

# Anthropometric Data Analysis for Body Shape Modeling in Korean

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**Abstract** : This paper deals with secular trend of height spanning 1979 to 2010 and also morphological growth patterns for Korean. It also investigates the comparison of the growth pattern between male and female based on the anthropometric data samples of KATS taken from the 1979 to 2010 surveys. The great rates of change in height occurred during 1979-1997 with 2-3 cm increase in both sexes at each surveys. After 1997 the change rate of height while increasing is remained within less than 1 cm till 2010 survey. This pattern is consistent with recent Korean cultural emphasis on health and physical fitness according to the economic development. The causes of the observed trends, insofar as they have been identified, are related to cultural processes.

**Keywords** : Morphology, Anthropometry, Size, Silhouette, Growth

## Introduction

Anthropometric data collection, including three-dimensional information, together with comparison of these data among countries are becoming necessary tools for the entire manufacturing community [26].

In the clothing industry, there is a critical problem of minimizing the number of sizes to be defined while maximizing their cover rates, in an attempt to strive for more rationalized production methods.

Anthropometric surveys devised by each country attempt to fulfill the requirements of the manufacturers, providing them with data and tools, and allowing them to face both the internal and export markets [4,18,19,22].

Thus, in Korea, the first national anthropometry survey was conducted in 1979 by a Korean government division, the Korean Agency for Technology and Standard [8]. At the time, data were collected concerning 17,000 samples residing in various parts of the country aged between six and fifty. A total number of 117 measurement dimensions

were taken using calipers and tape measures. Thanks to these data, the KATS established 46 items defining Korean standards concerning clothing, furniture, desks and chairs. Forty-one of them KSK 0035 to KSK 0096 were associated with the size designations of men's wear, women's wear, brassieres, socks, etc.

Following this survey, the Korean government has been presenting a national anthropometric survey every 5 or 6 years. The surveys of 1986, 1992, 1997, 2003 and 2010 were performed according to the following sequence [9-13]: The survey was performed with the traditional measurement method (2D) using an anthropometer, somatometer, caliper and tape measure. The 3-D body scan data collection (Body Line Scanner, Hamamatsu Co.) method (3D) was also adopted in order to obtain a good compromise and to modernize the fit and construction of their garments for the 2003 and 2010 surveys. All body dimensions were measured with the method defined by the ISO [5,6].

Surveys	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>
Years	1979	1986	1992	1997	2003	2010
Sample	17,000	21,650	8,800	13,000	14,000	14,000
Age Range	6-50	6-50	6-50	0-70	0-90	7-69
Dimensions	117	80	84	120	359	139
Methods	2D	2D	2D	2D	2D, 3D	2D, 3D

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This paper deals with secular trend of height spanning 1979 to 2010 and also morphological growth patterns for Korean. It also investigates the comparison of the growth pattern between male and female based on the anthropometric data samples of KATS taken between the 1997 and 2010 surveys.

## Methods

The anthropometric data of Korean measured in 1997 [11,14] and the data collected from 2003 and 2010 [12,13] as well as the women's data measured from 2003-2004 [21,22] which was conducted on 360 adult females between the ages of 20 and 60 were analysed in this section to obtain information on Korean women's physical features. The 2004 data, generated by direct traditional measurement, sliding gauge measurement and 3D body scanner measurement, consisted of anthropometric data of 140 women in their twenties and of 220 middle-aged women.

Data on size and annual growth changes of measurements of subjects aged from 0 to 60 years based on 1997 [14] and 2010 KATS samples were compared to clarify the tendency of maturation in body size.

The anthropometric data included stature, 3 girth dimensions (bust girth, waist girth and hip girth), 5 breadth dimensions (inter-bust point breadth, chest breadth, waist breadth, hip breadth and acromion to acromion breadth), 4 depth dimensions (chest depth, waist depth, abdominal depth and hip depth), 5 height dimensions (waist height, shoulder height, iliospinal height, crotch height and hip height) and span, which were analyzed to indicate body shape.

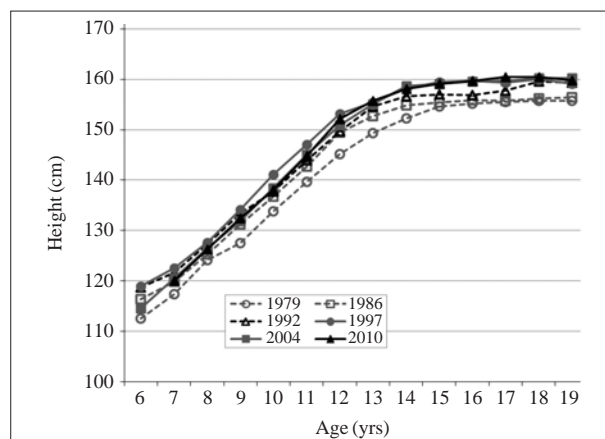
The drop values between bust and hip girth in women and between chest and waist girth in men are used to distinguish the body type. The 3D modeling of the standard body shape of men and women in their twenties obtained from 2010 KATS photos [13] are presented to define Korean's morphological features.

3D modeling data, body silhouette data of the mid-sagittal plane, front median line, form front and form side views measured by the sliding gauge, and index values calculated from the differences between bust-waist, bust-hip girth and waist-hip girth measurements, were used as elements for body shape and proportion comparison.

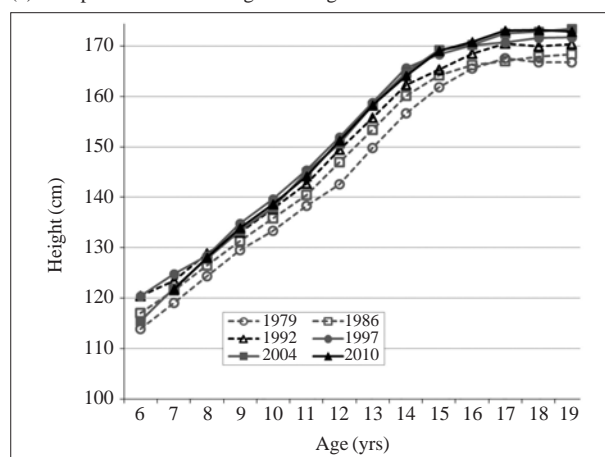
## Results

### 1. The secular trend of height in Korean

The changes of body height in subjects from 6 to 20 years are illustrated in Fig. 1. Fig. 1(a) is an example showing a secular change in mean height of female and male subjects' samples aged from 6 to 20 years taken between 1979 to 2010. As shown in Fig. 1(a), the mean height value of 18 years women is 155.7 cm in 1979, 156.2 cm in 1986, 160 cm in 1997, 160.2 cm in 2003, and 160 cm in the 2010 data. The mean height value of 18 years of men is 166.8 cm in 1979, 167.9 cm in 1986, 171.8 cm in 1997, 172.9 cm in 2003, and 172.9 cm in the 2010 data as shown in Fig. 1(b). As shown in Fig. 1(a) and (b), compared to 1979 data, the mean height of 1997 and 2010 for both sexes increased about 4 cm to 5 cm.



(a) Comparison of the changes of height in female

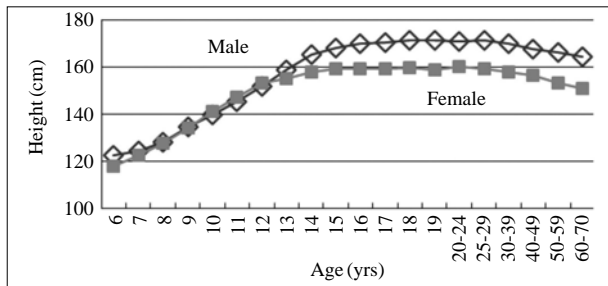


(b) Comparison of the changes of height in male

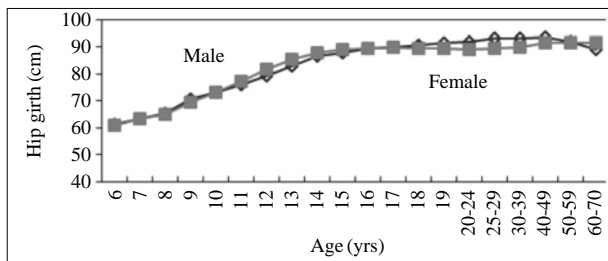
**Fig. 1.** Secular trend of height in groups of Korean male and female.

**2. The comparison of the growth pattern in both sexes**

The data on height and hip girth of male and female from 1997 and 2010 samples were compared according to age in both sexes (see Figs. 2 and 3). The average stature of male from 2010 data has been found to be 173.3 cm with a 95 percentile of 185.9 cm for young men in their twenties. In comparison with the 1997 data, which showed an aver-

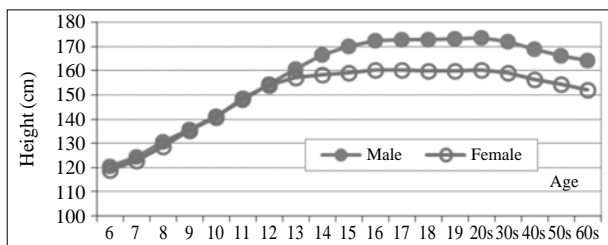


(a) Height

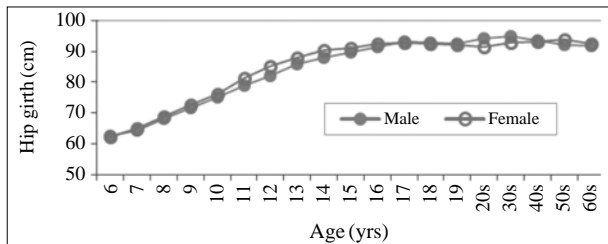


(b) Hip girth

**Fig. 2.** Growth pattern of height and hip girth in groups of Korean male and female from 1997 data set.



(a) Height



(b) Hip girth

**Fig. 3.** Growth pattern of height and hip girth in groups of Korean male and female from 2010 data set.

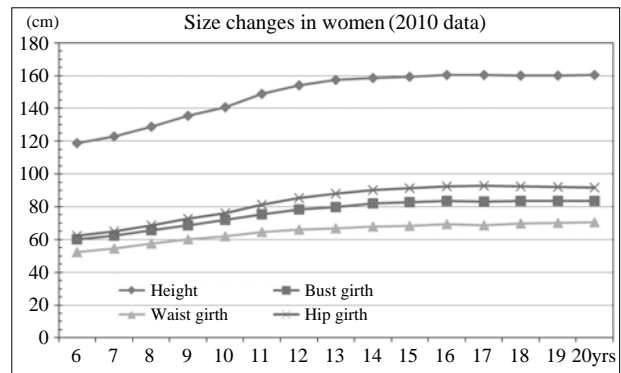
age stature of 171.8 cm, there has been a 2 cm increase.

The size changes of height, bust girth, waist girth and hip girth measurements, which present body development features and annual growth changes of measurements by age 6-20 years in the Korean female, are shown in Fig. 4.

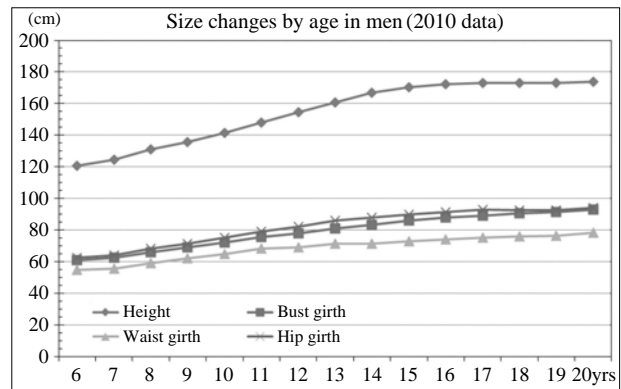
According to the 2010 data, the average bust, waist and hip girths of men were 93.0 cm, 80.2 cm and 94.3 cm, respectively. In 1997, the sizes of subjects in their twenties were 89.6 cm, 76.4 cm and 92.6 cm, respectively. As for the data of women, the average height, bust, waist and hip girth from 2010 data were 160.4 cm, 83.0 cm, 70.2 cm and 91.5 cm, respectively. In 1997, the results for the twenties were 159.8 cm, 82.0 cm, 65.8 cm and 89.2 cm, respectively.

The growth rate at each age based on data 1997 and 2010 are illustrated in Fig. 5.

For girls at age 10 years, the values of height, arm length, bust girth, waist girth and hip girth are, respectively, 140.7 cm, 47.6 cm, 72.0 cm, 62.0 cm and 76.2 cm. For boys at age 10, the values of height, arm length, bust girth, waist girth and hip girth are, respectively, 141.4 cm, 47.6 cm, 72.0 cm, 64.9 cm and 75.2 cm. Each year, height increases



(a) Womens data

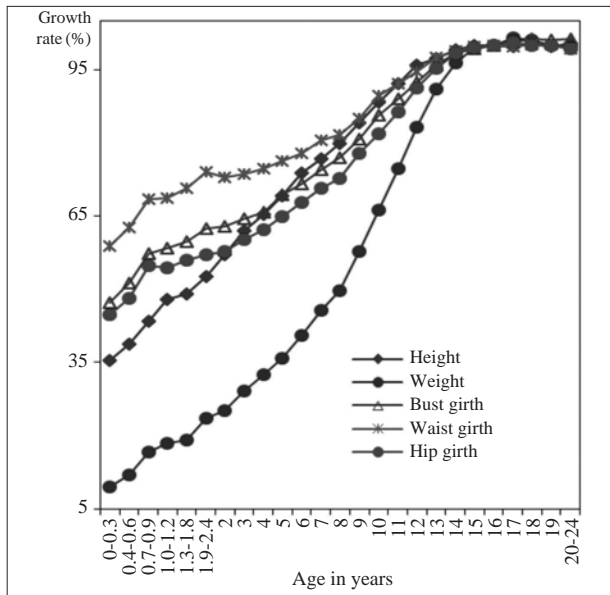


(b) Mens data

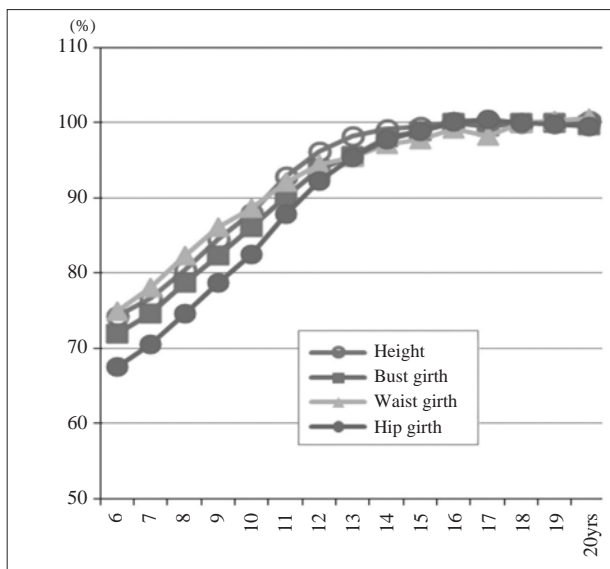
**Fig. 4.** Size changes of measurements in Korean.

4-6 cm between the ages of 6 and 12 years in both sexes. And then the height increases 2-3 cm per year in girls group and 4-5cm in boys group aged from 12 to 15 years.

At age 6, height reaches approximately 74% of the adult height and arm length, bust girth, waist girth and hip girth reach respectively 72%, 71.7%, 77.7% and 67.9% of the adult size (adults of age 16-17 years). At age 6, weight reaches about 40% of the weight of adults aged 16-17. On average, maturity in growth is reached at the age of 18-19 years for males and 16-17 years for females.



(a) Results from 1997 data



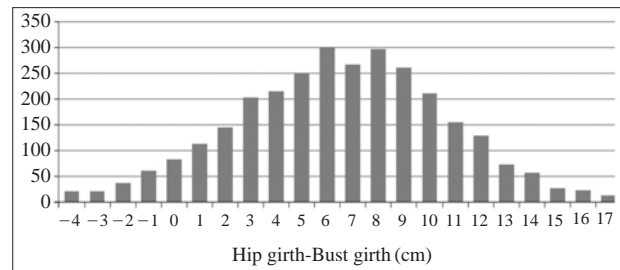
(b) Results from 2010 data

Fig. 5. Annual growth rate in four measurements of Korean female.

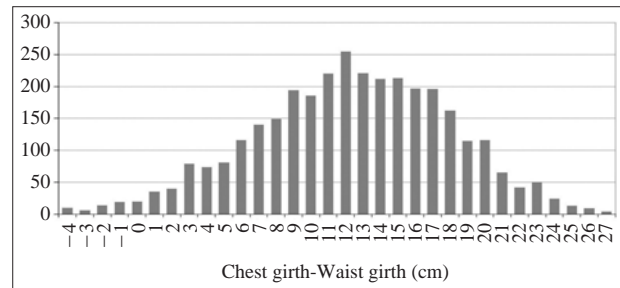
### 3. The distribution of drop value in women

Fig. 6(a) suggests the drop value between bust girth and hip girth based on the data of women body dimension taken in 2010 (N=2,978). The drop values are concentrated in the range from 6 to 9 cm which approximately represent 40% cover rate of women. Data are divided into three zones corresponding to different body types of Korean women.

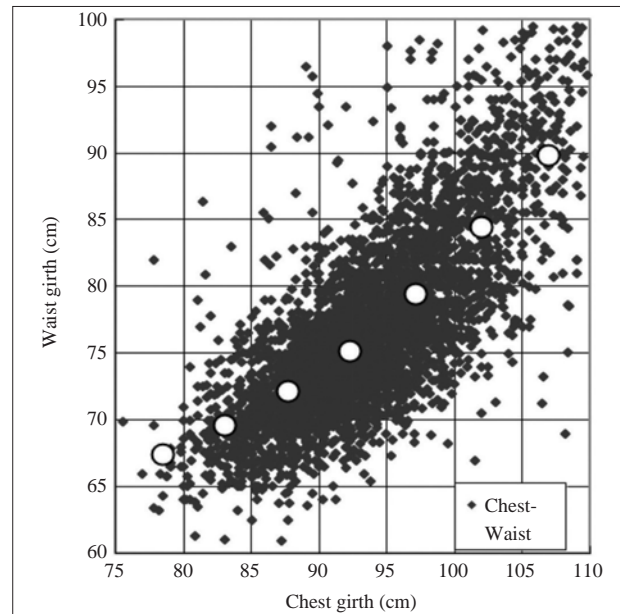
The three body shapes range in descriptive titles from N



(a) Distribution of drop values in women



(b) Distribution of drop values in men



(c) Distribution of chest-waist girth in men

Fig. 6. Drop values distribution in Korean.

(regular), H (slim hips) and A (broad hips) are as follows: Type N, whose drop value ranges from 6 cm to 10 cm, can be defined as the standard type for Korean women. Women who have a drop value between 10 cm and 16 cm belong to type A. This type indicates that she has a well-developed hip compared to that of Type H (drop value of -1 cm ~6 cm reflects a woman with a well-developed bust and slim hips).

Fig. 6(b) and (c) suggest the drop value between chest girth and waist girth based on the 2010 data set of men from 19 to 60 years. The drop values are concentrated in the range from 10 to 20 cm which approximately represent 50% cover rate of men.

Data are divided into three zones corresponding to different body types of Korean men. The three body shapes range in descriptive titles from A (athletic), Y (slim) and B (broad waist) are as follows: Type A, whose drop value ranges from 12 cm to 18cm, can be defined as the standard type for Korean men. Men who have a drop value between 18 cm and 22 cm belong to type Y. This type indicates that he has a slim waist compared to that of Type B (drop value of 6-10 cm reflects a men with a large size of waist). For men, the main relationships between chest and waist girths were summerizes as following: For Y type, chest girth is 18-22 cm smaller than waist girth. For A type, chest girth is 12-18 cm smaller than waist girth. For B type, chest girth is 6-12 cm smaller than waist girth. 3D modeling of defined three different body types of men according to the following size codings are illustrated in Fig. 7.

Size code according to body type for men

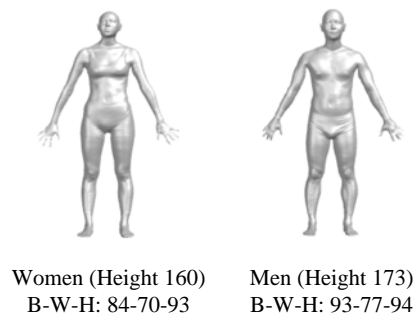
Height	Short	Regular	Tall
Age	25 yrs	24 yrs	22 yrs
Height	168.5 cm	172.0 cm	174.0 cm
Chest girth	94.6 cm	93.7 cm	92.7 cm
Waist girth	74.4 cm	79.2 cm	88.0 cm
Hip girth	100.9 cm	95.6 cm	103.6 cm
Size code	95 (Y type)-S	95 (A type)-R	95 (B type)-T



Fig. 7. An example of three different body type modeling in Korean men.

#### 4. Standard body type of Korean in twenties

As showing in Fig. 4, the means of height, bust, waist and hip girth are respectively, 173.2 cm, 93.0 cm, 78.4 cm and 94.3 cm in men aged 19 years, and respectively 160.2 cm, 83.6 cm, 69.3 cm and 92.8 cm in women aged 19 years. These sizes can be regarded as the standard young adult body shape in Korean as shown (Photos from “Size Korea 2010”).



#### 5. 3D body silhouette

Fig. 8 shows an example of body shape modeling of Korean women in their twenties using sliding gauge based on form front and side silhouette. This figure realizes a comparison of body silhouette shape according to the bust, waist and hip breadth and depth. We can evaluate the body silhouette with the index of bust and hips against waist. Desired S-Line body silhouette index of B/W and H/W of women in their twenties ranges from 1.50 to 1.66. And the

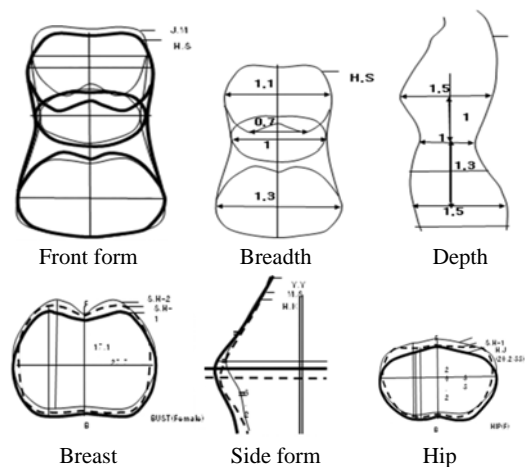
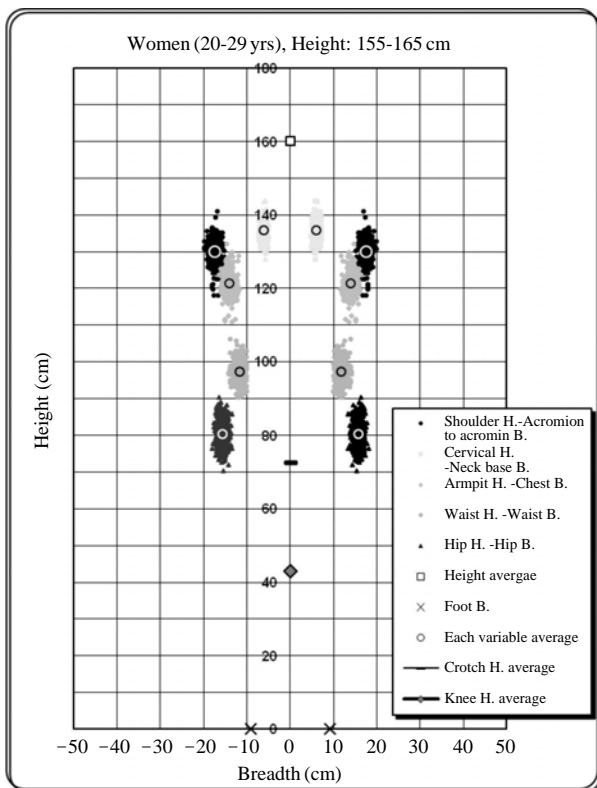


Fig. 8. An example of body shape modeling using sliding gauge data.



**Fig. 9.** Modeling of Korean women's body proportion using data plotting.

index move to range 1.30-1.20 in their 30-40ties, and then decrease to 1.00 in their 50-60ies.

Fig. 9 shows an example of body shape modeling of Korean women using body size data plotting from 235 women from 20 to 29 years selected as harmonious body shape.

This sort of figure realizes a comparison of existing shapes with the desired virtual ones (i.e. a well-proportioned body figure in which height corresponds to 8 times the height of the head) considered as a harmonious body shape by a given or targeted population.

## Discussion

In Korea, like many other countries, the mean height has been increasing in last several decades. In such countries anthropometric data will be outdated sooner or later. The information on the speed of the secular change in height in last several decades is useful to judge if the database is still representing the intended target population or to judge

how long the latest database will serve as the reference data [15]. Fig. 1 shows the secular trend of height in subjects from 6 to 20 years. The mean height of both adults remains almost the same in the surveys of 1997 and 2010. However, the mean height of girls aged from 8-9 years increased about 1-2 cm from 1997 to 2010 which shows the early fast maturing somatotype. Also, the mean height of girls aged from 8-9 years increased 7-8 cm in last several decades from 1986 to 1997 [9,11].

The comparison of the growth in both sexes are plotted in Fig. 2 and Fig. 3. In women, height increases from birth to maturity 3.2 times (for comparison it is 3.5 times for men) mainly due to rapid growth in leg length. The lines are very similar for both survey data. On average, maturity of growth in height is reached at the age of 18-19 years for males and 16-17 years for females.

As can be seen in Fig. 4, the means of height, bust, waist and hip girth are respectively, 173.2 cm, 93.0 cm, 78.4 cm and 94.3 cm in men aged 19 years, and respectively 160.2 cm, 83.6 cm, 69.3 cm and 92.8 cm in women aged 19 years. These sizes are as large as Europeans in height [3], and have a narrower hips compared to American data from the ASTM standard [1,23,17].

Fig. 5 shows the growth rate from age 0 to 20 years. In the body development features of the population group represented by the height, girl subjects are shown to grow upward rapidly during the height range 104-135 cm (approximately 4-9 years). For during the years represented by the height range 104-135 cm boy subjects also grow upwards rapidly, remaining slim, while in the latter years they tend to consolidate or broaden. The body girth dimensions which exhibit a jump in magnitude at the 140 cm height distinguish primarily for bust and hip development combined with the normal body 'consolidation' that occurs also with boys. It is only to be expected that limb development progresses proportionately with height development or approximately so. Increasing annual growth in bust, waist and hip girth, with 3.80 cm, 3.11 cm and 3.70 cm respectively at age 9-10 (with height of 134 cm) corresponds to female child-adult transformation in body shape. There have been increases in growth rates in the more recent period compared to 1986, and there is a definite trend toward earlier maturation and greater total body build. A number of studies have been carried out on the growth stages of puberty [2,25,27,28]. These reports showed that the puberty stages for boys appear at the age 9.1 to 12.5 years, while girls

reaches the stages as early as 10.0 years. The growth stages are highly correlated to height growth as shown in Fig. 5. The results of growth pattern and growth rate from the 2010 data are similar to those patterns of 1997 results.

Fig. 6 shows the body type of Korean divided by drop value. The values of chest girth according to waist girth are plotted in Fig. 6(c). The regular body type N in women has the 6-9 drop value for bust and hip girth. These drop value distributions are quite similar in Japanese body type showing from JIS [7,16,24].

Fig. 7 shows the standard type of Korean. Koreans have shown a large increase in stature since 1980. However, there has been virtually no change in sitting height in that period. Thus, height increases has been due entirely to an increases in leg length with the result that body shape has altered. Similar results were reported for Chinese [29].

Fig. 8 shows an example of body shape index plotting by calculation of the bust/waist and hip/waist values. As shown in Fig. 8, the cluster of both index B/W and H/W is moving from index 1.55 to 1.0 according to body shape. And then we can suggest from these data that the oldest groups are undergoing the biggest change in waist and with smaller bust, and a lean body [20,24].

Fig. 9 shows the comparison between existing shapes with the desired virtual ones (i.e. a 8 head-tall-well-proportioned body), and with body shapes from 235 women from 20 to 29 years selected as harmonious body shape.

According to the 8 head-tall-well proportioned body, the waist height position should be at 100 cm high for a woman being 160 cm high (see the horizontal line). The Fig. 9 shows that the selected subjects' waist height ranges from 90 to 102 cm. Thus, the range is wide due to diverse body shape that we observed. The results of body proportion show that the Korean women in their twenties have long legs and a 7.8 head- tall body proportion [17,24].

## Conclusion

As shown in the survey results, small differences in body proportions at birth are continuously multiplied by differential growth rates up until maturity, after which body shape changes are influenced by age, quality and quantity of food intake, exercise and social conditions. This pattern is consistent with recent Korean cultural emphasis on health and physical fitness according to the economic develop-

ment. The causes of the observed trends, insofar as they have been identified, are related to cultural processes. There are several studies which cover growth features of the entire range from birth to maturity, and they have reported the comparison of the growth patterns amongst European. Even though such research have been made, as for the clothing industry, the human modeling tools based on the anthropometric data and morphological features that cover all the countries should be developed for well fitting garments design.

## Acknowledgements

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## 한국인의 체형 특성 모델링을 위한 인체 측정데이터 분석 연구

이영숙

전남대학교 의류학과

**간추림** : 본 연구는 1979년부터 2010년까지 매 5-6년 간격으로 행하여진 한국인 인체치수데이터를 분석 비교하였다. 또한 1997년과 2010년에 측정되어진 데이터를 중심으로 인체 체형특성을 비교 분석하였다.

체형특성 분석은 체형을 나타내는 주요 부위인 키, 가슴둘레, 허리둘레, 엉덩이둘레에 대한 연령별 성장특성을 비교하였다. 또한 인체의 너비부위와 두께부위에 대한 분석을 통하여 인체의 실루엣 특성을 비교하였다.

1997년 이후 1997년까지는 한국인은 남녀모두 매 조사주기에서 2-3 cm 키의 증가를 보이고 있으며, 1997년 이후 부터는 2010년 6차 조사까지 1 cm 전후의 미미한 증가를 나타내었다.

이러한 키의 증가율은 한국인 인체특성의 변화가 사회적 경제적 여건에 의한 생활패턴의 변화로부터의 영향이 현저함을 설명하고 있다.

**찾아보기 낱말** : 체형, 인체측정, 사이즈, 성장, 실루엣