Growth Curves of Korean Girls from 13 to 18 Years

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Abstract
Periodically new regular updates of data obtained through surveys allow better human body shape modeling, as new softwares or new versions of existing ones, in particular 3-D softwares, give an helpful hand in the analysis of these data and the design of useful shapes. Efforts towards an increase in the use of mannequins in the field of clothes design, car design production, interior designs and an increase in the use of softwares (Solidworks, Catia, Blender, Rhino, etc.). In this paper we defined representative body sizes and body shapes according to the growth curves in Korean girls from 13 to 18 years and discuss the use of these tools for product design. PCA analysis, silhouette, posture and wire frame analysis were performed.

Keywords: Growth curve, girls, girth, height, shape, size

Introduction

In applications such as design and assessment of workspaces the more advanced and effective techniques of design use a combination of 3-D and 1-D methods [1].

For the last 20 years, 3D imagining technology has becoming increasingly mature. Many countries and organizations conducted 3D anthropometry surveys. CEASAR was the first large scale 3D survey performed in North America and Europe and 5000 full body scans data collected. Since CAESAR, there has been Size China, Size Germany, Size USA and many of more Size’s are in the planning. More recently, in 2012, Canadian Forces Anthropometry Survey was conducted through 2000 full-body scans and the Korean 3D survey performed during 2010-2014 with 3500 full body scans of subjects aged from 6 to 80.

These data provide quite an amount of information about the shape of people, and opens new opportunities for the design of products that better fit the human body. These data/informations differing from traditional ones in the fact that they have been obtained and analysed with new tools and techniques for processing and understanding [2].

Methods

The 6th Size Korea survey (2010) data concerning 1-D body measurements of Koreans and the survey data 2013 concerning 3-D measurements of 700 young females aged 13 to 18 were used to define the standard body modeling.

Extraction of the linear representative standard body shapes from 1-D measurements of the 2013 data was performed through a PCA analysis.

Probation of the appropriateness of standard shape modeling was achieved thanks to both the 3-D data of 2013 and the data from the direct measurements of 2010.

Statistical analysis, silhouette, posture and wireframe analysis were performed to select the shape modeling.

Results

Statistical analysis

A statistical shape model allows describing the space of human shape using a small number of parameters. One of the most effective approach is to apply Principal Component Analysis to the 3-D data. PCA can reduce complex human shapes to fewer than 50 key parameters with the majority of the variability represented by the first 5 components.

For the factor analysis, the following 14 parameters were taken in account: height, neck girth, crotch height, neck base girth, chest girth, bust girth, under bust girth, hip girth, abdomen girth, waist girth, armhole length, shoulder point length, arm length and back length.

Figures 1 and 2 show the plotting of the length and the circumference components using the girls’ data from 13 to 18 years in order to compare the differences of the growth curves according to age. The results showed that the length (height) component increased between 13 and 15 years of age and slowed down from age 15, compare to the sustained increase of the girth component until 18 years of age. A representative body shape for each group has been determined by selection body size and shape for observation of the subject with the nearest Mahalanobis Distance (MD) based on chest girth and height which are widely used in terms of 2D space components.

In order to divide the body shape, we defined four age groups namely: the 13 years group, 14 years group, 15 years group and 16-17-18 years group.

Regarding the 13, 14 and 15 years old, growth showed a linear tendency for both length and the girth components. For the 16-17-18 years group, the tendency is spread out according to the girth component.
Growth curves
The body size changes of Korean female from 13 to 18 years are shown in Table 1 and Figure 3.

Table 1. Measurements size
Silhouette analysis

A 3D body shape silhouette has been selected for female aged from 13 to 18 years and the silhouette was analysed by using the x, y, z coordinates, based on widely used chest, waist and hip for a selection of body shape characteristics of a group as shown in Figures 4.

![Body silhouette](image)

**Figure 4. Silhouette frames of the bust, waist and hip**

### (a) Body silhouette

### (b) Bust shapes

Analysis of obesity and asymmetry has been carried based on analysis of silhouette according to whether the silhouette is normal, obese, has shoulder asymmetry or is undersized. Contour size as well as length also has been analysed.

| Age   | Subject | area(cm²) | contour(mm) |
|-------|---------|-----------|-------------|
| 13 Yrs|         | 538.9     | 1071.07     |
| 14 Yrs|         | 569.88    | 1098.18     |
| 15 Yrs|         | 550.29    | 1059.8      |
| 16 Yrs|         | 576.97    | 1229.92     |
| 17 Yrs|         | 581.27    | 1023.75     |
| 18 Yrs|         | 535.64    | 1198.20     |

### (c) Waist shapes

| Age   | Subject | area(cm²) | contour(mm) |
|-------|---------|-----------|-------------|
| 13 Yrs|         | 429.16    | 763.6       |
| 14 Yrs|         | 411.23    | 753.47      |
| 15 Yrs|         | 416.1     | 834.59      |
| 16 Yrs|         | 419.6     | 751.38      |
| 17 Yrs|         | 449.54    | 782.84      |
| 18 Yrs|         | 434.09    | 764.43      |

### (d) Hip shapes

| Age   | Subject | area(cm²) | contour(mm) |
|-------|---------|-----------|-------------|
| 13 Yrs|         | 569.14    | 897.7       |
| 14 Yrs|         | 576.89    | 900.07      |
| 15 Yrs|         | 583.49    | 880.22      |
| 16 Yrs|         | 588.46    | 900.12      |
| 17 Yrs|         | 599.76    | 899.79      |
| 18 Yrs|         | 544.04    | 858.34      |
As shown in Figures 5 and 6, wire frames and the center alignment process were performed to define the standardized method for the classification of the shapes. In case of a normal model, a model with main body sizes similar to average has been selected. To distinguish obese model, a model with the highest BMI rate index has been selected. Index of degree of obesity has been obtained based on the analysis of width of waist from front view and of width of waist from side view obtained based on the analysis of silhouettes. Index of degree of shoulder asymmetry has been obtained based on the analysis of the distance between head and shoulder obtained by virtue of silhouette analysis.

Figure 5. Wire frames

The representative body models at each age are shown in Figure 7.

Figure 6. The shape of center alignment in five 13 years females

Figure 7. Modeling of females aged from 13 to 18 years

**Conclusion**

In order to examine the suitability of body shape modeling by virtue of one view, profile and wire frames of 3D body shape data, first, a representative model’s 3D body shape has been selected for one view analysis of 3D body shape data based on chest girth and height measures of 5 subjects showing the characteristics of typical girths and lengths measures obtained by PCA.

A human modeling that allows a simulation of 3D body data wearing wigs, shoes, tops and trousers can be applied for industries in the development process of wigs, shoes and clothing. The modeling is expected to be largely applied in the form of 3D printable STL format, clothing pattern and CAD systems.

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