融·合

东华大学服装学院·艺术设计学院教师论文集

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序 PREFACE

〉〉 东华大学服装学院从她诞生之日起，经历了成长和发展阶段，至今已有21个春秋。由刚建立时的1个系（服装系）3个专业到今天的6个系（服装设计与工程系、服装艺术设计系、工业设计系、视觉传达设计系、环境艺术设计系和表演系）10个专业。师资队伍不断壮大，学科门类逐步齐全。目前在校本科生人数已达到1900余人，硕士研究生360人，博士研究生35人，每年为国家在服装及艺术等领域输送了大量有用的人才。

〉〉近年来，学院在学科建设中取得较为突出的成绩。“服装设计与工程”学科分别被评为国家重点学科和上海市重点学科，并被列入国家“211工程”重点建设项目。“服装功能与人体工程”、“服装设计与信息数字化研究”及“中国服装博物馆”等方面科学研究均取得可喜成绩。“十五”期间我们成功研制了我国第一代舱内航天服暖体假人，并被应用于神州5号载人航天服的实验中。2003年10月学校收到了上海市委、市政府的贺信嘉奖。

〉〉设计艺术类学科也取得了令人瞩目的成就，其教学和研究从最初的服装艺术设计扩展到设计艺术学的诸多分支和美术学及表演艺术等领域，并在艺术设计史论、设计理论和实践以及设计教育等方面取得很多研究成果。

〉〉为了更好总结经验，寻找差距，我们以“融合”为主题汇编了这本论文集，其中分服饰史论研究、服装工程研究、服装艺术设计研究、视觉传达设计研究、环境艺术设计研究、工业设计研究、美术学研究和艺术设计教育研究等专题，收录有本学院教师近年来发表的55篇中英文论文，充分体现了我院在学科建设、学术研究、教育探索、发展方向上的融合姿态和愿望。并衷心希望得到广大同行、专家和领导的批评和指正。

服装学院学术委员会主任、教授、博导
2006.08

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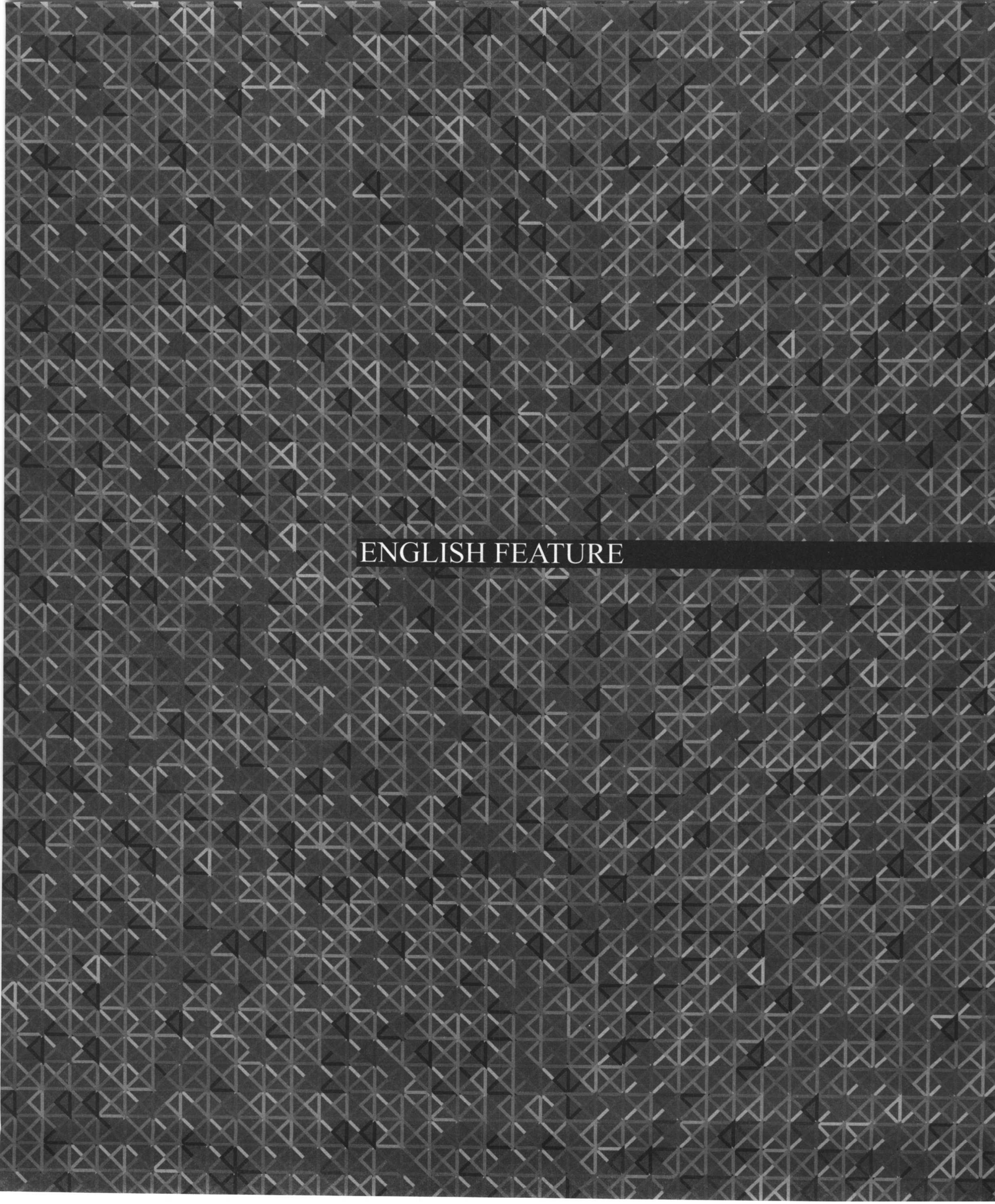

ENGLISH FEATURE

O Wang Gehui (王革辉), Zhang Weiyuan (张渭源), Postle Ron* and Phillips David

Comparison of Low Stress Mechanical Properties of Light Weight Wool and Wool Blend Fabrics using the KES-F and FAST Instruments

This study compares the test results of the FAST (Fabric Assurance by Simple Testing) with those of the KES-F (Kawabata Evaluation Systems for Fabrics) for a range of nineteen light weight wool and wool blend fabrics in terms of the low-stress mechanical properties of bending, shear, and tensile deformation. It is found that there are very significant correlations between the corresponding parameters for extensibility and shear rigidity obtained from the test results of the two systems. The correlation between the values of bending rigidity obtained from the two systems is only moderate. Furthermore, for the fabrics tested in this study, the values of bending rigidity, shear rigidity, and extensibility measured using the KES-F instruments are higher than those of the corresponding parameters measured using the FAST instruments. The linear regression equation is given for each pair of corresponding parameter.

Keywords: low stress mechanical properties, the KES-F system, the FAST system, light weight wool fabrics

Introduction

The handle and tailorability are very important for fabrics as clothing materials. Traditionally the handle of fabrics has been assessed subjectively by the sense of touch. Although the subjective assessment of handle has the advantage of simple and quick, it is inevitably less precise and influenced by individual differences[1,2]. Therefore, the objective assessment of fabric handle has been the attention focus of many research workers[3~9]. Tailorability has been defined as 'the ease with which the fabric can be converted into the intended end product'[10]. The concept of fabric tailorability has not been the subject of much interest until recently for three main reasons: 1) the lack of commercial availability of suitable instrumentation; 2) a lack of information about how to apply measurements of fabric mechanical and surface properties; and 3) the increasing levels of automation being introduced into the industry, and the even greater levels of automation possible in the foreseeable future[11].

One great achievement of Kawabata in the study of fabric handle and tailorability is the development of the KES-F instruments. The applications of the KES-F instruments to the textile and garment manufacturing industries have greatly improved the production development and the quality of fabrics and garments in Japan.

However, the high price and its relatively sophisticated structure and functions impede its applications to some extent to the textile and garment manufacturing industries outside Japan. More recently, the FAST system has been developed by CSIRO (Australia) and become commercially available. The FAST system is being adopted for routine measurements in industry because it is relatively simple and lower in price than the KES-F instruments.

The two systems use somewhat different measuring principles. For example, the FAST system employs the bias extension principle for measuring shear rigidity, whereas the KES-F shear tester uses the principle of simple shear at constant length sides. The principle of simple cantilever is used in the design of the FAST bending meter, whereas the KES-F bending tester uses the principle of pure bending. Yick et al.[12] studied the relationships between the two systems in terms of measured low-stress fabric mechanical properties of light-weight cotton, cotton/polyester and polyester fabrics. However, very few papers have dealt with the relationships between the two systems in terms of measured low-stress fabric mechanical properties of light weight wool and wool blend fabrics. The aim of this study, therefore, is to compare the test results of the FAST system with those of the KES-F system for the light weight wool and wool blend fabrics.

Experimental

Samples

A range of nineteen light weight wool and wool blend fabrics were measured using the KES-F and FAST instruments. A summary of the fabric construction parameters is presented in Table 1. The thickness of the fabrics was measured using the FAST compression meter at the load of 1.96 cN/cm2.

Table 1 The construction parameters of the samples

Fabric number	Fibre composition (%)	Mass per unit area (g/m^2)	Thickness (mm)	weave
1	100 W	176	0.442	plain
2	100 W	151	0.395	plain
3	100 W	157	0.386	plain
4	75W/25PE	163	0.395	twill
5	60W/40PE	179	0.443	twill
6	100 W	151	0.400	plain
7	100 W	186	0.504	plain
8	45W/55PE	149	0.402	plain
9	45W/55PE	153	0.435	plain
10	100 W	177	0.395	plain
11	100 W	145	0.500	plain
12	100 W	180	0.380	plain
13	50W/50PE	147	0.342	plain
14	50W/50PE	149	0.363	plain
15	70W/30PE	187	0.422	twill
16	50W/50PE	211	0.468	doeskin
17	60W/40PE	171	0.401	twill
18	80W/19V/1PE	217	0.481	twill
19	100 W	186	0.469	doeskin

W—wool, PE—polyester, V--viscose

The low-stress mechanical properties of bending, shear, and tensile deformation for the nineteen fabrics were measured using the KES-F and the FAST instruments, following the standard specimen size and test methods[13, 14]. Using the KES-F instruments, four specimens were measured for shear rigidity and three specimens were measured for bending rigidity and extensibility in each principle direction. With the FAST system, three specimens were measured for fabric extensibility and bending rigidity and six specimens were measured for shear rigidity (three in the 45? bias direction and three in the 135? bias direction). A summary of measured parameters from the KES-F and FAST instruments is given in Table 2.

Parameter	Symbol	Parameter measurement	Unit
Extensibility	EM	measured using the KES-F tensile tester at the load of 4.9 N/cm width	%
	E_{100}	Measured using the FAST tensile meter at the load of 0.98 N/cm width	%
Bending rigidity	B-_{KES}	measured as the average slope of the linear regions of the bending hysteresis curve to ±1.5 cm^{-1} curvature	μN.m
	B-_{FAST}	calculated from the measured cantilever bending length using the FAST bending meter and weight of the fabric	μN.m
Shear rigidity	S-_{KES}	measured as the average slope of the linear region of the shear hysteresis curve to ±2.5 degrees shear angle	N/m
	S-_{FAST}	measured from the bias tensile test using the FAST tensile meter under a tensile stress of 4.9 cN/cm width	N/m

Results and Discussion

Table 3 A Summary of the results measured using the KES-F and FAST instruments

Fabric No.	Extensibility (%)				Bending rigidity (μN.m)				Shear rigidity (N/m)	
	KES-F		FAST		KES-F		FAST		KES-F	FAST
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft		
1	2.6	3.3	1.5	2.2	9.81	9.73	4.4	5.0	59.86	60.0
2	2.4	4.2	2.4	3.9	9.56	6.19	5.1	3.4	33.51	30.0
3	2.5	3.4	2.1	2.9	6.39	5.51	3.0	1.9	28.64	29.0
4	2.6	4.1	2.0	3.3	7.36	6.18	3.9	3.4	32.94	25.0
5	3.4	4.5	2.7	4.0	8.50	7.11	3.4	3.6	32.36	26.0
6	2.4	3.4	1.7	2.9	7.56	4.99	4.6	2.2	32.93	27.0
7	3.8	6.3	2.9	6.7	10.91	7.36	6.7	5.8	32.94	27.0
8	1.9	2.2	1.5	1.9	9.81	8.62	4.9	4.6	42.1	35.0
9	2.1	3.1	1.6	2.1	9.61	9.28	6.1	4.6	40.67	33.0
10	2.4	4.6	2.2	4.0	7.51	6.25	4.9	2.9	36.08	31.0
13	4.4	8.4	3.2	7.9	8.17	5.89	4.3	2.2	25.49	21.0
16	2.1	5.3	2.4	4.4	8.09	6.13	8.2	6.1	33.22	24.0
17	2.2	3.3	2.0	3.2	7.48	6.13	6.6	5.3	33.51	28.0
19	2.2	3.2	1.9	2.6	8.34	6.95	7.5	6.3	36.66	30.0
20	2.2	4.9	1.7	4.2	8.42	6.79	8.5	6.2	35.8	32.8
21	1.9	2.6	1.4	1.8	12.51	7.23	12.8	7.1	41.24	41.0
23	2.1	4.3	1.6	3.2	11.08	6.42	10.2	5.7	41.81	41.5
24	2.4	6.4	1.9	5.6	14.47	10.55	11.4	12.4	35.23	30.1
25	4.3	4.1	3.7	3.3	7.44	4.33	6.5	3.4	35.8	29.1

Table 3 presents the results of the KES-F and the FAST measurements. A linear regression analysis was carried out on each set of results of corresponding parameters, yielding the linear relationships between the results obtained from the two methods. Figures 1 to 3 show the relationships between the corresponding sets of test parameters measured with the two systems. The coefficients and the predicted linear equations for the relationships are also given in the plots.

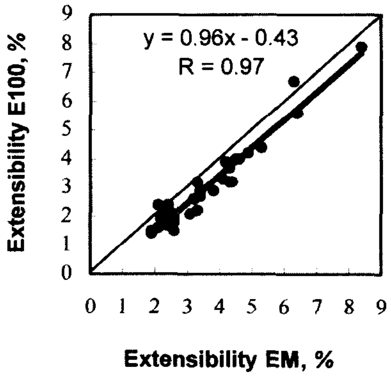

Figure 1. Comparison of the two measures of extensibility, one from the KES-F tensile tester and the other from the FAST extension meter.

The extensibility of a fabric determines the degree to which it is possible to stretch in both warp and weft directions. It is regarded as an important parameter in predicting the production and wearing properties of a garment.

Both the KES-F and the FAST systems use similar principle in measuring fabric extensibility. However, there is some difference in the aspect ratio (test specimen width to gauge length) of the clamped specimen between the KES-F tensile tester and the FAST extension meter. By using 5 cm specimen gauge length and 20 cm specimen width, the KES-F tensile tester provides a higher aspect ratio (4:1) than the FAST extension meter. In the later case, the gauge length is 10 cm and the width of the clamped specimen is 5 cm (giving an aspect ratio of 1:2).

For the convenience of the industrial application, the quoted values for the extensibility in both systems as shown in Table 2 are compared. As shown in Figure 1, there is a very significant relationship between the two measures of extensibility for the nineteen fabrics (thirty-eight data points: warp and weft directions) tested. The coefficient is 0.97. However, it is also shown that the FAST extension meter tends to provide a lower value of extensibility compared to that obtained from the KES-F tensile meter. This can be explained by the difference of the load in the extensibility test using the two methods.

Fabric bending rigidity is a very important parameter related to fabric tailorability. A fabric with too low bending rigidity may present difficulties in cutting, handling, sewing and producing a flat seam. Such a fabric is prone to puckering.

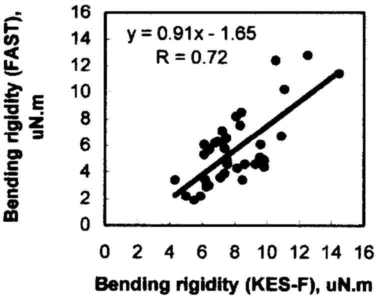

Figure 2 Comparison of the two measures of bending rigidity, one from the KES-F pure bending tester and the other from the FAST bending meter.

Figure 2 presents the relationship between the two measures of fabric bending rigidity using the KES-F bending meter and the FAST bending meter. The correlation coefficient is only moderate (0.72). And the values of bending rigidity tested from the FAST bending meter are generally lower than the values obtained from the KES-F bending tester. The results can be explained mainly by the difference of the principles adopted for measuring fabric bending rigidity. The FAST bending meter measures fabric bending length using the cantilever bending principle. From the bending length obtained, the fabric bending rigidity is calculated (bending rigidity = fabric mass/area x bending length 3). Therefore, the results from the FAST system are very sensitive to the measured values of bending length. It was noticed that, during the experiment, the specimens sometimes clung to the slide and drop suddenly. Although the specimen was tested again when such an instance was encountered, it can be assumed that the value of the measured bending length may be larger than it should be and thus the variation of the results may increase.

Fabric shear rigidity affects not only garment appearance but also fabric performance in garment manufacturing. If the shear rigidity is too low then the fabric is easily distorted and can skew during handling, laying up, cutting and sewing. If the shear rigidity is too high, then the fabric can be difficult to form and mould at the sleeve head and will be difficult to form into smooth three dimensional shape.

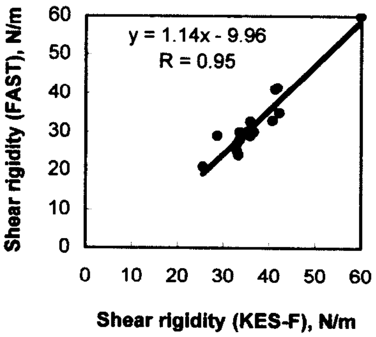

Figure 3 Comparison of the two measures of shear rigidity, one from the KES-F shear tester and the other from the FAST bias extension.

Figure 3 shows the relationship between the measures of shear rigidity obtained from the two instruments. Even though the measurement principles of the KES-F shear tester and the FAST bias extension meter are quite different from each other, the relationship between the values obtained from these two methods is very high (0.95). Figure 3 also reveals that the shear rigidity values from the KES-F system are generally slightly larger than the corresponding values from the FAST system. This may be caused by the bias cut of the specimen in the FAST shear test and the ‘waisting’ effect of a test specimen under load is more significant when the aspect ratio is lower.

Conclusions

In this study, a range of nineteen light weight wool and wool blend commercially produced fabrics were measured using the KES-F system and the FAST system. The results were compared in terms of the low-stress mechanical properties of bending, shear, and tensile deformation.

For extensibility and shear rigidity, extremely high correlations were found between the results obtained from the test results of the two systems. However, the correlation was only moderate for bending rigidity. It was explained in terms of the different measurement techniques. Moreover, it was found that the values of extensibility, bending rigidity and shear rigidity measured using the KES-F system were generally larger than the corresponding values measured using the FAST system for the tested fabrics in this study. The regression equation for relationship between each pair of parameters was also given in this paper. ■

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Cold Sensitivity Differences among Body Sections under Clothing

The sensitivity of the human body to perception of cold sensation varies over sections of the body. Wear trails conducted for this research show that different locations on the body respond differently to cold stimulus, especially with respect to the degree of local skin temperature decrease, the relationship between the local skin temperature decrease and elapsed time, and subjective cold sensitivity sequence, but some adjacent body sections have similar characteristics. The torso of the body is the most sensitive, followed by the thighs, upper limbs, and calves. Body sections closer to the core of the body are more sensitive to cold stimulation than are limbs.

Keywords: clothing comfort, cold sensitivity, sensory response, skin temperature, human body sections.

Human comfort is influenced by thermal sensations arising from the interaction between the skin and the surrounding environment. People perceive a continuum of cold sensations from indifferent, to cool, to cold. Thermal sensitivity of humans varies widely to the surface of the body [6]. Many researchers describe the distribution of cold and warm spots in the skin of humans [3,7,5,4,1,11]. These distributions are considered as the reason why different parts of the body respond differently to cold.

Clothing has a major effect on modulating the relationship between a cooler environment and the perceived coolness of the wearer. Therefore, it is necessary to develop a systematic understanding of sensitivity differences to cold among clothed body sections, especially for clothing designed to protect against cold weather. For cold protective clothing, thermal insulation values may not be equally effective in different areas of the body. Since the weight of the clothing can be detrimental to extended wear, cold protective clothing should be designed to maximize thermal insulation material for those body sections which are more sensitive to cold, while leaving other parts of the body sections less covered to minimize clothing weight and bulk. Thus cold weather clothing should be designed to provide insulation for the most cold-sensitive sections. Strategically distributing thermal insulation on the body will benefit the wearer.

While other skin sensation studies have focused on human physiology, this present study simulated real wearing conditions and investigated the combined effects of clothing and the environment on human physiological and psychological responses. Nine sections of the body were studied, including the front of the right thigh (RT), the right calf (RS), the back of the left thigh (BT), the left forearm (LF), the front of the right upper arm (FF), the left part of the lower back (LW), the left part of the upper back (LS), the left part of the abdomen (LA), and the left part of the chest (LB).

Methods

Experimental Garments: The overall experimental garments were custom made for each subject participating in the study (Table 1). Wearing these ensembles subjects could feel comfortable while their mean skin temperature is about 33° C in a man-made climate chamber (temperature 20.5 ± 0.5° C, humidity 50 ± 10%).

TABLE 1. Details of fabric & clothing.

Fabric		Clothing	
Yarn constitution	95%Cotton, 5%Spandex	Length, cm	140 ± 1
Weave construction	Warp-knitted plush loop	Breast girth, cm	90 ± 0.5
Yarn linear density, tex	27.8	Hip girth, cm	95 ± 1
Thickness[a], mm	2.46	Waist girth, cm	82 ± 0.5
Density, $g \cdot m^{-2}$	340	Intrinsic thermal insulation, clo	0.98

[a] Measured using a Frazier Compress meter with a 7.6 cm diameter presser foot and 7.0g/cm pressure.

Experimental garments were tight-fitting (Figure 1). For each body section investigated, the experimental clothing contained a removable 400cm2 patch attached by nylon tabs. These patches could be removed to expose the wearer' s specific body section to the ambient environment. Apart from size, the design of the garments and the other physical properties are identical. The test garment was worn only in combination with a panty.

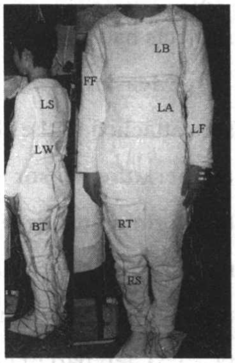

FIGURE1. The experimental garment.

Subjects: The eight female subjects were healthy and aged 21 ± 1 years. They had an average height of 162.05 ± 1.02 cm and an average body mass of 50.02 ± 0.85 kg. The subjects reported to the laboratory at the same time of day to minimize circadian effects on the body temperature, and they were all at the early follicular phase of their menstrual cycles. The general purpose, procedures, and risks were fully explained, and informed consent was given by all the subjects, but they were not informed of the body exposure sequence to avoid influencing their subjective judgments.

Experimental Protocol: All experiments were conducted in a climatic chamber at an ambient temperature of 20.5 ± 0.5° C and a relative humidity of 50 ± 10%. The subjects rested in the chamber for 50 minutes after changing their clothes to experimental garments. Ten minutes after tests were started, one removable patch in the experimental garment was moved away to expose the body section underneath it to the ambient environment. In the second trial, organized according to the Thurstone paired comparisons method [9], two removable patches were simultaneously disclosed, exposing two body sections underneath them; then the subjects were required to report instantly which unclothed body section was colder. After the 30-minute exposure the removable patches were reattached for a period of 20 minutes, and the whole test took 50 minutes (Figure 2). The exposure order of body sections was random, and the interval time between tests was enough to avoid the effects of previous perceptions.

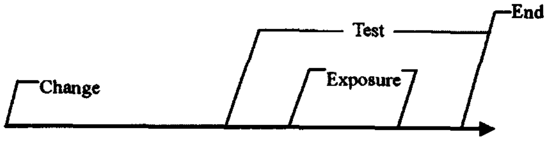

FIGURE2. The experiment protocol.

In our prior investigation to do the experiment design, we observed that the exposed body section’s skin temperature slowly decreased during the first 20min after the exposure, and this 20min period was the main stage of the temperature decrease after the section was exposed in the trial condition. It generally took 20min for the skin temperature of the exposed body section to restore to the normal level before the next exposure. At the same time when the unclothed body section was stimulated by the same extent of cold, subjects had an obvious subjective coolness sensation.

Measurements: Body temperature and skin temperature were recorded continuously from patch sensors attached to the skin surface (accuracy ± 0.05 ° C), and data were stored at 42-second intervals. The temperature sensor was a silicon rubber patch incorporating a PT100 thin film temperature detector (conforming to BS 1904 and DIN43760). The exposed body section’s skin temperature was measured at the center of the exposed area, and body temperature is measured at the left armpit. To estimate an overall mean skin temperature (MST), skin temperatures were recorded at twelve different positions, which were face (B), left part of chest (F), left part of upper back (K), left forearm (N), left hand (Q), front of right thigh