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COMMUNICATIONS

Comparison of body shape between USA and Korean women

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Abstract

Purpose – The purpose of this paper is to compare body shape between USA and Korean women. It aims to analyze the distribution and proportion of body shapes of two countries and compare the differences of body shape according to age.

Design/methodology/approach – SizeUSA and SizeKorea measurement data were evaluated using the Female Figure Identification Technique for apparel system developed at North Carolina State University. Once the samples were defined by shape, comparisons were made of the distribution according to age and country through statistical analysis.

Findings – The paper finds that the largest shape category was the rectangle shape in both countries, but the distribution within each shape category for Korean women was different from that of USA women. More body shape categories were found in the USA women than in Korean women. In addition, most body shape categories had different body proportions when comparing the USA women and Korean women. The USA women had the higher measurements in the waist, high hip, and hips height and the larger measurements in the bust, waist, high hip, and hips circumference.

Research limitations/implications – Of the over 6,300 US female subjects in this study, only five failed to be identified by the seven shapes identified. These subjects had over 50.2 in. of hip circumference, over 10 in. larger hips than bust circumference, and over 15.5 in. larger hips than waist circumference. Further refinement of the mathematical definitions or a second group of criteria may be required for sorting the women that have no shape as defined by this study.

Originality/value – The opportunity to compare the body shapes between two very different countries, using national anthropometric survey data, is very rare, indeed. This comparison allows the opportunity to discover ways to improve the sizing systems of each country, as well as impact the development of international sizing standards that could have a significant impact on brands producing product for a variety of international consumers.

Keywords Women, Measurement characteristics, United States of America, South Korea

Paper type Research paper

Introduction

Most people want clothing that fits well. Although each person's definition of that may well be subjective, the satisfaction with clothing fit will be higher if the body type of the wearer can be considered when the clothing is designed and manufactured. New developments within the apparel industry can now enable the customization of clothing fit through automatic measuring with 3D body scanning, in addition to enabling a better understanding of the adjustments that need to be made that might allow better fit for a mass market. The demand for manufacturing clothing that considers the traits of various body types is getting higher.

Body types differ between races. The body sizes, shapes, and proportions of each are different. There has been a great deal of research regarding fit preferences (LaBat and Delong, 1990; Alexander *et al.*, 2005), or satisfaction with clothing and body cathexis among races or countries (Rabolt *et al.*, 2004; Newcomb and Istook, 2005). But, there has been little research conducted that compared the body type among races.

The major factor that has an influence on fit and satisfaction with clothing is body type. It is very important to find the characteristics of each body type among races or countries. As the economic, social, and cultural interchanges among countries increase, many global apparel brands like Banana Republic, Gap, and Crew are becoming more popular in many countries. Body type comparisons between countries allow the opportunity to discover ways to improve the sizing systems of each country, as well as impact the development of international sizing standards that could have a significant impact on brands producing product for a variety of international consumers that have different sizes and shapes.

Simple mean comparison of body size between countries is not meaningful to understand the body size and shapes because there are various body types within each country. In this study, we compared the body shapes between USA and Korean women. The distribution and traits of body shapes between two countries were analyzed and the differences according to age were compared. The body proportion of each body type between two countries was compared through statistical analysis.

Purpose of the study

The purpose of this study was to compare the body shape and body proportion between USA women and Korean women by analyzing the distribution and traits of body shapes and comparing the differences of body shape according to age.

Review of literature

The national anthropometric survey in the USA

Historically, almost all US sizing surveys conducted were for the US military for the purpose of sizing equipment and military apparel. In the mid-1990s, a project was processed to provide civilian measurement information, in addition to military information using a full body 3D scanner. This project, known as Civilian American and European Surface Anthropometry Resource (CAESAR), was put together jointly by the Society of Automotive Engineers and the US Air Force, and was designed around a new 3D laser body scanning technology. A Cyberware scanner was used in the US States to gather data and a Techmath (now known as Human Solutions) scanner was used in Europe. In addition to the scanned measurements that were taken, quite a number of physical measurements were also taken. This study was designed to

generate information that could serve multiple industries including automobile, aerospace, furniture, apparel, and others (TC^2, 2004).

The SizeUSA project, completed in September 2003, was anthropometric research developed to gather US sizing data that would be representative of the US adult population (based on an NHANES sampling protocol) with the use of the TC^2 3D body scanner, which uses white light to define the 3D image of a subject. The image data were used in combination with the body measurement system measurement extraction software to obtain more than 130 measurements for each subject (TC^2, 2006). Over 10,000 subjects were scanned, evaluated and surveyed during the research project. About 65 percent of the subjects scanned were women and 35 percent men. The objective of the SizeUSA National Sizing Survey was to measure the body dimensions of a representative sample of the US population, so the variety of age, ethnicity, gender, and geographic area was considered when determining the sampling methodology (TC^2, 2004).

The national anthropometric survey in Korea
A National Anthropometric Survey in Korea has been carried out every 5-6 years since 1979 and size and shape information about human bodies have been provided to the various industrial areas. The first National Anthropometric Survey in Korea was conducted in 1979. The 18,013 Koreans from 0 years to 45 years were measured and there were 117 total measurements. With the result of first survey, a standard for 46 kinds of industrial products such as clothing, shoes and school instruments was developed. The second anthropometric survey was in 1986 and 21,648 Koreans from 0 years to 51 years were measured on 80 items. The third survey was in 1992 and 8,886 Korean from 6 years to 50 years were measured on 84 items on the basis of the Korean Standard KS A 7003 and KS A 7004. With the result of third survey, 41 standards were developed or revised. The fourth survey of 13,062 Koreans from 0 years to 70 years was measured in 1997. About 120 items were selected by KS A 7003 and measured by KS A 7004. For the first time, the elderly people from 50 years to 70 years were measured. Based on the results of the four national anthropometric surveys, more accurate body data of Koreans were provided to industries and more suitable clothing, shoes, furniture and the other equipment were manufactured Korean Agency for Technology and Standards (KATS, 2006).

The demands of industry are varied and constantly changing making it difficult to meet the needs of all from the four previous studies. It became important to find a way to collect body information that could provide data to meet the wide variety of needs for different industries. The SizeKorea project was developed as the fifth National Anthropometric Survey to satisfy the changing demands of each industrial area. This survey was conducted from March 2003 to November 2004, and included not only the traditional physical anthropometric measuring techniques, but also 3D body scanning and body movement. The 19,700 Koreans from 0 years to 90 years were measured on 119 traditional items, 35 action items and 205 3D items. The purpose of SizeKorea was to:

- gather size and shape information of the Korean body which corresponded to international criteria;
- obtain 3D Korean body data which has importance to many industrial areas; and
- build a database of body measurements for the development and revision of industrial products and system standards (KATS, 2004).

Body type classification in the US Sizing system
The body types of the apparel sizing systems in USA have been classified by body
proportions as might be influenced by age (Glock and Kunz, 2005). Commonly used
size ranges classified by body types for women are Junior, Petite, Misses, Women, and
Plus sizes. Junior sizes were designed for the more youthful (less well developed), short,
and slim figure. The torso is cut shorter and the bustline higher than in Misses. They
are 1.62-1.67 m (5.4-5.6 in.) in height. Sizes are odd numbers and range from size 3 to 15.
The Petite size range has the general circumferential proportions of the Misses sizes,
but their height ranges from 1.52 to 1.62 m (5-5.4 in.) and the sizes are even
numbers from 2 to 14. Misses sizes were designed for the woman who has average
proportions and height. They have a longer back waist length than Juniors and a more
mature female figure with a height from 1.62 to 1.73 m (5.4-5.8 in.). Sizes are even
numbers and range from 2 to 20. Women's sizes generally range from 14 to 24.
The torso has larger proportions and a fuller figure than Misses. Height ranges from
1.62 to 1.75 m (5.4-5.9 in.). Plus Sizes are larger figure types corresponding to Misses 16
and larger. The Height is over 1.62 m (5.4 in.) and sizes range from 12 to 32 (Stamper
et al., 1991; Ashdown, 1998; Glock and Kunz, 2005).

ASTM (formerly the American Society for Testing and Materials, 2001) updated the
standard for Misses sizes, designation D5585-95, in 2001. All of the standards related to
body sizing are slated for update every five years. This timeline has no relationship to
measurement surveys that have been conducted. Generally, any changes to the
standards have been based on industry (military, apparel manufacturers, and retailers)
practice, rather than representative measurement data.

Body type classification in Korean Sizing system
Body type has been the fundamental basis of sizing systems in Korea. KATS suggested
the apparel sizing system according to body type based on the ISO sizing system in 1998
and improved it in 2004. The sizing system for women's apparel includes three basic
body types. The upper body can be classified into an A, H, or N type, according to the
difference between Hips circumference and Bust circumference. The A type has a small
bust and large hip, with a difference between Hips and Bust ranging from 9 to 21 cm
(3.54-8.27 in.). The H type has large bust and hips, and the difference between Hips and
Bust ranges from − 14 to − 3 cm (− 5.51 to − 1.18 in.). The N type is the average type
with a difference ranging from 3 to 9 cm (1.18-3.54 in.). The lower body is classified into
three types, as well: the average type, the small waist type, and the large waist type. The
criterion for classification is the difference between hips circumference and waist
circumference. The average type has the difference between hips and waist from 14 to
22 cm (5.51-8.66 in.) and the small waist type with a difference from 22 to 38 cm
(8.66-14.96 in.). The difference range of the large waist type is from − 4 to − 14 cm
(− 1.57 to − 5.51 in.) (Korean Standard Association, 2004).

FFIT software
The software Female Figure Identification Technique (FFIT) for Apparel© was
developed as a starting point for the representation of female figure shapes in a
mathematical way (Simmons, 2002). The software was developed as a part of a doctoral
dissertation, which aimed at creating "a methodology for characterization of body
types/forms that would more appropriately replicate the diverse shapes of the American

population" (Simmons, 2002). The aim of the research was "to utilize software that can take 3D data and 'sort' it into congruous and related shape categories (body or shape sort) based on measurements, proportion, and shape" (Simmons, 2002, p. 3). The study resulted in development of preliminary subgroups for the female population that may aid in better fit of clothing, after careful review of all previous studies done on somatotyping, body typing (no study was conducted before FFIT for Apparel© using 3D bodyscan data) and by expert knowledge of researchers who worked in the apparel field for more than thirty years. Six body measurements taken from the body scan data of women were used to predict the body shapes of women.

Further research was conducted to validate the FFIT methodology. Discriminant analysis was performed to assess the classification accuracy of the FFIT© software and compare it to the Discriminant function developed from the results of visual analysis. The classification accuracy of the Discriminant function developed from the training data set is 66.01 percent for the test dataset, while the classification accuracy of the FFIT© software is 89.27 percent for the test dataset. The predictive validity of the Discriminant function is higher by itself and the performance of the FFIT© software is better than the Discriminant function (Devarajan and Istook, 2004).

An additional objective of this research was to identify whether the nine shape groups are statistically different. The results obtained from the MANOVA analysis found that the nine shape groups proposed in the software are significantly different and the five variables used by the software significantly influence the group membership (body shape). The software could be used on a larger random sample set, representing the general US population and expected to produce good classification accuracies (Devarajan and Istook, 2004).

Method

Data

The 3D data of 6,310 women of SizeUSA and 1,799 women of SizeKorea were analyzed for comparing body shapes. The 3D data of SizeUSA was measured with the scanner of TC^2 from 2002 to 2003, and the subjects were women over 18 years of age. The 3D data of SizeKorea was measured with the Cyberware scanner in 2003 and the subjects were women over 18 years of age. The Body Measurement Software (BMS) of TC^2 was utilized for extracting measurements from the two 3D data sets and the six measurements that were needed to sort and compare the shapes were extracted.

Analysis instrument

Shape sorting and shape category information. The criteria for shape sorting was the FFIT for Apparel© discussed previously (Simmons *et al.*, 2004a, b). The reliability of the criteria was scrutinized through preliminary analysis to determine the criteria are effective for sorting not only the USA women but also Korean women. The criteria were defined by mathematical analysis and visual check. Body shapes were sorted with the mathematical description by FFIT© for Apparel and visually verified individually to determine that the shape designation given by FFIT© was correct. About seven of the nine body shape categories were adapted to classify the shape of subjects (the Oval and Diamond shapes were not used for this study due to the lack of availability of measurement data from SizeUSA). The seven shapes were the hourglass, spoon, bottom hourglass, top hourglass, inverted triangle, triangle, and rectangle shapes.

Hourglass. The hourglass category and the rectangle category were the basis from which many of the other categories were created. The body measurements used to define the hourglass shape were the bust, waist, and hips. The underlying criteria of the hourglass shape says that if a subject has a very small difference in the comparison of the circumferences of the bust and hips AND if the ratios of bust-to-waist and hips-to-waist are about equal and significant, then the shape will be defined as an hourglass. The person with an hourglass shape has the appearance of being proportional in the bust and hips with a defined waistline. The mathematical formula defined for hourglass shape is:

If (bust-hips)< = 1 Then
    If (hips-bust)<3.6 Then
        If (bust-waist)> = 9 Or (hips-waist)> = 10 Then
            shape = "Hourglass"

Bottom hourglass. This shape category is a subset of the hourglass category. This shape was determined by utilizing the same body measurements of the bust, waist, and hips, as in the hourglass. The bottom hourglass category utilizes the underlying criteria that if a subject has a larger hips circumference than bust circumference AND if the ratios of the bust-to-waist and hips-to-waist are significant enough to produce a definite waistline, then the shape will be defined as a bottom hourglass. The mathematical formula defined for bottom hourglass category is:

If (hips-bust)> = 3.6 And (hips-bust)<10 Then
    If (hips-waist)> = 9 Then
        If (highhip/waist)<1.193 Then
            shape = "Bottom Hourglass"

Top hourglass. This shape category is also a subset of the hourglass category. The underlying criteria for the top hourglass shape says that if a subject has a larger bust circumference than hips circumference and if the ratios of their bust-to-waist and hips-to-waist measurements are significant enough to produce a definite waistline, then the shape will be defined as a top hourglass. The mathematical formula defined for top hourglass shape is:

If (bust-hips)>1 And (bust-hips)<10 Then
    If (bust-waist)> = 9 Then
        shape = "Top Hourglass"

Spoon. The shape category of Spoon was determined by utilizing the body measurements of the bust, waist, hips, and high hip. The Spoon shape category utilizes the underlying criteria that if a subject has a larger circumferential difference in their hips and bust and if their bust-to-waist ratios is lower than the hourglass shape and the high hip to waist ratio is great, then that shape will be defined as a Spoon. The mathematical formula defined for Spoon shape is:

If (hips-bust)>2 Then
    If (hips-waist)> = 7 Then
        If (highhip/waist)> = 1.193 Then
            shape = "Spoon"

Triangle. The shape category of triangle was determined by utilizing the body measurements of the bust, waist, and hips. The triangle shape category utilizes the underlying criteria that if a subject has a larger hips circumference than their bust and if the ratio of their hips-to-waist is small, then the subject can be identified as having a triangle shape. The person with a triangle shape has the appearance of being larger in the hips than the bust without having a defined waistline. This shape differs from the bottom hourglass because the triangle does not consider the bust-to-waist ratio where the bottom hourglass does. The mathematical formula defined for the triangle shape is:

> If (hips-bust)$> = 3.6$ Then
>> If (hips-waist)<9 Then
>>> shape $=$ "triangle"

Inverted triangle. The shape category of inverted triangle was determined by utilizing the same body measurements of the bust, waist, and hips as in the triangle. The inverted triangle shape category utilizes the underlying criteria that if a subject has a larger bust circumference than their hips and if the ratio of their bust-to-waist is small, then it will fall into the shape category of an inverted triangle. The person with an inverted triangle shape has the appearance of being heavy in the bust as compared to the hips but not having a defined waistline. This shape differs from the top hourglass because the inverted triangle does not consider the hips-to-waist ratio where the top hourglass does. The mathematical formula defined for inverted triangle category is:

> If (bust-hips)$> = 3.6$ Then
>> If (bust-waist)<9 Then
>>> shape $=$ "Inverted Triangle"

Rectangle. The rectangle category was determined by utilizing the bust, waist, and hips circumferences. The underlying criteria for this shape is that if the bust and hips circumferences are fairly equal and bust-to-waist and hips-to-waist ratios are low, then the shape will be defined as a rectangle. The person with a rectangle shape is characterized by not having a clearly discernible waistline. Therefore, the bust, waist, and hips are more inline with each other. The mathematical formula defined for rectangle shape is:

> If (hips-bust)<3.6 And (bust-hips)<3.6 Then
>> If (bust-waist)<9 And (hips-waist)<10 Then
>>> shape $=$ "Rectangle"

Results

Comparison of distribution of shape categories between USA and Korean women

The distribution of shape categories between USA (Table I) and Korean (Table II) women was compared. The distribution according to age group was analyzed and the most frequent shape of each country was determined.

Hourglass. The hourglass shape was the third largest shape category of the USA women. It had the distribution with 11.8 percent of the US subjects and getting older, it showed lower distribution (Table I). In Korean women, the hourglass shape was the fifth largest shape category. The distribution of the hourglass shape category was under 0.5 percent and the hourglass shape appeared just under 35-years old group of Korean women (Table II). Figure 1 is an example of a true hourglass shape. She has the appearance of
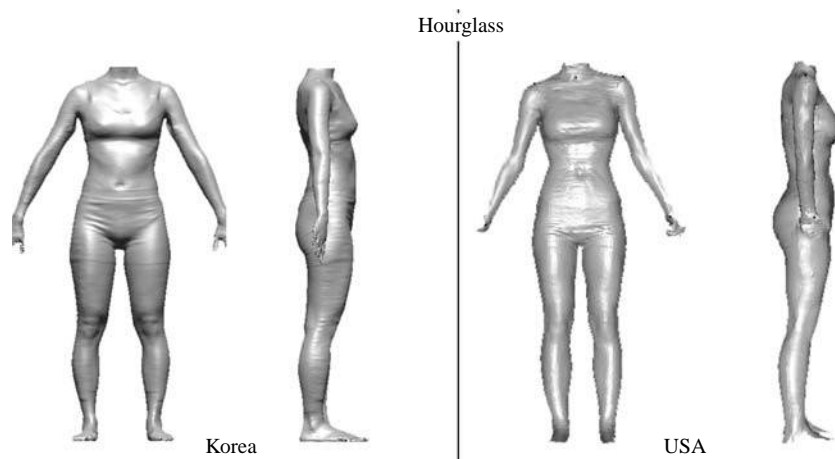
| | USA women | | | | | | |
	18 ~ 25 years (percent)	26 ~ 35 years (percent)	36 ~ 45 years (percent)	46 ~ 55 years (percent)	56 ~ 65 years (percent)	66 ~ years (percent)	Total
Hourglass	239 (3.8)	206 (3.3)	154 (2.4)	103 (1.6)	36 (0.6)	7 (0.1)	745 (11.8)
Spoon	191 (3.0)	311 (4.9)	337 (5.3)	269 (4.3)	163 (2.6)	84 (1.3)	1,355 (21.5)
Bottom hourglass	237 (3.8)	160 (2.5)	105 (1.7)	61 (1.0)	21 (0.3)	5 (0.1)	589 (9.4)
Top hourglass	40 (0.6)	43 (0.7)	51 (0.8)	40 (0.6)	18 (0.3)	–	192 (3.0)
Inverted triangle	2 (0)	8 (0.1)	7 (0.1)	11 (0.2)	6 (0.1)	–	34 (0.5)
Triangle	79 (1.3)	64 (1.0)	55 (0.9)	53 (0.8)	34 (0.5)	16 (0.3)	301 (4.8)
Rectangle	749 (11.9)	656 (10.4)	631 (10.0)	602 (9.5)	327 (5.2)	124 (2.0)	3,089 (49.0)
Not classified			1 (0)	3 (0.1)	1 (0)		5 (0.1)
Total	1,537 (24.4)	1,448 (22.9)	1,341 (21.3)	1,142 (18.1)	606 (9.6)	236 (3.7)	6,310 (100)

Table I.
Distribution of body shape categories in the USA women

| | Korean women | | | | | | |
	18 ~ 25 years (percent)	26 ~ 35 years (percent)	36 ~ 45 years (percent)	46 ~ 55 years (percent)	56 ~ 65 years (percent)	66 ~ years (percent)	Total (percent)
Hourglass	7 (0.4)	2 (0.1)	–	–	–	–	9 (0.5)
Spoon	81 (4.5)	57 (3.2)	15 (0.8)	2 (0.1)	2 (0.1)	–	157 (8.7)
Bottom hourglass	57 (3.2)	20 (1.1)	2 (0.1)	–	–	–	79 (4.4)
Top hourglass	–	–	–	–	–	–	0 (0.0)
Inverted triangle	–	–	–	3 (0.2)	–	–	3 (0.2)
Triangle	101 (5.6)	104 (5.8)	49 (2.7)	17 (1.0)	4 (0.2)	6 (0.3)	281 (15.6)
Rectangle	186 (10.3)	295 (16.4)	261 (14.5)	225 (12.5)	171 (9.5)	132 (7.3)	1,270 (70.6)
Total	432 (24.0)	478 (26.6)	327 (18.2)	247 (13.7)	177 (9.8)	138 (7.7)	1,799 (100)

Table II.
Distribution of body shape categories in Korean women

Hourglass

Korea   USA

Figure 1.
The example of the
hourglass shape

being proportional in the bust and hips with a defined waistline. The ratios of her
bust-to-waist and hips-to-waist are about equal. She has a back line being proportional in
the lateral upper and lower body.

Bottom hourglass. The bottom hourglass shape was the fourth largest shape
category with 9.4 percent of the US subjects. It showed lower distribution as subjects
aged like the hourglass shape category (Table I). In Korean women, the bottom
hourglass shape distributed with 4.4 percent of subjects and was the fourth largest
shape category. The distribution of bottom hourglass appeared just under 45-years old
group (Table II). Figure 2 is an example of a true bottom hourglass shape. She has the
circumferential measurements that meet the bottom hourglass shape criteria. The
ratios of her bust-to-waist and hips-to-waist are significant with her hips
measurements being slightly larger than her bust. She also has a defined waistline.
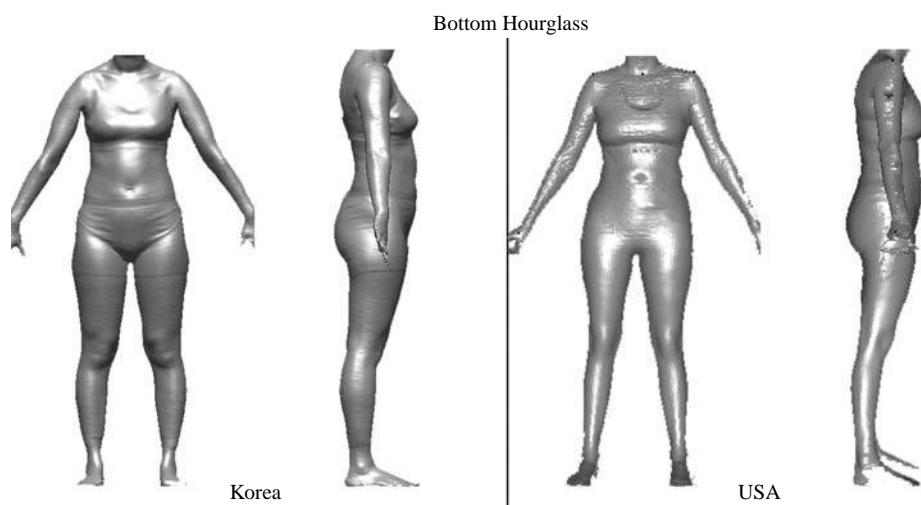

Bottom Hourglass

Korea   USA

Figure 2.
The example of the bottom
hourglass shape

Top hourglass. The top hourglass shape was the sixth largest shape category of the USA women. It did not appear in the over 66-years old group. It showed larger distribution under 55-years old group than over 56-years old group of the USA women (Table I). The top hourglass shape did not appear in Korean women (Table II). Figure 3 is an example of the top hourglass shape.

Spoon. The Spoon shape was the second largest shape category of the USA women and it showed the distribution with 21.5 percent of the subjects. The 14.5 of 21.5 percent Spoon subjects was in 26 ~ 55 years old group of the USA women (Table I). The Spoon was the third largest shape category of Korean women with 8.7 percent of the subjects. The distribution of Spoon shape was different according to age. The Spoon shape showed the larger distribution under 45-years old than over 45-years old group of Korean women (Table II). In Figure 4, the subject has the circumferential measurements that meet the Spoon shape criteria and is an example of a true Spoon shape. She has a definite waistline and there is a distinct shelf that protrudes from the hip area in the front view. She has the flatter curve in her lateral body or at least in her upper back. Her ratio of upper body-to-lower body in lateral shape is larger than that of the hourglass shape and usually the back waist point of the Spoon shape is lower than that of the hourglass shape.

Triangle. The triangle was the fifth largest shape category of the USA women with 4.8 percent of the subjects. It showed lower distribution when getting older like hourglass and bottom hourglass shape category (Table I). In Korean women, the triangle shape was the second largest shape category. The body shape of 15.6 percent subjects met the definition for triangle shape. The triangle shape category was seen over all age groups but frequently in younger age group than in older group of Korean women (Table II). In Figure 5, the subject has the circumferential measurements that meet the triangle shape criteria and is an example of a true triangle shape. She has the appearance of being larger in the hips than the bust without having a defined waistline.
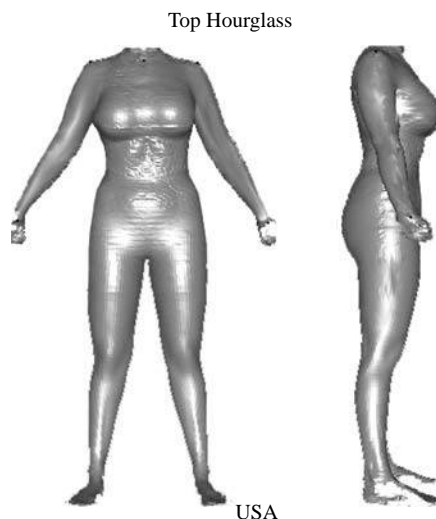

Top Hourglass

USA

Figure 3.
The example of the top hourglass shape
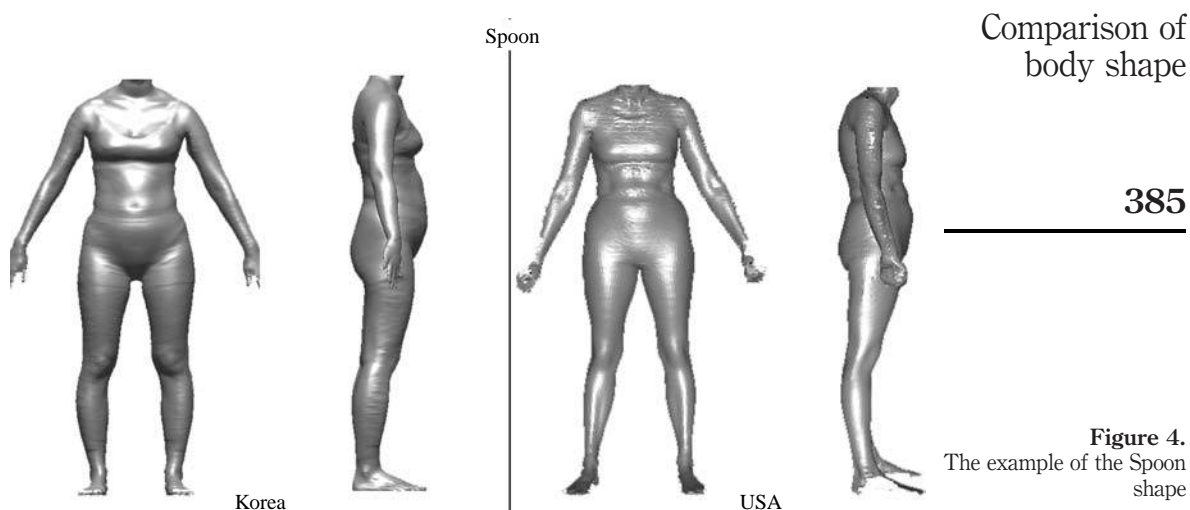
Spoon

Korea

USA

Figure 4.
The example of the Spoon shape
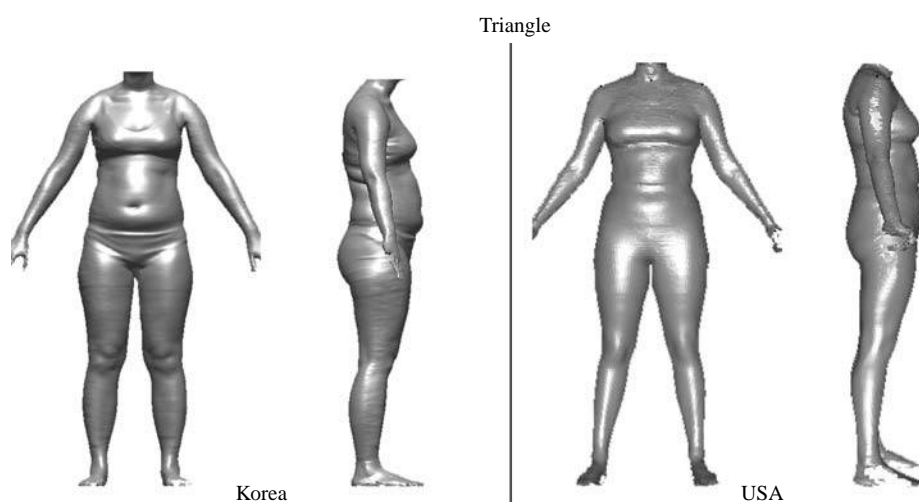
Triangle

Korea

USA

Figure 5.
The example of the triangle shape

Some of the triangle shape category have protruding abdomen and they also looked like the triangle in the lateral shape.

Inverted triangle. The inverted triangle shape category showed the least distribution with 0.5 percent of subjects of the USA women. The inverted triangle and top hourglass shape category did not appear over 66-years old group of the USA women (Table I). In Korean women, the distribution of the inverted triangle shape category was just 3 subjects (0.2 percent) and it was the sixth largest shape category. The inverted triangle shape appeared just in 46 ~ 55 years old group of Korean women (Table II). Figure 6 has the circumferential measurements that meet the inverted triangle shape criteria and is an example of a true inverted triangle shape. She has the
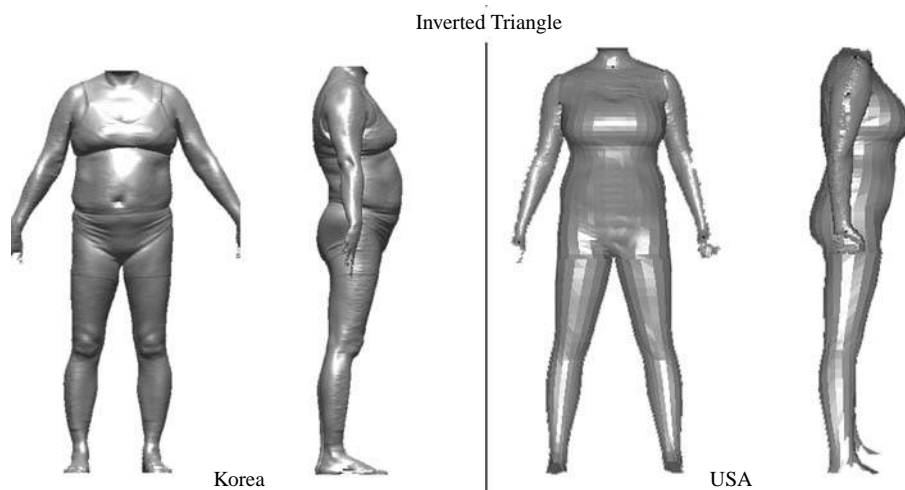
Inverted Triangle

Korea

USA

appearance of being heavy in the bust as compared to the hips but not having a defined waistline.

Rectangle. The rectangle shape was the largest shape category of the USA women. The 49.0 percent of subjects of the USA women met the definition for rectangle shape (Table I). In Korean women, the body shape of 70.6 percent subjects met the definition for rectangle shape previously defined. The rectangle shape distributed over all age groups and it was also the most frequent category in each age group of Korean women (Table II). The rectangle shape is the largest shape category in both countries, so it includes several sub-shapes. Some subjects of the rectangle shape category have the bust, waist, and hips that are relatively inline with each other in both front and lateral shape. Other subjects of the rectangle shape category have a discernible waistline in the front shape but the flatter backline in the lateral shape. But the common feature among them is that her bust and hips circumferences are fairly equal and bust-to-waist and hip-to-waist ratios are low. Figure 7 has the circumferential measurements that meet the rectangle shape criteria and is an example of a true rectangle shape.

Five subjects of the USA women were not classified into any group. They had over 50.2 in. of hips circumference, over 10 in. larger hips than bust circumference, and over 15.5 in. larger hips than waist circumference. It implicates the possibility that it is difficult to define the body shape of the women that have large hips, especially if her hips circumference is much bigger than her bust and waist circumference.

Comparison of body proportion between USA and Korean women
The body proportion for each shape category between USA women and Korean women was also compared. The ratios of bust height to cervical height, waist height to cervical height, high-hip height to cervical height, hips height to cervical height, bust circumference to cervical height, waist circumference to cervical height, high-hip circumference to cervical height, and hips circumference to cervical height were utilized for analyzing body proportion. Table III demonstrates the comparison of body proportion.
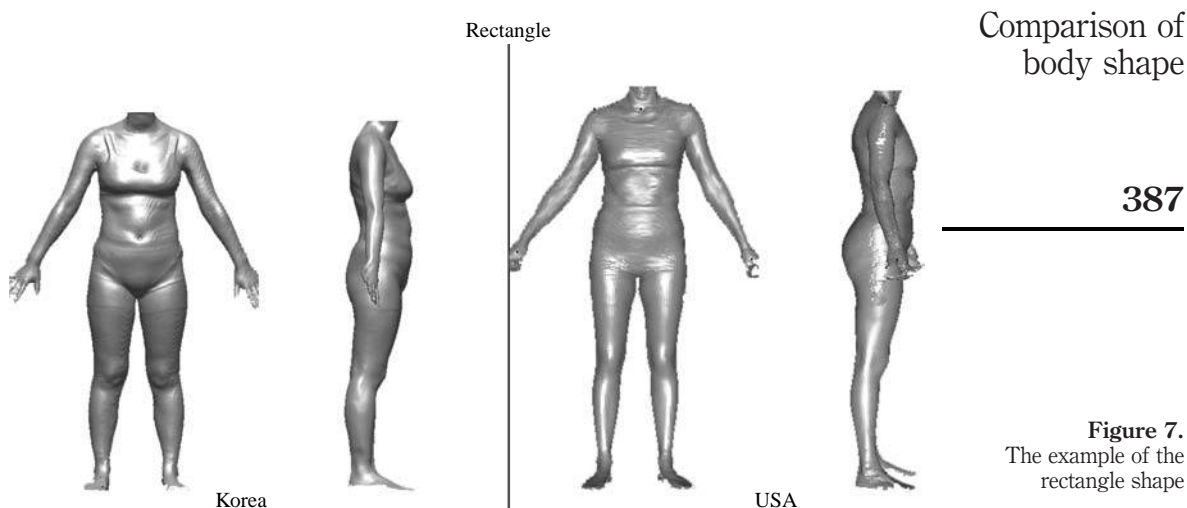
Rectangle

Korea

USA

Figure 7.
The example of the
rectangle shape

Hourglass. Korean women had the higher proportion of bust height to cervical height and the lower proportion of hips height to cervical height than the USA women. There were no significant differences in the proportion of waist height and high-hip height to cervical height between two countries. The bust, waist, high hip, and hips circumferences of the USA women were greater than that of Korean women.

Bottom hourglass, spoon, and triangle. The proportion of waist, high hip, and hips heights of the USA women were greater than those of Korean women. The proportion of the bust height of the USA women was less than that of Korean women. The bust, waist, high hip, and hips circumferences to cervical height of the USA women were greater than those of Korean women.

Inverted triangle. Korean women had less proportion of waist and high-hip height to cervical height than the USA women. There were no significant differences in the proportion of four circumferences to cervical height between USA and Korean women.

Rectangle. There was no significant difference in the bust height proportion to cervical height between two countries. The proportion of waist height, high-hip height, hips height, and four circumferences to cervical height were greater in the USA women than in Korean women.

Discussions and conclusion
The body shape was determined using the FFIT for Apparel© methodology and was visually verified that the shape designation given by FFIT© for Apparel was correct for both the USA women and Korean women. The mathematical description of this study was the proper criteria for sorting the body shape.

The largest shape category for Korean women was the rectangle shape and the next was the triangle shape, and then spoon, bottom hourglass, hourglass, and inverted triangle shape category were followed (Table I). The top hourglass shape did not appear in Korean women. The younger age groups like 18 ~ 25 years and 26 ~ 35 years old group included various body shapes more than other age groups, but getting older,

Hourglass	USA (n = 745)	Korea (n = 9)	t-value
Bust height	0.807	0.819	−2.389*
Waist height	0.698	0.704	−1.114
High-hip height	0.639	0.640	−0.169
Hips height	0.571	0.558	2.438*
Bust girth	0.690	0.611	3.612***
Waist girth	0.539	0.469	3.226**
High-hip girth	0.651	0.552	3.708***
Hip girth	0.709	0.659	2.196*

Bottom hourglass	USA (n = 589)	Korea (n = 79)	t-value
Bust height	0.801	0.813	−5.869***
Waist height	0.696	0.686	4.416***
High-hip height	0.638	0.623	6.361***
Hips height	0.570	0.553	8.004***
Bust girth	0.697	0.592	8.809***
Waist girth	0.602	0.508	7.567***
High-hip girth	0.701	0.591	7.610***
Hip girth	0.770	0.682	6.709***

Triangle	USA (n = 301)	Korea (n = 281)	t-value
Bust height	0.780	0.808	−3.094**
Waist height	0.679	0.665	5.189***
High-hip height	0.623	0.604	7.549***
Hips height	0.570	0.548	9.506***
Bust girth	0.700	0.607	13.787***
Waist girth	0.646	0.557	12.269***
High-hip girth	0.740	0.635	13.544***
Hip girth	0.769	0.689	11.128***

Spoon	Korea (n = 157)	USA (n = 1,355)	t-value
Bust height	0.814	0.800	−10.236***
Waist height	0.680	0.693	9.347***
High-hip height	0.616	0.632	11.052***
Hips height	0.555	0.568	9.884***
Bust girth	0.580	0.671	15.652***
Waist girth	0.489	0.565	12.963***
High-hip girth	0.594	0.696	14.735***
Hip girth	0.660	0.740	12.520***

Inverted triangle	Korea (n = 3)	USA (n = 34)	t-value
Bust height	0.810	0.805	−0.547
Waist height	0.632	0.672	2.808**
High-hip height	0.591	0.626	3.163**
Hips height	0.564	0.579	1.782
Bust girth	0.795	0.865	1.574
Waist girth	0.672	0.729	1.114
High-hip girth	0.712	0.779	1.463
Hip girth	0.713	0.772	1.318

Rectangle	Korea (n = 1,267)	USA (n = 3,089)	t-value
Bust height	0.801	0.802	1.089
Waist height	0.663	0.686	24.914***
High-hip height	0.604	0.631	32.437***
Hips height	0.554	0.572	23.781***
Bust girth	0.678	0.739	22.527***
Waist girth	0.607	0.629	7.428***
High-hip girth	0.673	0.720	16.301***
Hip girth	0.700	0.742	16.945***

Notes: Top hourglass shape was excluded because it did not appear in Korean women; the values of all measurements mean the proportions divided by cervical height; *$0.01 \leq p < 0.05$; **$0.001 \leq p < 0.01$; and ***$p < 0.001$

Table III.
Comparison of body proportion between USA and Korean women

the triangle and rectangle shape were the major shape categories in Korean women. In over 56-years old, most subjects belonged to the rectangle shape category.

The distribution of each shape category in the USA women was different from that of Korean women. The distribution of the rectangle shape, the most frequent shape category in both countries was 70.6 percent of subjects in Korean women and 49.0 percent of subjects in the USA women. The hourglass shape category was just 0.5 percent of subjects in Korean women, but 11.8 percent of subjects in the USA women. The Spoon shape category showed the greater distribution in the USA women (21.5 percent) than in Korean women (8.7 percent). The triangle shape appeared in 15.6 percent of Korean women, but in just 4.8 percent of the USA women. The top hourglass shape that did not appear in Korean women was shown in 3.0 percent of the USA women. More various body shape categories were found in the USA women than in Korean women.

Most of the body shapes had different body proportions between USA women and Korean women. The USA women had a higher proportion in waist, high hip, and hips heights except bust height and the greater proportion in bust, waist, high hip, and hips circumference.

Implications, limitations and recommendation
Implications
Research comparing the body shape between two countries which utilizes the data of national anthropometric surveys is extremely rare. The results of this research may be used as a guideline which might help improve the sizing system of each country, as well as ISO, and also help global brands produce apparel for various international consumers that have different sizes and shapes.

Limitations
It is very important to know the body shape category for producing more suitable clothing for each individual. However, it is not easy to define the shape of the human body because the human body has a very complex structure and each individual has unique body characteristics.

All of the Korean subjects were classified into one of the six body shape categories except the top hourglass. However, five USA women subjects were not classified into any of the seven body shape categories. Women in this group had over 50.2 in. of hip circumference, over 10 in. larger hips than bust circumference, and over 15.5 in. larger hips than waist circumference. Since, two of the shapes (Oval and Diamond) originally defined by the FFIT© for Apparel methodology were not included in this study (due to lack of essential measurement data), it may well be that these women would have been classified in one of the two other shapes. The further refinement of the mathematical definitions or second step criteria may be required for sorting the women that are very large. In addition, the variety of human body shapes includes the possibility that some of the females may have body shapes that fall right between the edge of two shapes and might not be classified properly.

Recommendations for future research
This study focused on the classification and comparison of body shapes between USA and Korean women. The results of this study supply the framework for the

development of new sizing systems. It is vital to analyze the size of each body shape category for the development of new sizing systems connected with body shapes.

The mass customization system needs a great deal of information between the body shape and garment patterns, in order to have the best success with the ultimate fit of customized garments. Further study needs to include the creation of slopers to better fit the shapes of women.

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