight lining pattern, thus indicating that the dynamic drape and silhouette have been also affected by the lining pattern. Among the lining fabrics, the ES2 (1) skirt showed the largest hemline areas of the six skirts. And the hemline areas varied regularly with the movement of the mannequin. The CU skirts showed the smallest in comparison with other linings. This result was related to drape property of the lining fabric. The observation of the skirts with CU lining showed a tendency for the skirt back and the skirt front to bend inward when the mannequin reached its forwardmost and rewardmost points, respectively. The differences observed among the three lining fabrics were affected by the differences on their drape, bending and shear characteristics.

2. Hemline travel

The cumulative distance of hemline travel in the horizontal direction with each skirt was calculated as the values obtained for that skirt in several of the 4.8 s videotaped intervals. The center part of the skirt traveled a lot to be compared with the side part of the skirt. As the similar tendency was found between the front skirt and back, the mean values of the cumulative distance of the front skirt from ③ to ⑮ and the

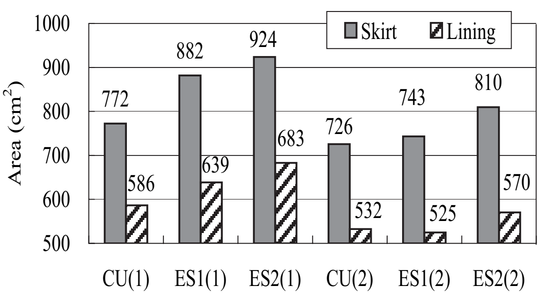


Fig. 6. Skirt and lining hemline area (static state)

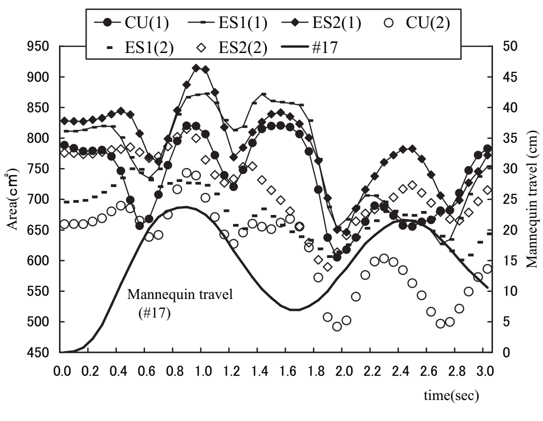


Fig. 7. Change of skirt hemline area with time (dynamic state)

lining from #20 to #32 for the flared lining and from #19 to #27 for the straight lining in Fig. 3, were shown in Fig. 8.

The comparatively long distances found for the skirts with CU linings indicated that softer linings have been able to enhance skirt movement, an effect of which was attributable to the dynamic vibration properties of the fabrics as reported by Matsudaira[6)] and by Izumi and Niwa.[7)] The dynamic vibration ratio was in inverse proportion to the fabric's shear, $2HG/G^{0.5}$ values as calculated in Table 1. These values imply that CU linings can maintain better movement than either ES1 or ES2 linings.

The skirts with the straight pattern tended to move less than those with the flared pattern with ES 1 and ES2 linings. However, there were only small differences of the distances between the straight pattern skirts and the linings; it wasn't necessarily the same movement of the skirt and the lining. The soft and supple CU linings resulted in a smoother, more graceful skirt movement, which can be explained at least in part the greater functional mobility comfort found for the CU linings in the above wearing test.

3. Interfabric area

Figure 9 showed the area of the space between the outer and lining fabrics at the skirt front with each skirt. Bar graphs showed maximal values and black diamonds showed the mean values with standard deviation, obtained in several of the 4.8 s videotaped intervals. We have to notice that the areas of the skirts with the flared lining and the straight lining didn't correspond to the same extent, being calculated at the same part as hemline travels.

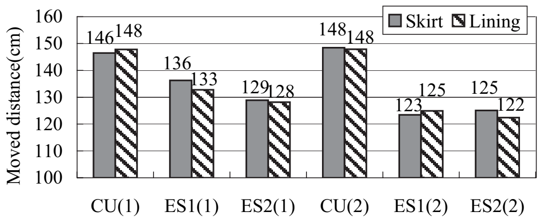


Fig. 8. Skirt and lining hemline travel distance at skirt front

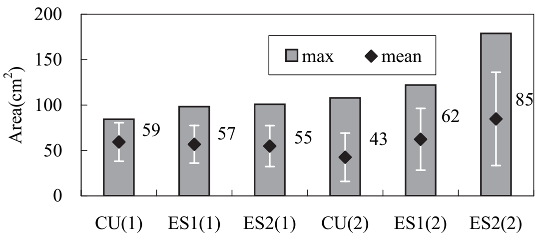


Fig. 9. Space area between skirt and lining hemlines at skirt front

With the skirts having the flared lining patterns, the differences among the lining fabrics were relatively small in contrast those of the straight patterns. The means and variation of ES2(2) were the biggest, those of ES1(2) were intermediate, and those of CU(2) were the smallest. Observation also showed that the outer fabric and the ES2(2) lining moved most separately, which leaded to the low ratings for the functional mobility comfort on the ES2 skirt with the straight pattern in the wearing test.

These results indicated that the outer and the lining with the flared pattern tend to move together, and thus the softer linings are more effective for the skirts with the straight pattern.

CONCLUSION

(1) The results of wearing test on functional mobility of semi-flared *chiffon* skirts suggest that the flared lining pattern enables us easier walking and crouching, compared with the straight lining pattern. This is because the flared lining allows more space in the lower portion of the skirt. The motion analysis also shows that the flared lining had more tendencies to move together with the outer fabric, without being separated. This tendency also indicates that the flared pattern is superior to the straight pattern in functional mobility.

(2) For comfort on the skin, cupro is considered more superior and preferable in summer season than the polyester linings, ES1 and ES2. This is related to mechanical characteristics such as drape, bending, and shearing, and moisture properties of the fiber. However, no clear distinction can be found between evaluations on straight pattern CU(2) and flare pattern ES2(1) and ES1(1). It is therefore suggested that the flared pattern with less contact with the skin improves the evaluation for comfort.

(3) The skirts with the flared lining pattern tended to have wider hemline area for both static and dynamic shapes. The dynamic observations of the skirts with the CU lining show supple and stir movement. This tendency indicates that the characteristics of lining fabric have influence on configuration of the *chiffon* skirt.

(4) The results of this study can indicate that the lining pattern and lining fabric are related to shape and flow of the *chiffon* skirts as well as functional

mobility and sensorial comfort on the skin. We propose that continuous study with scientific methods how to use the lining, which will inform suppliers and consumers of making more graceful and more comfortable garments.

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セミフレアスカートの快適性と形状に及ぼす裏地の影響

川端博子，松本あゆみ*，吉澤知佐**

（埼玉大学教育学部，*元埼玉大学，**旭化成せんい㈱）

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セミフレアスカートにおける裏地の効果について，着用評価とスカートの裾線形状から追究した．3 種の裏地（キュプラ，差別化ポリエステル，ポリエステル一般裏地）に，2 種の異なるパターン（スカートと同型でフレア状に裁断したものと脇スリット入りのストレートな形状のもの）を組み合わせた 6 枚のスカートについてテストした．13 人の女子学生が着用評価を行った結果，フレア形状の裏地をつけたスカートは快適と感じられ，中でも動作性に優れていた．また，キュプラ裏地のものは肌ざわりにおいて他より優れていた．動作分析法により，マネキンに着せたスカートの裾線の形状を静的・動的状態で観察した．静的状態においてフレア形状の裏地のスカートの裾面積は大きく，かつ裾線形状は左右対称であった．スカートの動きの観察から，フレア形状の裏地のスカートは裾面積および裾の移動距離が大きかった．また，フレア形状の裏地のスカートでは表地と裏地の間隙が少なく，一体となって動く様子が捉えられておりこのことも動作性を高める要因と考えられる．キュプラ裏地のものは裾面積が小さく広がりの少ない形状を呈したが，もっとも移動量が多く躍動感のある動きを示していた．このことは裏地のかたさと動的振動係数とかかわると推察される．これらのことから，スカートの快適性と形状は裏地のパターンと種類の両方から影響を受けることが明らかとなった．

キーワード：セミフレアスカート，裏地，裏地のパターン，動作分析，スカートの形状，快適性．