Journal of Fiber Bioengineering and Informatics 6:4 (2013) 453–465
doi:10.3993/jfbi12201309

Lower Body Classification of Young Women for Pants Size Optimization

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Abstract

Pants fit have always been a problem in China's pant market. To qualitatively improve how well pants fit consumers, we analyzed the lower body shapes of 179 young women from an anthropometric aspect. We first used a 3D measuring method to obtain 85 measurements related to lower body shape. Then, by applying principal component factor analysis method, we used 7 principal components to describe lower body shape. The first 2 factors, heavy-thin factor and abdomen-hip factor, had the highest cumulative contribution rate, 40.475%. Therefore, the hipline of the first principal component and the abdomen-hip differential of the second principal component were used as 2 key indexes to classify the lower body into 9 types. After using both the interior extrapolation method based on interval division and the k-means cluster method to further classify the lower body shape, we concluded that the former is more suitable. Therefore, we classified lower body shape into 9 types, the coverage of which reached 80.45% of the total samples. By taking both the degree of stoutness of the lower body and the difference of abdomen-hip shape into consideration, this classification can provide a theoretical basis for pants size optimization to improve pants fit in the waist, abdomen, and hip portions.

Keywords: Young Women; Lower Body Shape; Factor Analysis; Hipline; Abdomen-hip Differential

1 Introduction

Pants are very common clothing in our daily lives, and how well the garment fits is one of the major concerns considered by people when buying pants [1]. In the current Chinese pants market, pant sizes are mostly based on the waistline and classified by waistline-and-hipline factor. Research has shown that only 25% of Chinese college students can buy pants that actually fit their waist and hips well [2]. As Debs Hatfield said, "In order to find the most suitable pants, people must fully understand their body shape, which is not easy, because there is no single and clear classification to describe the human body shapes. In most cases, there are two or more mixed types" [3]. Therefore, the pants fit problem can only be solved by performing in-depth research on lower body types and establishing scientific standards for lower body size classification.

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With the development and maturity of 3D body scan technology, many developed countries have applied this technique to study the human figure. Connell *et al.* collected 3D scan data from 529 women aged 19–55 years, thus acquiring critical data related to body shape, which the researchers used to establish Body Scan Analysis Scales (BSAS) [4]. Ashdown *et al.* recorded the size of the key parts of specific groups by measuring 203 women with 3D scans, and thereby established an effective size standard for apparel products as well as a corresponding mathematical model to evaluate clothing fit [5]. Calabro scanned the lower bodies of 151 young women aged approximately 19–24 years and classified the samples according to body mass index (BMI). Through massive data analysis, she found the major factors that affect pants construction are age, body shape, and size, with body shape and size playing the most important role [6]. A number of scholars in China have also done some research on human body shape. Chen and Wang analyzed some body data closely related to clothing and divided the human body into four types: normal, chest-out, hunchback, and big-belly [7]. Using a non-contact laser 3D body scanner, Gu and Zhang obtained some data on body length and girth by measuring more than 300 college students aged approximately 18–24 years [8]. Through cluster analysis, they suggested that human body classification should be based on chest, waist, and hip factors, and provided the classification indicators of these 3 factors. Jing Wang *et al.* obtained 28 measurements of 108 young women aged 18–25 years in the Midwest area and extracted 2 common factors, based on which they used fast cluster analysis to classify the sample body into 4 types; however, their classification index and grading value were not clear [9]. Ying Huang *et al.* performed principal component factor analysis on the 36 indexes of 180 women aged 25–55 in east China by using a 3D measuring system, and concluded that the girths of the waist, abdomen, and hip have the most significant impact on an adult female's lower body shape. They classified the research objects into 4 types based on cluster analysis using "waist-hip differential" as the classification index. However, the waist-hip differential as a classification index was not involved in the analysis. Therefore, this classification method is not as robust as it could be [10]. Chen *et al.* obtained 13 measurements related to pants pattern making, and through factor analysis confirmed the hipline, height, and front rise as the basic parts for women's pants size [11].

The current status of Chinese and international research shows that in China, very little research has been done on lower body shape, and no classification exists to effectively and reasonably describe lower body shapes. Therefore, this paper aims to establish a suitable lower body shape classification standard for Chinese women. The abovementioned body shape classification studies were based mainly on factor analysis and cluster analysis, which provided a reference for the research method of this paper.

Since 3D measurement can provide relatively accurate and effective data, the human body data used in the research presented in this paper is based on 3D measurement.

Young women aged approximately 18–29 years are more likely to have bodies that are nonparous and have less fat accumulation, which means their bodies are of a relatively standard type representing women in their 20 s [12]. Therefore, we researched 3D body scan data of women in this age group to establish a new lower body classification standard.

2 Approach

2.1 Acquisition of Lower Body Shape Data

Data of 179 women aged 18–29 years were extracted from a 3D human body database. According