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Study on Rules of Young Female Lower Body Height

Lei Huang [1, 2, a], Ting Chen[1,2, b], Pin-ying Gu [1,2,c] Hai-yan Kong[1, 2,a]

and Guo-lian Liu[1, 2,a]

[1]National Engineering Laboratory for Modern Silk, 199 Ren Ai Road, Suzhou, Jiang Su, China
[2]College of Textile and Clothing Engineering, Soochow University, Suzhou, Jiang Su, China
[a]jstchlcn@yahoo.com.cn, [b]ct398304378@163.com, [c]gpyapple@yahoo.cn

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Abstract: In this study, three-dimensional body measurement instrument was used to measure 425 female bodies aged from 18 to 26 years old. Imageware software was used to obtain the point cloud images of female body and measure their key parts' altitudes (waist, abdomen, buttocks, thigh, knee). Then, SPSS16.0 was used to analyze the key parts' altitudes and height to find the regression equations of them. Finally, the altitude rules of young female lower body were tested to ensure its correctness. In this paper, the result can provide basis of altitude confirmation rules for the study on automatically pattern design system of women skirts.

Introduction

People demand more individuation and fitness of the clothing with the development of the times [1]. At the same time, the development of computer technology promotes the garment industry to be high-speed and automatic, and it has also laid the technical foundation for the digital tailored production (MTM). Today, in garment industry, the automatic nesting and automatic cutting system has almost been developed comprehensively, but the automatically pattern design system has not been fully developed [2].

To achieve the development of automatically pattern design system of women skirts, the first thing we need to do is measuring human body's key parts' size . Traditional measurement is waste of time and less efficient. Besides, when different person measures the same part, the data could be very different. Although the non-contact 3D body measurement instrument has limitations in price and function [3], it can not only preserve the 3D human body image completely, but also measure accurately, conveniently, fast with small error [4]. All in all, the 3D body measurement instrument has superior prospects.

In this paper, we started from young women's key parts' altitudes, used the 3D body measurement instrument to scan human body and obtained the point cloud images, and the key parts' altitudes were measured by Imageware. Next, the data we measured were analyzed and the regression equations between the key parts' altitudes and height were found out. Finally, correctness verification was done to the regression equation. In this paper, basis was provided for the development on automatically pattern design system of women skirts.

Anthropometry

Objects, time and equipment. From 2007 March to 2010 October, the non-contact 3D body scanner Symcad of Telmat was used to measure 425 female students who were aged from 18 to 24.

Measuring items. Imageware was used as measuring software, and the altitudes of waist, abdomen, buttocks, thigh, knee were measured from the point cloud images of human body. In addition, height was measured by hand.

Methods of measuring. First, point cloud images were extracted from the 3D body scanner, then Imageware was used to streamline the point cloud images and determine the position of waist, abdomen, buttock, thigh and knee from the body side. After that, the horizontal line of cross-section was drawn at the position of waist, abdomen, buttock, thigh and knee. Last, the altitudes from human foot to waist, abdomen, buttocks, thigh and knee were measured.

Data analysis

Classification of young female body. One's key parts' altitudes and height has a certain relationship. If each person's ratio of one key part's altitudes and height was in a small range, it suggested that we can find certain rules to fit one's key parts' altitudes only by her height. The classifications of the ratio of one's key parts' altitudes and total height were shown in Table 1.

Table 1 Classification of young female body size

Ratio Range / Number of People / Part	0.52-0.55	0.56-0.63	0.64-0.68	Total number (N)
Altitudes of Waist	11	407	7	425
Ratio Range / Number of People / Part	0.48-0.50	0.51-0．60	0.61-0.63	Total number
Altitudes of Abdomen	12	409	4	425
Ratio Range / Number of People / Part	0.40-0.45	0．46-0.52	0.53-0.56	Total number
Altitudes of Buttocks	11	407	7	425
Ratio Range / Number of People / Part	0.24-0.38	0.39-0.46	0.47-0.49	Total number
Altitudes of Thigh	15	404	6	425
Ratio Range / Number of People / Part	0.18-0.23	0.24-0.27	0.28-0.29	Total number
Altitudes of Knee	12	405	8	425

As we anticipated, the ratio is in a small range, according to the principle of the effectiveness of 95%, we selected 407, 409, 407, 404, 405 people as samples to do the research.

Correlation of height and key parts' altitudes. To work out how the key parts' altitudes change with one's height, the first step was analyzing whether they were significantly correlated. The correlation analysis of the key parts' altitudes and total height are shown in Table 2.

Table 2 correlation of the key parts' altitudes and height

	Person Correlation	Sig.(2-tailed)	N
Altitudes of Waist	0.792**	0.000	407
Altitudes of Abdomen	0.771**	0.000	409
Altitudes of Buttocks	0.777**	0.000	407
Altitudes of Thigh	0.663**	0.000	404
Altitudes of Knee	0.736**	0.000	405

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 Cofficients

	Unstandardized Cofficients		t	Sig.
	B	Std.Error		
Waist	-9.554	3.999	-2.389	0.017
	0.651	0.025	26.110	0.000
Abdomen	-10.901	4.008	-2.720	0.007
	0.610	0.025	24.395	0.000
Buttocks	-11.191	3.600	-3.108	0.002
	0.557	0.022	24.823	0.000
Thigh	-9.062	4.328	-2.094	0.037
	0.479	0.027	17.745	0.000
Knee	-7.752	2.216	-3.398	0.001
	0.302	0.014	21.852	0.000

Table 2 showed that the correlation coefficient of altitudes of waist, abdomen, hip, thigh and knee were 0.792, 0.771, 0.777, 0.648 and 0.736. Their two-tailed significance levels were 0.000 <0.001, which indicated that one's key parts' altitudes and height had significant correlations. So it was possible to use linear regression to analyze the relationship between one's height and key part's altitudes.

The scatter of human body's key parts' altitudes and height. From the analysis above, we could draw the conclusion that correlation between key parts' altitudes and total height was significant. As the scatter plots of other key parts' altitudes and height were similar to the scatter plot of waist altitudes and height, only the scatter of waist altitudes and height was listed in Figure 1.

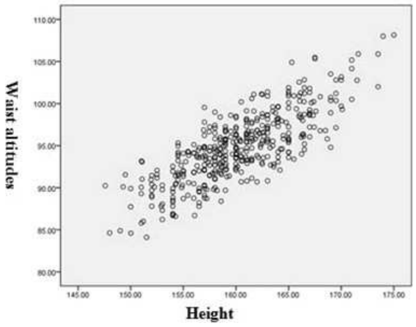


Fig.1

Figure 1 showed that the key parts' altitudes has good linear relationship with height, so the key parts' altitudes was set to be the dependent variable, the height was set to be the independent variables, the equations of them were a linear relationship.So altitudes linear fitting is feasible.

Altitudes fitting. From above we know the key parts' altitudes of human body had linear relationship with height. Table 3 was the result of linear regression.

From Table 3 we knew that the values of t who was to verify the significance of regression equation's constant was-2.389, -2.720, -3.108, -2.094 and -3.498, the probability was 0.017, 0.007, 0.002, 0.037 and 0.001; The values of t who was to verify the significance of regression equation's coefficient was 26.110, 24.395, 24.823, 17.745, 21.852, the probability was 0.000<0.001, it meant that the regression coefficient was significant. And the regression equations were gotten.

$$Y1=-9.554+0.651*X \quad (1)$$

$$Y2=-10.901+0.610*X \quad (2)$$

$$Y3=-11.191+0.557*X \quad (3)$$

$$Y4=-9.062+0.479*X \quad (4)$$

$$Y5=-7.752+0.302*X \quad (5)$$

X stood for height, Y1, Y2, Y3, Y4, Y5 stood for altitudes of waist, abdomen, hip, thigh and knee.

Error analysis.

According to the equations above, the altitudes of each sample were substituted into them, and the altitude theoretical values of waist, abdomen, hip, thigh and knee were obtained. Comparison of the theoretical values and the values measured by Imageware was made, the discrepancy of them was S. The error distribution was shown in the table below.

Table 4 Error analysis

Key Parts	Sample Number	$\lvert S \rvert \le 2$	Proportion	$\lvert S \rvert \le 3$	Proportion	Error Range
Waist	407	211	52%	313	77%	(-4.96, 4.94)
Abdomen	409	229	56%	311	76%	(-4.84, 4.92)
Hip	407	243	60%	331	81%	(-4.99, 4.98)
Thigh	404	210	52%	286	71%	(-4.93, 4.99)
Knee	405	350	86%	397	98%	(-3.14, 3.35)

From Table 4, we knew that the proportions of the discrepancy within ±2 and cm±3 cm were more than 50 percents and70 percents. The data within the experimental permissible error occupied most of the samples, so it was feasible to calculate one's key parts' altitudes by one's total height.

Data Verification

20 new samples were measured by Imageware to obtain their values of waist altitudes, abdominal altitudes, hip altitudes, thigh altitudes and knee altitudes. Then get the theoretical values through the equations above. Then the measured values and the theoretical values were compared and verified. The result was shown in Table 5.

Table 5 Validation of data errors

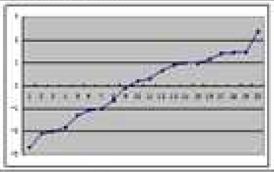
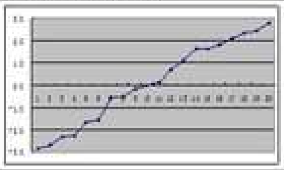
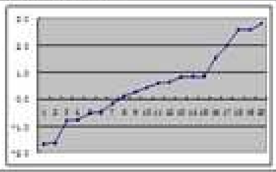
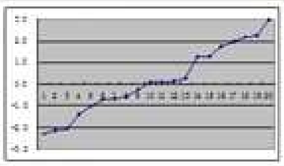
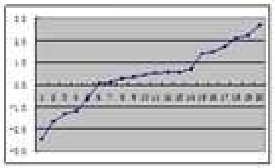
	Waist Error Line	Abdominal Error Line	Hip Error Line
			
Error Range	(-2.7, 2.4)	(-2.9, 2.8)	(-1.7, 2.8)
	Thigh Error Line	Knee Error Line	
			
Error Range	(-2.3, 3.0)	(-2.5, 2.7)	

Table 5 showed that the errors of the validation samples were within ±3 cm, which was permissible. So calculating one's key parts' altitudes by height was feasible in this research.

Conclusions

In this paper, Imageware was used to measure the point cloud images of human body and obtain the key parts' altitudes. SPSS was used to analyze the data measured and get the equations of the key parts' altitudes by height. The equations were verified to ensure it's correct. This research laid the foundation for the development of automatically pattern design system of women skirts.

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