

Development of the Sizing System for Clothing Based on Korean Anthropometry Data

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Abstract

Standardization is one of the most important invention that humans devised reflecting their culture and their history. For our purpose, standardization can be defined as an agreement among parties concerning the features/characteristics of clothes that one can consider as convenient, efficient and/or safe. However, more generally, all that each society of humans agrees upon, thus, language, writing symbols, rules or laws, which allows to maintain order in groups, customs to keep traditions and so on can be considered as the results or acts of standardization.

A standard sizing system for clothes is a system that is developed based on body shape and size classifications method. To develop an efficient sizing system, we have to classify the database from the majority of the samples.

This paper deals with secular trends of height, chest/bust girth, waist girth and hip girth spanning 1979 to 2010 as well as the morphological feature patterns for Koreans. It also investigates the comparison of the growth pattern and body proportions between male and female based on the anthropometric data samples of KATS taken from the 2010 surveys. The results are classified with body size and shape categories according to the drop values by age and sex in order to develop the new guidelines for the size designation systems based on these body dimensions from the analyzed anthropometric database. These new guidelines for the size designation system will eliminate the confusion that currently exists among countries and individual apparel designers.

Keywords: Anthropometry, clothing, morphology, sizing system, size designation, growth

1. Introduction

The domain of standardization can be considered to begin at the individual manufacturing level, and go up to the level of each industries and then each country, till eventually, to the international level. These days, with globalization, the process also goes from top to bottom, from the international level down to each country and each factory [1]. In the present production processes, standardization, by reducing differences and disorder, by guaranteeing quality, by increasing production efficiency and the rapidity of improvements, plays an ever important role in promoting international trade. Further, it makes it easier to expand, and more comfortable to practice [2, 3].

As a means to further improved quality and production efficiency, standardization plays with the improved systems in business and its simplification. However, with simplicity and harmonization, standardization now means better human relations between and inside manufacturing and commercial units. In fact, everyone benefits from it on all levels, from the producing units to the accounting sections and then the marketing ones, the national and international carriers, the delivery man and finally the consumer.

The EN sizing standard only specifies body measurements [4, 5]. It is a size designation system to communicate with those labels indicated with body dimensions, not clothing sizes. These new guidelines for the size designation system will eliminate the confusion that currently exists among countries and individual apparel designers.

As the basis for the new sizing standards, anthropometric data collection, including three-dimensional information, together with the comparison of these data among countries are becoming necessary tools for the entire manufacturing community [6].

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Thus, in Korea, the first national anthropometry survey was conducted in 1979 by a Korean Government division, the Korean Agency for Technology and Standard [7]. At the time, data were collected on 17,000 sample individuals 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 the Korean standard 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: the surveys were 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 for the 2003 and 2010 surveys. All body dimensions were measured with the method defined by the ISO [8, 9].

Survey	1 st	2 nd	3 rd	4 th	5 th	6 th
Year	1979	1986	1992	1997	2003	2010
Sample size	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
Dimension	117	80	84	120	170	139
Method	2D	2D	2D	2D	2D + 3D	2D + 3D

The purpose of this study was to examine the various sizing systems and specified anthropometric data as well as the fit issues used today. The method of this paper deals with the secular trend of height spanning from 1979 to 2010 along with the morphological feature patterns for Koreans. It also investigates the comparison of the growth pattern between male and female and the body shape classification according to the drop values based on the anthropometric data samples of KATS taken from the 2010 surveys in order to develop and define the new guidelines for the size designation systems of clothes.

2. Methods

The anthropometric data of Koreans measured from 1979-2010 (KATS, 1979-2010 data set) were analyzed in this paper in order to obtain information on Koreans' physical features.

The anthropometric data included stature, 3 girth dimensions (bust/chest 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), 4 height dimensions (waist height, crotch height, hip height and knee height), which were analyzed to indicate body shape and body proportion.

Data on size and annual growth changes of measurements of subjects aged from 6 to 20 years were used to clarify the tendency of maturation in body size.

Drop values between the key dimensions and the distributions between key dimensions were analyzed to define the size categories for the size designation systems.

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 data plotting from the height and breadth measurements, were used as elements for body shape and proportion comparison.

The 3D standard body shape of men and women in their twenties obtained from the 2010 KATS photos [10] and the 1997 Lee data [11] are presented to define Korean's morphological standard features.

The sizing variations among country standards were compared to establish the new guidelines for the size designation systems.

3. Results

3.1. Secular trends in mean height

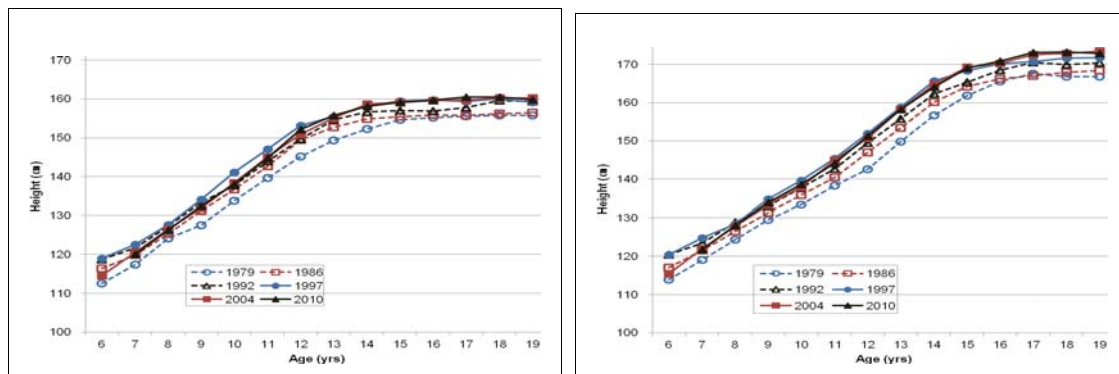
The changes of body height in subjects from 6 to 20 years are illustrated in Figures 1 (a) and (b).

Fig. 1(a) is an example showing a secular change in mean height of female and Fig.1 (b) is showing a secular change in mean height of male subjects' samples taken between 1979 to 2010, who were aged from 6 to 20 years. The information on the speed of the secular change in height in the last

several decades is useful to judge to observe whether the database is still representing the intended target population or to judge how long the latest database will serve as the reference data.

As shown in Fig. 1(a), the mean height value of 18-year-old 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 10-year-old girls 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-year-old 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. The mean height value of 10-year-old boys 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, as shown Fig. 1(b).

As shown in Figures 1 (a) and (b), compared to the 1979 data, the mean height of 1997 and 2010 for both sexes increased approximately 4 cm to 5 cm. 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 indicates early fast maturing somatotype. Also, the mean height of girls aged from 8-9 years increased by 7-8 cm in the last several decades from 1986 to 1997 [12].



(a): Secular trends of height in females

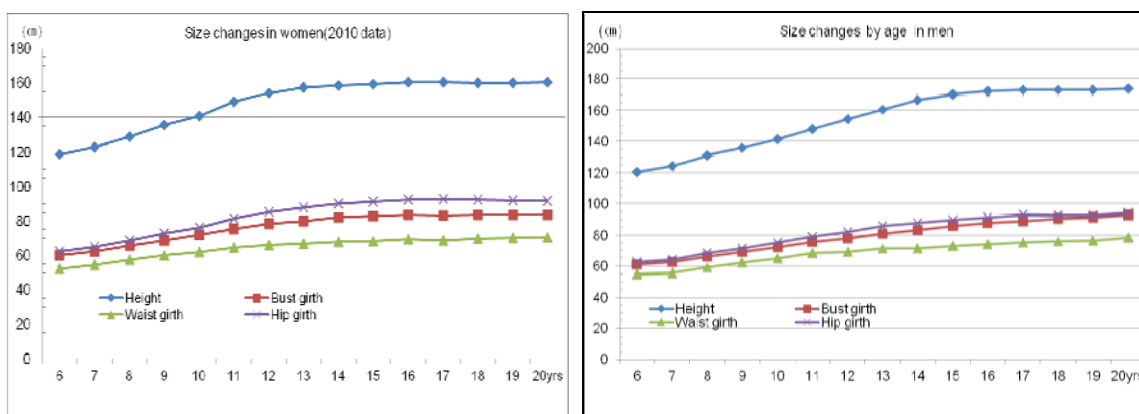
(b): Secular trends of height in males

Fig. 1. Secular trend of height in Korean groups.

3.2. Size comparison of key dimensions

3.2.1. Size change

The size changes of height, bust girth, waist girth and hip girth measurements, which present the body development features and annual growth patterns of measurements in Koreans aged 6-20, are shown in Figs. 2 (a) and (b).



(a): Women's data

(b): Men's data

Fig. 2. Comparison of key dimensions in Koreans.

At age 6, the values of height, bust girth, waist girth and hip girth are 118.9 cm, 60.2 cm, 52.4 cm and 62.4 cm. The growth rates of these dimensions are respectively 74.3%, 72.0%, 74.9% and 67.6% of the adult size. Each year, height increases by 4-6 cm between the ages of 6 and 12 years, and 2-4 cm per year in other girth dimensions (bust and hip) for subjects aged from 12 to 15 years.

On average, maturity of growth in height is reached at the age of 18-19 years for males and 16-17 years for females. For girls at age 10, the values of height, arm length, bust girth, waist girth and hip girth are 140.7 cm, 47.6cm, 72.0 cm, 62.0 cm and 76.2 cm, respectively (Fig. 2-a). For boys at age 10, the values of height, arm length, bust girth, waist girth and hip girth are, 141.4 cm, 47.6cm, 72.0 cm, 64.9 cm and 75.2 cm, respectively (Fig. 2-b). Each year, height increases by 4-6 cm between the ages of 6 and 12 years in both sexes. Then, height increases 2-3 cm per year in the girls group and 4-5 cm in the boys group aged from 12 to 15 years.

3.2.2. Growth comparison between sexes

The data on height and hip girth of male and female from the 2010 samples were compared according to age in both sexes (see Figure 3). The average stature of males from the 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 average stature of 171.8 cm, there was a 2 cm increase. Changes in hip girth of males from the 2010 data has been found to be 60 cm at the age of 6, and the same tendency was found in the female size. At the age of 11, there was a differences in size between male and female hip shape.

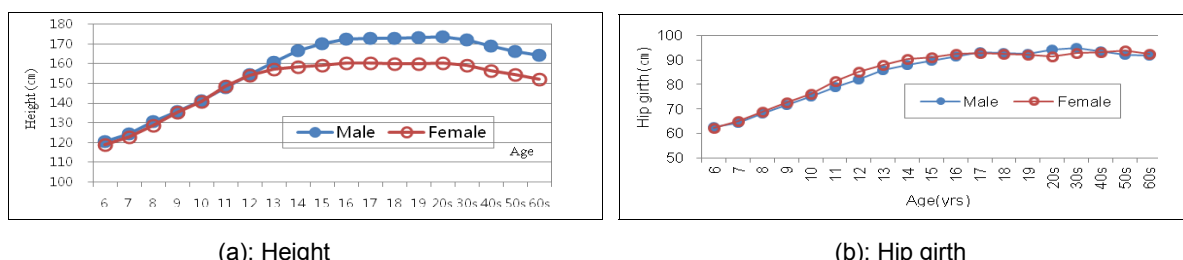


Fig. 3. Growth pattern of hip girth in Korean male and female groups from the 2010 data set.

3.3. Body proportion

Figs. 4 (a) and (b) show the size changes of height dimension in knee height, waist height, hip height and iliospinal height based on the 2010 Korean male and female data set. The proportions of knee height, waist height, hip height and iliospinal height of female group in their twenties from the 2010 data are 0.26, 0.61, 0.38, 0.49 and 0.54 times to the height, respectively. These values can be used to make pattern grading, work space and accessories design in order to predict the body length of each part [13].

Body proportion is critical for manufacture body fitting clothes. The proportion ratio index of body height dimension corresponding to height should be taken into consideration when designing good product construction systems. Five body dimensions, namely, total body height, waist height, hip height, crotch height and knee height, are considered to be very important parameters for well-fitted balanced design and functionality.

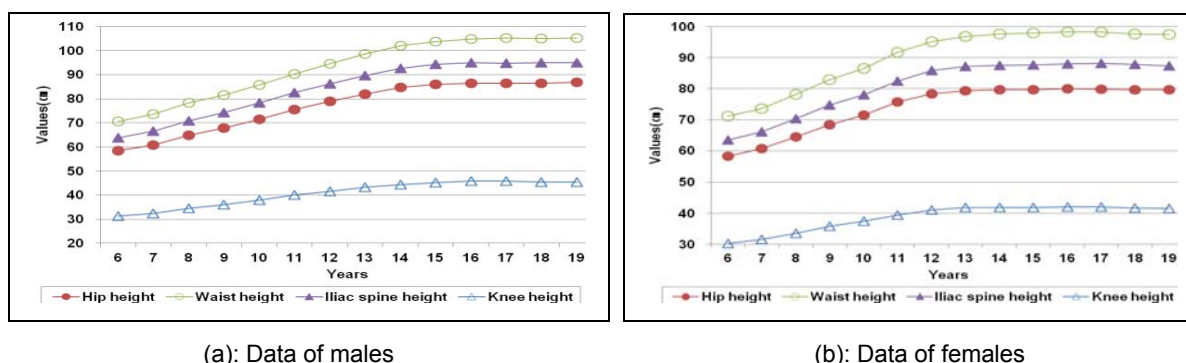


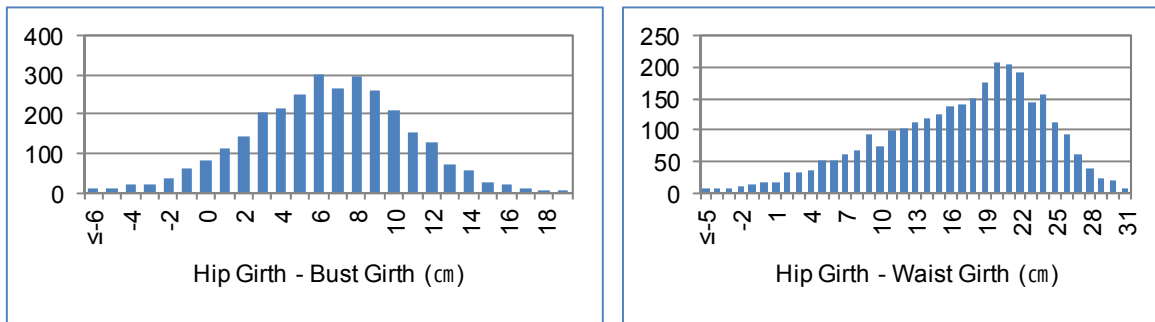
Fig. 4. Height measurements of Koreans from the 2010 data.

3.4. The distribution of drop value in Koreans

3.4.1. Drop value distribution in Koreans

Figure 5 suggests the drop value between bust girth and hip girth, hip and waist girth based on the data of female body dimension taken in 2010 (N=2,978). As shown in Fig. 5(a), the drop values between bust and hip are concentrated in the range from 6 to 9 cm, which approximately represent a 40% cover rate of females. The drop values between hip and waist are concentrated in the range from 19 to 22 cm, which approximately represent a 40% cover rate of females (Fig. 5-b)). Data are divided into three zones corresponding to different body types of Korean women. The three body shapes range in descriptive titles from N (regular), H (slim hips) and A (broad hips), 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 a woman 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).

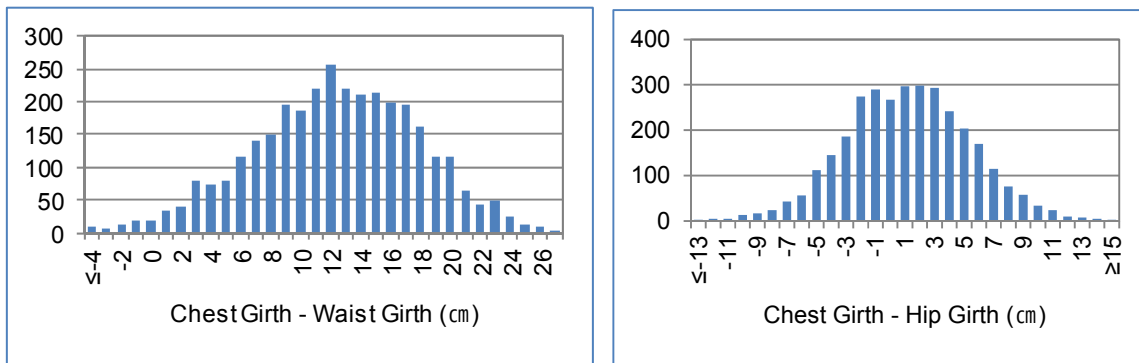
Figures 6 (a) and (b) suggest the drop value between chest girth and waist girth, chest girth and hip girth based on the 2010 data set of men from 19 to 60 years. The drop values are concentrated in the range from 10 to 18 cm, which approximately represent a 50% cover rate of men.



(a): Drop values between hip and bust in women

(b): Drop values between hip and waist in women

Fig.5. Drop values between Key dimensions in Korean women.



(a): Drop values between chest and waist in men

(b): Drop values between chest and hip in men

Fig.6. Distribution of drop values in Korean men.

3.4.2. The distribution between key dimensions

To develop the size range for women's and men's clothing, the size distribution between bust (chest) and height and the distribution between bust and hip girth in women, between chest and waist girth in men are analyzed, as shown in Figs. 7(a) and (b) and Figs. 8(a) and (b). The size range in the height of women are distributed from 150 cm to 175 cm, with an 85% cover rate. The size range of bust and hip girth in women are distributed from 76 cm to 98 cm and, 84-104 cm, respectively, with an 85% cover rate. The size range of height, chest and waist in men are distributed from 84-108 cm and 64-100 cm, respectively, with an 85% cover rate.

Body size distribution sector is critical for size designation of body fitting clothes. The distribution ratio index of body height dimension corresponding to the bust (chest) should be taken into consideration when designing good product construction systems.

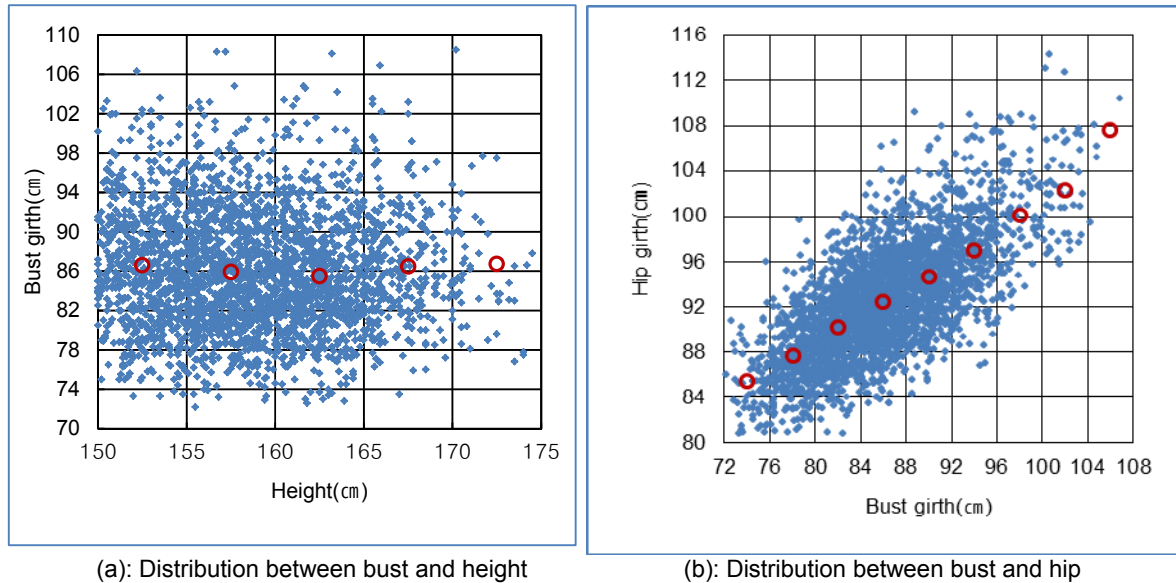


Fig. 7. Distribution of the size between bust and height, bust and hip in groups of Korean women from the 2010 data set.

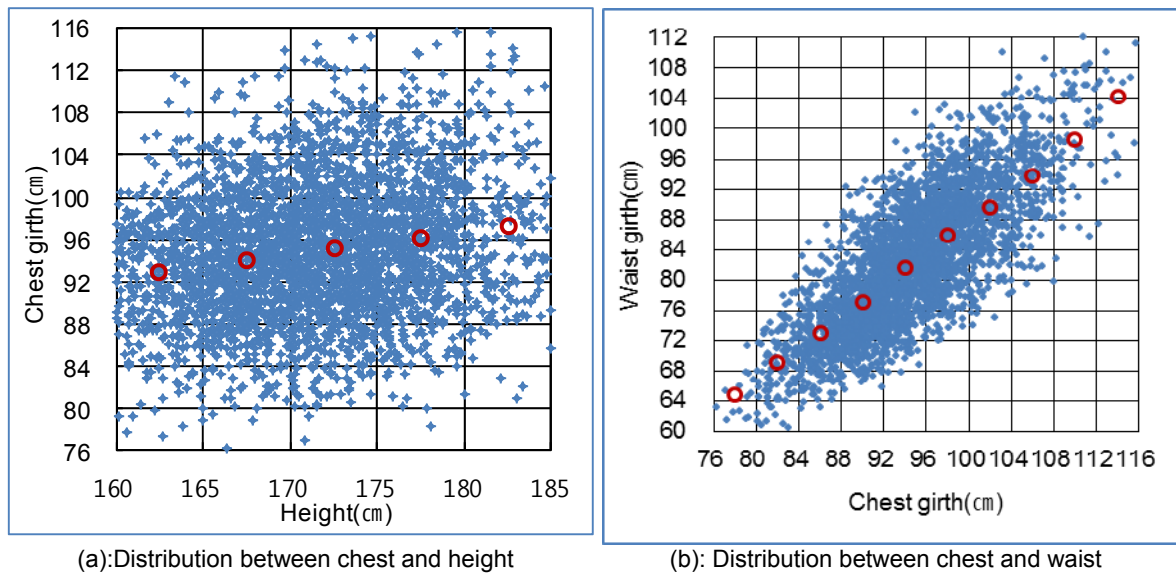


Fig. 8. Distribution of the size between chest and height, chest and waist in groups of Korean men from the 2010 data set.

3.5. 3D body modeling in Koreans

Figs. 9 and 10 show an example of body shape modeling of Korean women in their twenties using body size data plotting and the form from front and side view using the sliding gauge. 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 8 times to the height of the head) considered as a harmonious body shape by a given or targeted population [14].

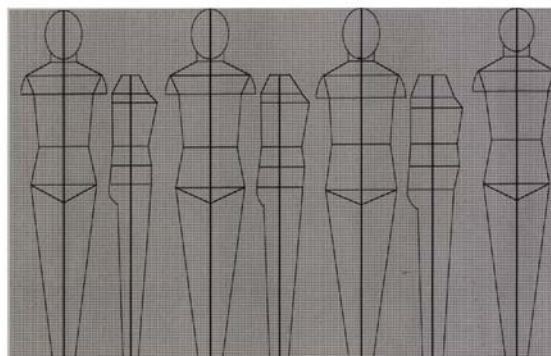
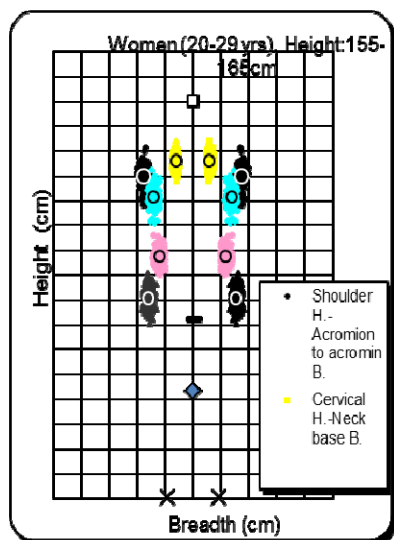


Fig. 9. 3D modeling from data plotting.

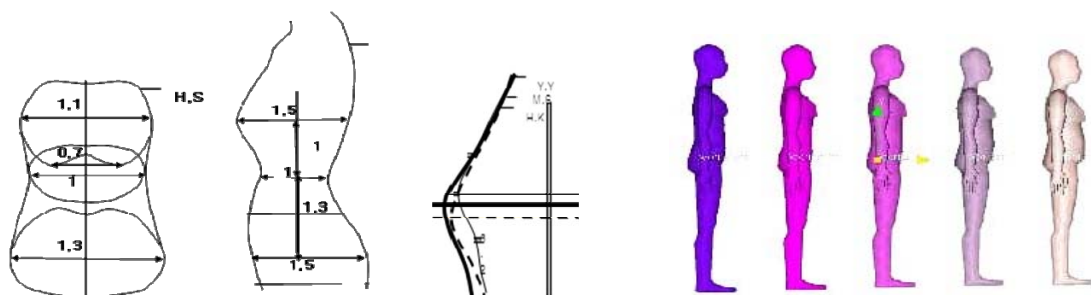


Fig.10. 3D modeling from front and side view.

3.6. Size designation systems in Korean Standards

3.6.1. Size designation in men's wear

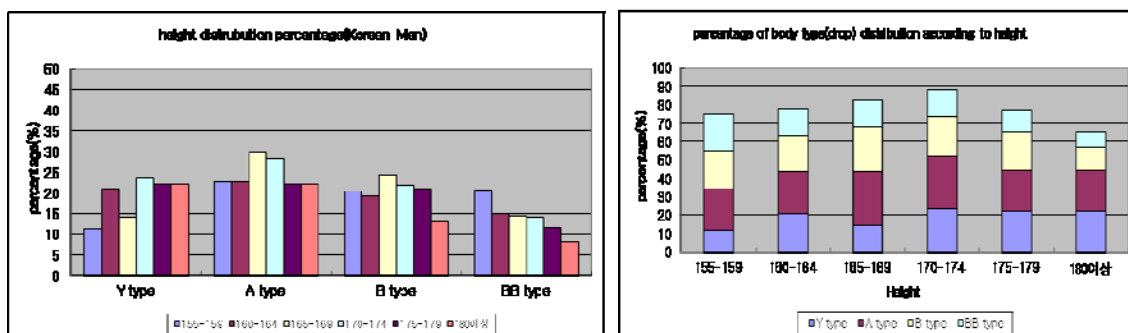
The size range of the three key dimensions and intervals are determined as follows:

Body Type	Drop Value (cm)		
	short	Regular	Tall
Y type (Drop 20)	18	20	22
A type (Drop 16)	14	16	18
B type (Drop 10)	6	10	12
BB type (Drop 2 ~ 6)	2	4	6

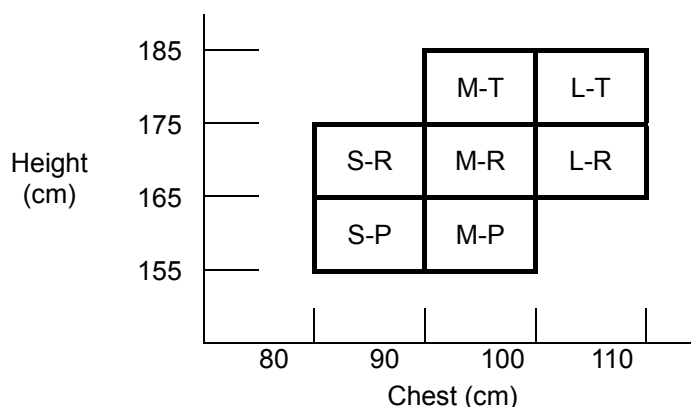
Height Type	Height Range (cm)
Short	163(155 ~ 165)
Regular	173(165 ~ 175)
Tall	180(175 ~ 185)

Fig. 11 (a) shows the cover rates according to body type and height type in Korean men. For men's wear, chest dimension ranges from 73 cm to 106 cm, hip dimension from 78 cm to 112 cm and waist girth from 68 cm to 106 cm. Chest and hip measurements are established at intervals of 3 cm and waist dimension at intervals of 2 cm. Height dimension, which ranges from 155 cm to 185 cm, is divided into three groups, referred to as "short," "regular" and "tall," with an interval of 10 cm.

In the case of upper body garments of men in their twenties, the letter code size ranges corresponding to S, M L and LL are as shown in Fig. 11 (b).



(a) : Cover rate according to body type and height in men



(b) : Size range of the letter code in men's wear

Fig. 11. Size designation systems in men's wear.

3.6.2. Size designation systems in women's wear

In KS K 0051(2009), bust and hip measurements are established at intervals of 3 cm and of 5 cm for height dimensions ranging from 145 cm to 175 cm. Body type is classified into 3 groups, according to the drop value between bust girth and hip girth. Type N, whose drop value is 6-9 cm, can be defined as the standard (regular) Korean women body type.

Type N whose drop value is 6 cm, falling under the size range 4 cm-10 cm, can be defined as the regular Korean women body type. Women, whose drop value of 12 cm ranges between 10 cm and 16 cm, belong to type A as follows.

Height Type	Height Range (cm)
Petite(P)	150(145-155)
Regular(R)	160(155-165)

Body Type	Mean Drop Value (Hip- Bust, cm)
A	12 (range of drop value is over 10cm)
M	6 (range of drop values from 4- 9 cm)
H	0 (bust-hip drop value +3- -4 cm)
Long(L)	170(165-175)

Letter codes S.M.L XL representing the size ranges of bust girth and height, in each size code, are shown in Fig. 12.

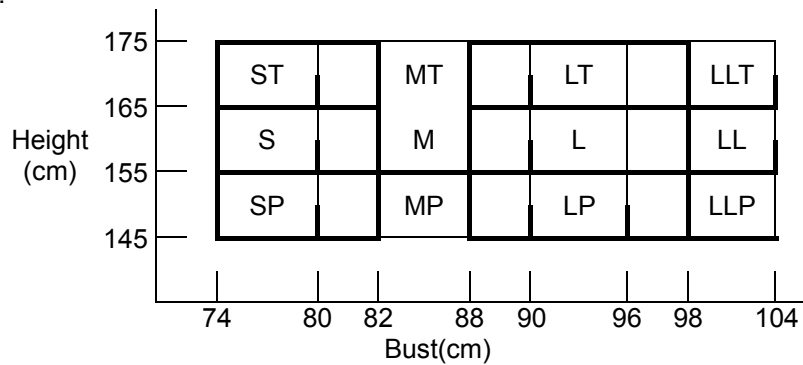


Fig. 12. Size designation systems of letter code in women's wear.

3.7. Standard body type of Koreans in twenties

3.7.1. Standard body type of Korean from the data 2010

According to the 2010 data, the average, height, chest, waist and hip girth of men were 173.3 cm, 93.0 cm, 77.4 cm and 94.3 cm, respectively.

As for the data of women, the average height, bust, waist and hip girth from the 2010 data were 160.4 cm, 83.0 cm, 69.3 cm and 92.8 cm, respectively.

The average stature of male from the 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 average stature of 171.8 cm, there has been a 2 cm increase.

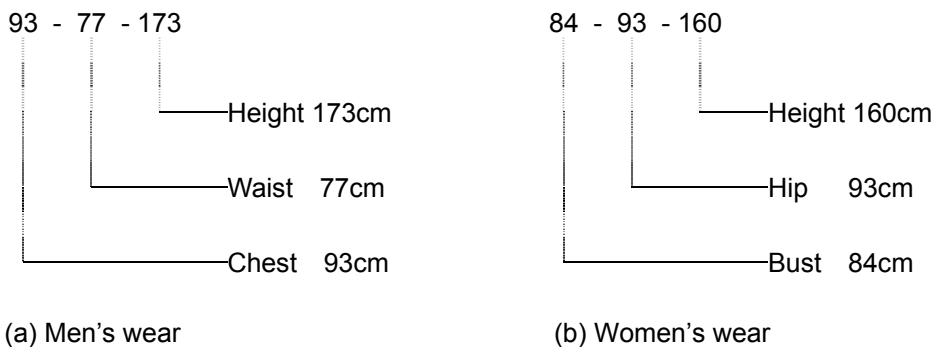


Fig.13. Regular size of KS.

The means of height, chest/bust, waist and hip girth are 173 cm, 93 cm, 77.4 cm and 94 cm, respectively, in 19-year-old men, and respectively 160 cm, 84 cm, 69.3 cm and 93 cm in 19-year-old women. These sizes can be regarded as the standard young adult female and male body shape in Korea, as shown below in Fig. 14 (Photos from "Size korea 2010").

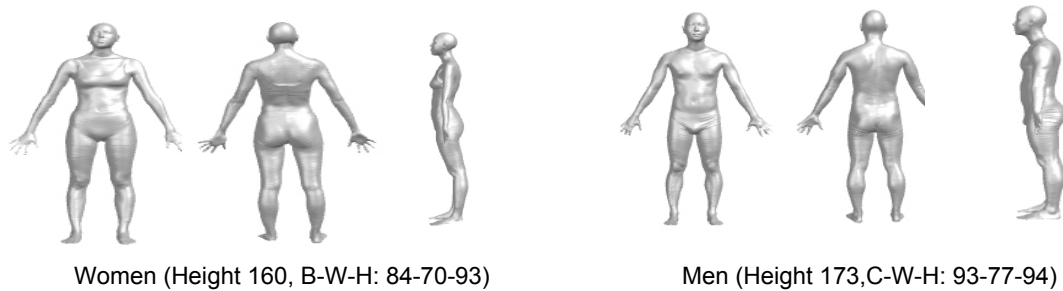


Fig. 14. Standard body shape of Korean women and men from 2010 data.

3.7.2. Standard of Koreans from the data 1997

As for the data of women subjects in their twenties, the average height, bust, waist and hip girth from 1997 data were 159.8 cm, 82.0 cm, 65.8 cm and 89.2 cm, respectively. In 1997, the results for men in their twenties regarding the means of height, chest, waist and hip are 171.6 cm, 89.6 cm, 76.4 cm and 92.6 cm, respectively as shown in Fig. 15. The average stature of male from the 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 average stature of 171.6 cm, there has been a 2 cm increase. These sizes can be regarded as the standard young adult body shape in Korea, as indicated in Fig. 16 (Photos from Lee data 1997).

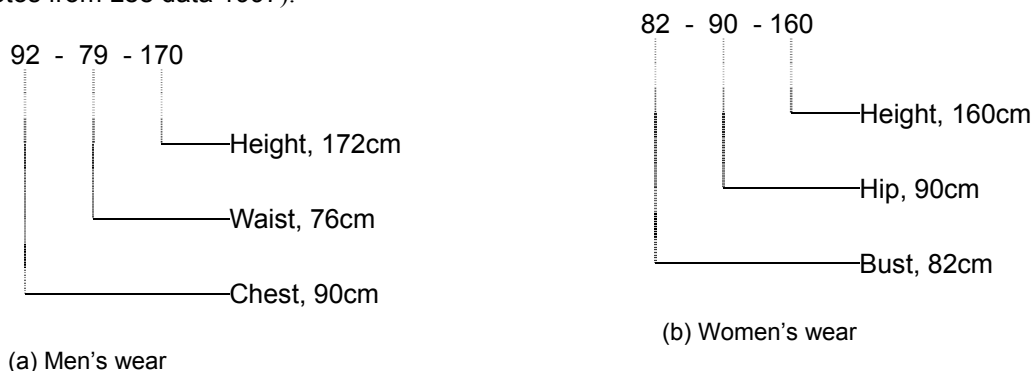


Fig.15. Regular size of KS.



Fig.16. Standard body shape of Koreans from 1997 data.

3.8. Compatibility of the sizing system

3.8.1. Different sizing labeling with wame bust measurement

ISO standards include the ISO/TC 133 norm pertaining to clothing that is applied in most European countries. As member states, European countries respect the ISO standards when establishing their clothing size standards and size labeling system. However, despite ISO's efforts, countries could not neglect consumer's preference for national clothing sizing system with which they are familiar with, and thus, they still continue to use the former national sizing system. Therefore, clothing based on the same physical features follows different sizing systems. Even when following the same sizing system, in practice, the corresponding measurements are different and thus bring confusion to consumers who pursue imported products or products from abroad.

For instance, a 92 cm bust girth clothing is labeled differently in different countries, as shown below:

Japan	France
15	40
UK	Italy
14	44

3.8.2. Sizing standards of garments according to countries

Garment sizes can be by large divided into three, the European, American and the Asian systems, each having its own characteristics. In Table 1, we have reviewed the Korean, Japanese, French, Italian, German and American sizing norms distinguishing male and female sizes. We also look at their conformity to the ISO standards and the conformity between themselves [15-20].

Table 1. Size chart of each size code by standards ISO, KS, JIS, AFNOR, Italy, DIN and ASTM.

	80	84	88	92	96	100	104	108	112
ISO									
Size code	80	84	88	92	96	100	104		
bust	80	84	88	92	96	100	104		
waist	63	69	74	79	83	87	92		
hip	87	92	96	99	103	106	109		
height	160	160	160	160	160	160	160		
KS									
Size code	79	84	88	91	94	100			
bust	79	84	88	91	94	100			
waist	65	67	73	74	76	80			
hip	88	90	94	96	98	102			
height	160-164	160-164	160-164	160-164	160-164	160-164			
JIS									
Size code	7YR	9YR	13YR	15Yr	17YR	19YR			
bust	80	83	89	92	96	100			
waist	61	64	67	70	73	76			
hip	85	87	91	93	95	97			
height	158	158	158	158	158	158			
AFNOR									
Size code	34n	36n	38n	40n	42n	44n	46n	48n	
bust	80	84	88	92	96	100	104	110	
waist	58.6	61.8	65.2	68.8	72.6	76.25	79.85	85.3	
hip	84	88	92	96	100	104	108	112	
height	160	160	160	160	160	160	160	160	
Italy									
Size code	38	40	42	44	46	48	50	52	
bust	80	84	88	92	96	100	104	110	
waist	59	62	65	69	73	77	81	85	
hip	86	90	94	98	102	106	110	116	
height	164	164	164	164	164	164	164	164	
DIN									
Size code	17	18	19	20	21	22	23		
bust	80	84	88	92	96	100	104		
waist	65	68	72	76	80	84	88		
hip	90	94	97	100	103	106	109		
height	160	160	160	160	160	160	160		
ASTM									
Size code	2	4	8	10	12	14	16		
bust	83.8	86.7	92.1	94.6	98.4	102.5	107.0		
waist	64.4	66.4	71.1	73.6	78.1	82.6	87.6		
hip	91.14	94.3	99.7	102.2	106.1	109.8	114.3		
height	166.3	166.3	166.3	166.4	166.4	166.4	166.4		

4. Conclusions

The clothing sizing system is a recurrent problem with requires further research and improvement regarding sizing system standards, body measuring system and size labeling system in association with clothing manufacturers, consumers and researchers. Because the making and availability of statistics for general public information has long been studied in Korea, the main purpose of anthropometric data gathering and surveys in the country tended to rely on the traditional and 3D body scan methods. 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. The higher level information processing and control of studied of human body growth and developing the compatible sizing system of clothes will eliminate the confusion that currently exists among countries and individual apparel designers.

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