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Analyzing Fabric Properties and Short Modeling Through 3D Scanning and Computer Prediction

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Abstract:

In this study, a considerable variety of fabrics were categorized into five distinct groups. These fabric samples were utilized to create experimental shorts. By focusing on the cross-sections of the hipline, a correlation analysis was performed to examine the relationship between the sectional shape index and the fabrics' physical and mechanical properties, identifying key influencing factors. Utilizing data from 3D scanning, morphological sections and polar coordinates for each characteristic section were constructed. Subsequently, the differences in the cross-sectional curves were analyzed.

Keywords:

Fabric, physical and mechanical properties, cross-sectional shapes, computer prediction.

1. Introduction

The quality and shape of fabrics determine the style of clothing [1]. Clothing with same structure will have different effects even under the same wearing condition due to the difference of fabric performance[2].Fashion molding design is closely related to fabric. With the introduction of computer prediction in the design, it will be able to see the shape effect of the garment without the use of the real fabric, which saves the cost and improves the efficiency. There are many physical and mechanical properties of the fabric. If we need to test and operate the computer system, it will reduce the computing efficiency of the prediction software. This paper established the relationship between the physical and mechanical properties of the fabric and the wear form of shorts. And the characteristic parameters in the physical and mechanical properties of the fabric are selected to participate in the calculation, and the effect of the shorts modeling is predicted according to the properties of the fabric, in order to improve the efficiency and authenticity of computer prediction on the clothing dressing effect.

2. Experiment

2.1 Sample selection of typical fabric

According to the actual application of trouser fabric, 42 kinds of suitable fabric were collected from the market as experimental samples, and the physical and mechanical properties of 16 items were obtained by using the KES fabric style tester, the YG (B) 141D digital fabric thickness meter and the PB303-N electronic precision balance. On the basis of principal component analysis, we got 5 main factors, and the space of physical and mechanical performance index was reduced from 16 to 7 dimensions[3], that were B, 2HB, MIU, RT, G, W and T. Then the K- mean clustering method was used to classify a large number of samples and select 5 typical samples [4]. The properties of the typical sample fabric are shown in Table 1.

Table 1 Physical and mechanical properties of typical sample

	No. 1	No. 2	No. 3	No.4	No.5
B(cN•cm2/cm)	0.215	0.0383	0.1481	0.064	0.1123
2HB(cN•cm/cm)	0.3534	0.0218	0.2374	0.1287	0.202
MIU	0.191	0.125	0.173	0.165	0.184
RT(%)	48.1	93.88	59.09	53.75	55.56

G {cN/[cm•(°)]}	2.94	0.53	2.41	1.51	1.84
W(g/m2)	417.75	87.92	224.00	146.08	273.08
T(mm)	1.03	0.20	0.60	0.38	0.77

2.2 Three dimensional scanning test

This experiment taked the modified 160/68A female lower body model (GB/T 1335. 2-2008) as the experimental objects [5]. We used the 5 typical sample fabric to make the same model shorts respectively. The 5 pieces of shorts were dressed in the model in turn, and the $TC^2$3D body scanner was used to scan the model and the dressing model respectively, strictly referring to the regulations of the national standard GB-T 23698-2009 [6], three repeated measurements are required for each replacement.

2.3 Selection of morphological index of characteristic section

3Dmax software was used to intercept the cross-section of hipline which were obtained by TC^2 3D scanner [7], and to obtain the data points. After corrected of the hipline cross-section, the net body and the clothing section of the RBF neural network model were constructed. The outer contour and the space distance index are extracted as profile feature parameters, which are shown in Fig.1.

The cross-sectional width and thickness of shorts in outer contour index are respectively the length and width of the rectangle outside the characteristic cross-sectional curve, reflecting the overall shape of the wearing shorts. Space distance index is the distance between the human body surface and the shorts surface that is extracted from 0°to 360°every 15 degrees, which reflects the real deformation of the shorts after the human body is dressed. The trunk section is symmetrical in left and right, so we just need to take the value of 90~270°.

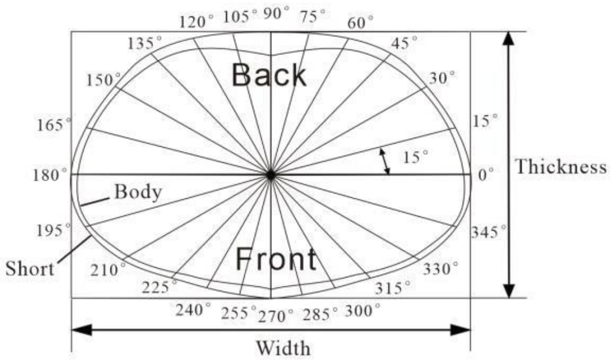

Fig.1 Selection of morphological index of characteristic cross-section

3. Results and Discussion

3.1 Correlation analysis of cross-sectional shapes of hipline and the outer contour index

There’s a significant correlation between shorts width and lgB, RT, lgW, lg2HB at 0.01 levels (bilateral), lgG, lgT at 0.05 levels (bilateral). The thickness of shorts is significantly correlated with lgB, lg2HB, RT, lgG, lgW at 0.01 levels (bilateral), and lgT at 0.05 levels (bilateral) respectively. In addition to MIU, other properties are related to the contour of the hipline cross-sections.

As shown in Fig.2(a) and (b), LgB and lg2HB indicate the bending property of the fabric. The smaller the bending stiffness is, the softer the fabric is, the smaller the bending lag moment, the better ability to recover. The outer contour index of hipline increases with the increase of lgB and lg2HB. The shapes formed by the fabric with poor hardness and mobility are relatively thick. The contour of the hipline cross-section is consistent with that of the waistline with the change of RT and lgG. As seen in Fig.3(b) and (c), with the increase of lgW and lgT, the width and the thickness of hipline cross-section all increase, thus the shapes of the hipline cross-section produced by the heavy fabric can be thicker.

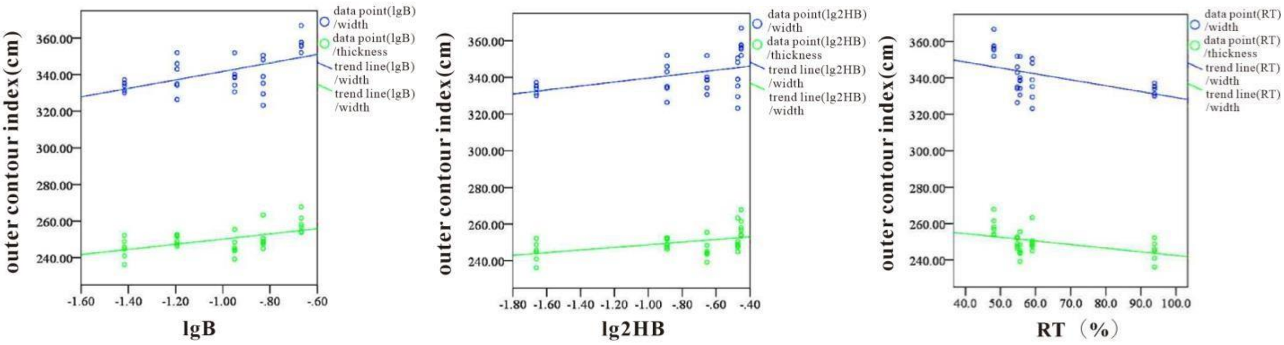

Fig.2 (a)(b)(c) are the scatter point trend graphs of outer contour index and lgB,lg2HB,RT

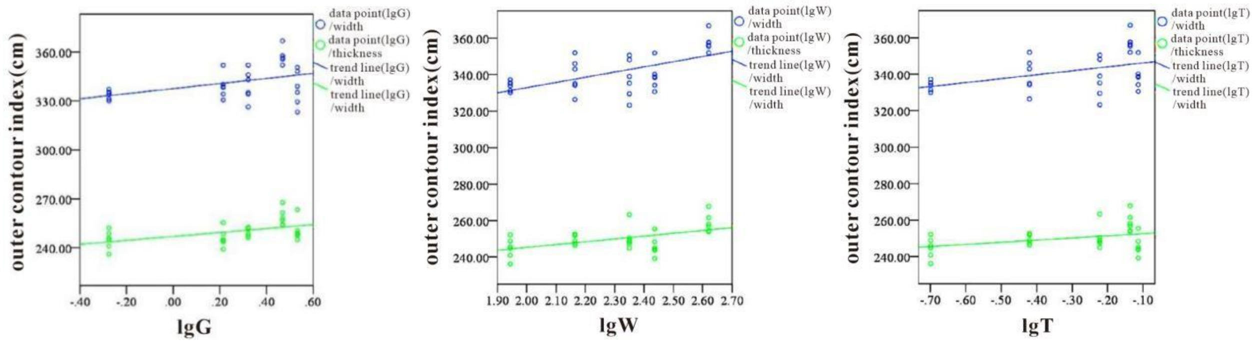

Fig.3 (a)(b)(c) are the scatter point trend graphs of contour index and lgG, lgW, lgT

3.2 Correlation analysis of cross-sectional shapes of hipline and the space distance index

There's a significant correlation between the space distance at 90 ~105° and lgB, lg2HB, RT, lgG, lgW, lgT at the 0.01 level (bilateral). The 120 °is significantly correlated with lgB, lgG at 0.01 levels (bilateral), and with lg2HB, RT and lgW at 0.05 levels (bilateral), respectively. The 135°significantly correlated with MIU at 0.05 level (bilateral). The 165° is significantly correlated with lgW at 0.05 level (bilateral). The 180°is significantly correlated with lgB, RT, lgW at 0.01 levels (bilateral), and with lg2HB, lgG , lgT at 0.05 levels (bilateral), respectively. At the front, the space distance at 195° is significantly correlated with lg2HB and lgW at 0.05 level (bilateral). The 240° and 255° is significantly correlated with lgB and MIU at 0.05 levels (bilateral), respectively. There is no significant correlation between the 210 ~225°, 270°and fabric properties.

By correlation analysis, the space distance at 90 ~120°, 180 ~195°and 240°increase with the increase of lgB and lg2HB. So the space distance formed by the stiffened fabric on the back, the side seam and the front of short is large. The 90 ~120°and 180°decrease with the increase of RT. The elasticity of the fabric increases with the increase of RT, and the plastic capacity is stronger with the change of body shape and is more attached to the body. The deformation resistance of the fabric increases with the shear stiffness increases, so the fabric has larger lgG, the space distance between the back and the side seam is larger. The 90 ~120°and 165 ~195°increase with the increase of lgW, and the slope in the back is larger than that near the side seam. In addition, from Fig.5(c), the space distance between 90 ~105°, 180°increase with the increase of lgT, and the slope of the back is larger than that near the side seam. So with the increase of weight and thickness, the space distance in the back increases faster than in the side seam, and the space distance formed by the thick and heavy fabric is larger. Due to the support of the buttock point, the space distance of this part is relatively small. The 135 ~165°is the area affected by the buttock point, so the change of the fabric properties has little effect on this part.

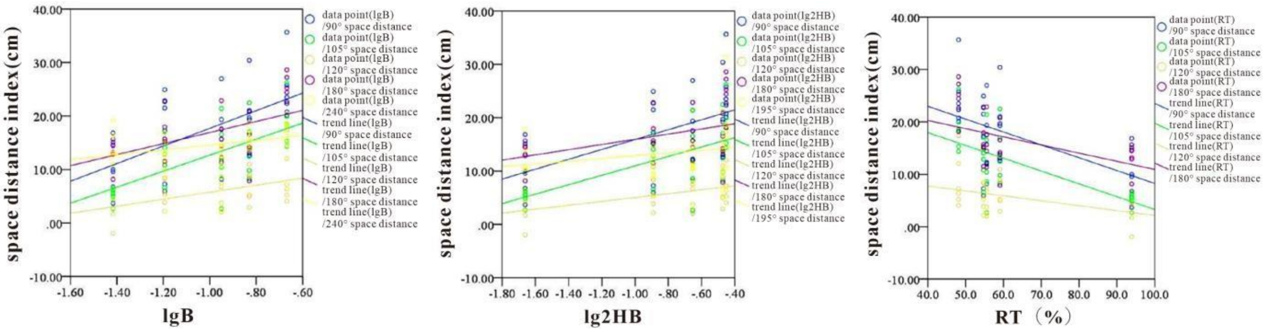

Fig.4 (a)(b)(c) are the scatter point trend graphs of space distance index and lgB,lg2HB,RT

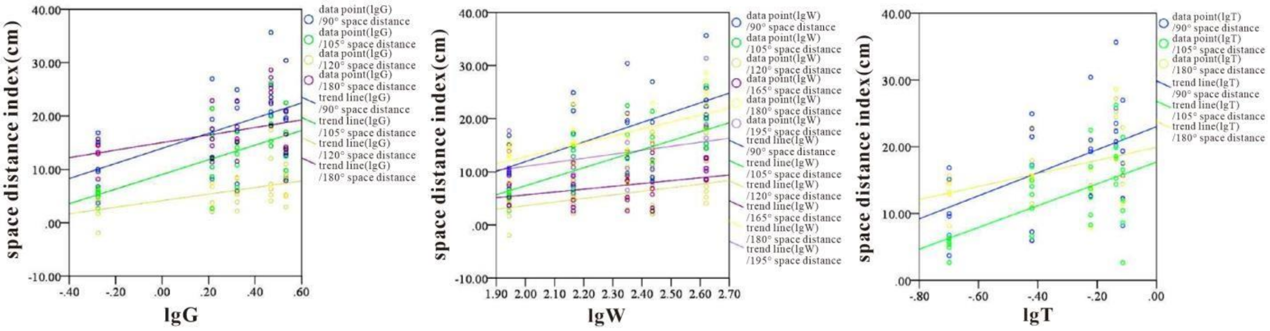

Fig.5 (a)(b)(c) are the scatter point trend graphs of space distance index and lgG,lgW, lgT

3.3 Analysis of the cross-sectional shapes of hipline

The section from the hip to the crotch is the action area of lower body surface, and the ease is larger than that of the waist and the abdominal circumference. As a result, different fabrics will show more obvious shapes at different times. As shown in Fig.6, the contour of fabric No.1 is smooth and straight. The wrinkles of No.3 to 5 on the side seam and the front of the shorts is higher than that of the No.1, but the amplitude of the wave is not large. And No.2 is the most lightweight, soft and smooth fabric of the all, it can be seen from the Fig.6, the surface waves of cross-section at hipline are large and wrinkled, and the side seam is close to the body. As shown in Fig.7, it can also be seen that the polar coordinate waveform curve of No. 1 is smooth, and the other become soft and flexible with the fabric bending, shear stiffness, and the average coefficient of friction be smaller. The frequency and amplitude of the curve is increased, especially at 180 ~360°, that is the side seams and the front. In addition, we can see the curves at 50°and 130°are very close. This is due to the support effect of the buttocks, and the fabric changes little in the vicinity.

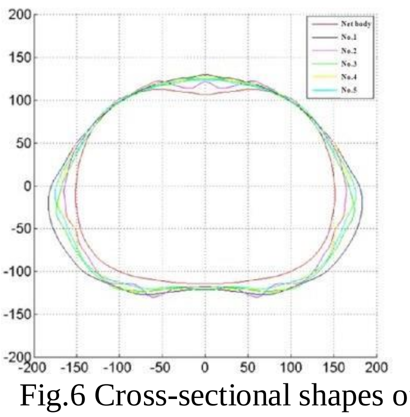

Fig.6 Cross-sectional shapes of hipline

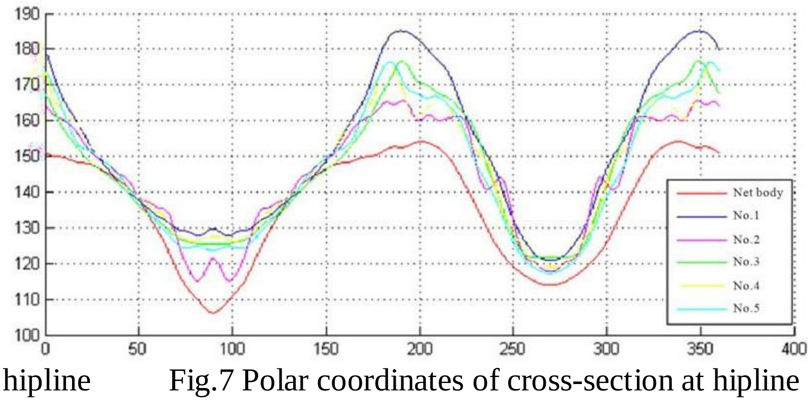

Fig.7 Polar coordinates of cross-section at hipline

4. Conclusion

In this study, we derived the following final analysis:

1. Beyond the measurement of MIU, other characteristics of the fabric influence the contour of cross-sections at the hipline. As fabric elasticity increases, the plasticity of the hipline in shorts is enhanced, with the back and side seams adhering more closely to the body. Conversely, hard and thick fabrics tend to create gaps between the back and side seams. Thick, stiff, and rough fabrics maintain a smoother shape compared to others. Shorts made from light, soft, smooth, and easily deformable fabrics exhibit cross-sectional shapes at

the hipline characterized by pronounced wavy patterns and numerous folds, with the side seam closely following the body's contour.

2. Shorts constructed from highly elastic fabrics exhibit reduced width and thickness, while those made from stiffer fabrics are notably crisper and larger in these dimensions. The cross-sectional shape formed by heavy, high bending stiffness, and lagging hard fabrics is distinctly crisp. In contrast, the cross-sectional shape formed by soft and flexible fabrics adheres more closely to the body.

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