The Categorisation of Selected Women's Body Forms of Ghana: Implications for Product Development

Dr. Mercy Kuma-Kpobee (a) Dr. Afua Van-Dyke (b)

(A)College of Agriculture and Consumer Sciences
Department of Family and Consumer Sciences, University of Ghana, Legon. Ghana.
(B)College of Agriculture and Consumer Sciences, Department of Family and Consumer Sciences,
University of Ghana, Legon, Ghana.

ABSTRACT

Ergonomics is the application of set average sizes of humans to products to increase comfort, efficiency and productivity. This is necessary as size is related to the dimension of an individual's body, which is as a result of variation among people, involving generations, ethnic groups, sex and race among other factors. The study was undertaken to categorise the key dimensions of selected Ghanaian women between the ages of 20-54 years old. A sample of 600 women was selected from three metropolitan centres in Ghana for the anthropometric survey using traditional or manual measuring technique. The anthropometric survey confirmed that the average key dimensions (bust, waist and hip girths) of the sample are larger when compared with those of other studies conducted where the participants were of white ethnic origins. This has practical implications when producing garments for the Ghanaian consumer using other size charts from different target groups or surveys. Thus the need for products to be developed for target groups using specific anthropometric data has been confirmed. This study is important for the development of the Ghanaian manufacturing industry in the provision of ergonomic products as well as quality fitting garments to promote consumer comfort and safety.

Key words: anthropometry, garment sizing, body shape

1 INTRODUCTION

Anthropometry is the science of measurement of the human body and is derived from the Greek word "anthropos" which means human and 'metrikos' relating to measuring (Roebuck, 1995, p.1; Konz, 1995 p. 110). According to Roebuck (1995) anthropometry deals with the geometry, mass properties, and strength capabilities of the human body. Tsang et al, (2000) also described anthropometry as the study of human physical dimensions, such as size and the distance between anatomical points which are confined to width, length and girth measurements. Pheasant and Haslegrave (2006) concur with the view that anthropometry is a branch of human science which deals with the measurements of the human body in terms of size, shape, mobility, flexibility and working capacity. Cooklin (1990) however, suggests that anthropometry is the systematic collection of and correlation of

measurements of the human body for the supply of data for various reasons. Pheasant (1986) expanded this definition and called it 'applied anthropometrics' which involves 'numerical data in terms of size, shape, and other physical characteristics of the body and its application to the design context'. Anthropometry has also been referred to as human factors engineering and according to Croney (1980), it is the practice of measuring the human body which is used by designers and ergonomists for modelling environments, systems or garments for optimum use. In this regard, anthropometric data are important in ergonomics to ensure that physical mismatches between products and users are avoided (Bridger, 2003). In the current globalised world, it is important that the anthropometric data of target populations are used for product development due to the natural variation of human populations which has implications for the way products are designed. Vronti (2005) and Otieno (1999) suggest that styles may be globally desired but sizes must be local in order to cater for specific populations with distinct body characteristic as found in different geographical locations.

It has been observed that most individuals have different body proportions that require specific fit requirements. Miller (1993) and Kuma (1999) found that black women have distinct fit requirements and concluded that body proportions differ according to their racial origin. Similarly, Giddings and Boles (1990) also found in their study that black male subjects have specific fit problems around the thigh area due to differences in body proportions which underpins the development of size charts for specific populations.

There are several sizing systems in the world today that are mostly found in the developed world. The American sizing system has categorised the female figure types into four main groups namely Women, Misses, Half-sizes and Junior which describes the body characteristics (Bond, et al, 2000; Chun-Yoon and Jasper, 1993). Women sizes were made for more matured women, Misses' sizes were made for the youthful figure, Juniors were styled for young girls and Half-sizes were made for the shorter figure. Chun-Yoon and Jasper, (1993) further explained that, the sizing systems developed in UK (1957), Germany (1983), and Hungary (1986) on the other hand, classified figure types by height and the drop value. According to these authors, a sizing system was developed by the Joint Clothing Council in the UK for ready-to-wear clothes defined by three figure types by height. In this system, a woman's height below 155cm is classified as short height; a range between 155cm and 165cm is classified as average height and above 165cm is classified as tall height.

The German sizing system was developed by DOB-Verband in 1983 (DOB Verband, 1994) in which nine figure types were classified by height and hip types. The height was divided into three main groups' namely normal or average height, short and tall heights respectively which are further divided into three groups based on the hip size (Winks, 1997; Chun-Yoon and Jasper, 1993). The Hungarian sizing system (MSZ 6100/1-86) classifies women's figures by height and body build. The figure types are classified as normal figure with hip

4 cm larger than the bust measurement, and the full figure which has the hip 8 cm larger than the bust measurement (Winks, 1997).

In Ghana for instance a pilot study on university students was conducted to categorise females into body shapes and sizes through the measurement of the key dimensions (height, bust, waist and hip) (Fianu, Ayertey and Francois, 2004). However, there has never been a nation-wide anthropometric survey on the Ghanaian female population to categorise the body forms. According to Zwane and Magagula (2007) it appears that most developing countries in Africa adapt the British sizing system for their local use although there are differences in the figure types. A national anthropometric survey was initiated South Africa by African Body Dimensions (ADB) in 2004 to develop a comprehensive database required for clothing size and fit to cater for the diverse population of South Africa. This survey was conducted using the 3D body scanner housed in mobile unit for measurements to be taken all over the country (Yu, 2004b). Otieno (1999) conducted an anthropometric survey in Kenya however; the subjects were children between the ages of 3-6 years old and therefore did not include the adult population.

Many companies spend large amount of money on protective clothing for their employees and ensuring good fit is the basic requirement for the item to function correctly (Bridger, 2004). Fit and quality are important issues currently in garment production globally for manufacturers and consumers (LaBat and DeLong, 1990; Otieno, Harrow and Lea-Greenwood, 2005) as garment fit and poor interface design of household and industrial products are costly and frustrating for both consumers and manufacturers. Although there are several national anthropometric surveys conducted worldwide, it appears that this has had minimal impact in Africa regarding the collection of anthropometric data. The lack of anthropometric data in Ghana could hinder the ergonomic design of products especially for the workplace which can lead to accidents and injuries. The main objective of the study was to categorise the key dimensions and formulate a body measurement chart for Ghanaian women aged 20-54 years old.

2 MATERIAL AND METHODS

2.1 Subjects

The anthropometric survey was conducted in three metropolitan cities in Ghana namely Kumasi, Accra and Takoradi and consisted of Ghanaian women between the ages of 20 to 54 years old. A stratified sampling technique was employed in order to draw a representative sample of 600 women from the target population. According to Pheasant (1990) 500-1000 subjects are adequate representative sample size for an anthropometric survey. The 2002 population census (Ghana Statistical Service, 2002) already categorised the population into a number of age groups or strata and was therefore used as a sampling frame. A disproportionate sample was drawn based on the percentage distribution of women falling into each of the age groups. In most surveys one can use a sound methodological principle to select a random sample which is

representative of the total population but this is not the case for an anthropometric survey which is based on subjects' willingness to participate (Patterson and Warden, 1983-84).

2.2 Measurement Procedure and Equipment

A total of 21 body measurements were recorded for each subject which include 10 linear, 10 girth measurements as well as the weight. The body measurement procedure and landmarking followed the guidelines set for carrying out anthropometric survey by BS EN 13402-1:2001, ISO 8559 (1989) standards in using traditional methods and instruments. As a first step in the measurement procedure, landmarks were identified on the subject's body using the tape measure, elastic tape and coloured adhesive labels with the centres marked out. Landmarks placed on the body are important in ensuring accurate measurements (Croney, 1980; Ujevic et al., 2006; Strydom and de Klerk, 2006; Yu, 2004a), which denote the position, the beginning and the end of a measurement.

Due to the sensitivity of the measuring procedure, the purpose and benefits of the survey was explained to each subject before the commencement of the actual measurement. The subjects were measured over unpadded bra and short tights provided due to concerns of decency and cultural differences as explained by Cameron (1984). This was done in accordance with the guidelines set in the ISO 8559 (1987) and BS EN 13402 (2001) standards which suggests that subjects could be measured in other garments provided they are not too bulky or too tight to constrict the body with bare foot. All the measurements were taken in an erect standing posture, over the bra and short tights with most parts of the body exposed for landmarking which is a critical aspect of the measurement procedure. The Anthropometer was regularly calibrated and girth measurements were recorded using calibrated tape measures. The weight was recorded using a well calibrated bathroom scale. At each location the measurements were taken in an enclosure to address issues of decency and on a flat non carpeted floor for maximum accuracy.

2.3 Data analysis

The data from the survey were calculated using the SPSS program version 18 (Statistical Package for the Social Sciences). The anthropometric data sets generated have been analyzed and sizes were generated for garment categories.

3 RESULTS AND DISCUSSION

3.1 Selection of Key Dimensions

Control or key dimensions are body measurements on which a sizing system is built and are used to represent a garment size (Winks, 1997; Beazley, 1998). McConville et al. (1979) suggest that, the selected key dimensions must satisfy certain criteria as they must: be convenient to measure, be an integral part of a garment, have a high degree of correlation with other measurements and be highly correlated with each other. The correlation co-efficient of the selected key dimensions and their relationship with other dimensions are presented in Table 1. This study adopted the BS 7231 (BSI, 1990)

standard as a guideline for identifying strength of relationships between the body dimensions which was utilised in previous surveys (Beazley, 1998; Otieno, 1999; Otieno and Fairhurst, 2000; Gupta and Gangadhar, 2004) and defined as follows:

1. Below 0.5 indicates no relationship;
2. From 0.5 to 0.75 indicates a mild relationship;
3. Above 0.76 indicates a strong relationship.

Table 1: Correlation Co-efficient of key Dimensions and their relationships with other dimensions

Body Dimensions	Bust Girth	Waist Girth	Lower Hip Girth	Height
Bust girth	1	**.904**	**.824**	.151
Waist girth	**.904**	1	**.813**	.102
Lower Hip girth	**.824**	**.813**	1	.174
Height of subjects	.151	.102	.174	1
Neck girth	.706	.690	.644	.276
Shoulder width	.489	.467	.454	.268
Shoulder length	.252	.207	.240	.203
Across chest	.727	**.760**	.648	.193
Chest girth	**.931**	**.907**	**.829**	.169
Across back	.749	.736	.669	.215
Under bust	**.902**	**.915**	**.793**	.161
Upper hip girth	**.877**	**.881**	**.891**	.135
Thigh girth	.748	.722	**.855**	.152
Front waist length	.706	.655	.600	.302
7th cervical to waist	.386	.395	.371	.420
Upper arm girth	**.841**	**.860**	**.830**	.048
Wrist girth	.681	.686	.692	.222
Shoulder to wrist bone	.345	.346	.353	.605
Side waist to knee	.186	.158	.264	.468
Side waist to ankle	.132	.084	.171	**.758**
Weight	**.899**	**.897**	**.911**	.297

Correlation is significant at the 0.01 level (2-tailed). (Strong correlations are highlighted)

From the results in Table 1, the bust was selected as a key dimension as it showed strong correlation to seven other dimensions (McConville et al., 1979) and mild correlation to six body dimensions. The waist girth showed eight strong correlations to other dimensions and five mild correlations and lower hip showed eight strong correlation to other dimensions and five mild correlations. The height however showed mild correlation to the shoulder to the wrist bone (.605) and side waist to ankle (.758) but was selected as a key dimension as it is a main determinant for garment lengths; and has been selected in previous surveys (Gupta and Gangadhar, 2004, Beazley, 1998 and Kemsley, 1957). This falls in line with ISO 3637:1977

recommendations that, the bust girth, hip girth and height be used as key dimensions for whole body garments. Different key dimensions may however be used or selected for different garment types such as the bust girth for upper body garments, waist and hip girths for lower body garments and height, waist, bust and hip girths for whole body garments for example full length dresses. It was also observed that, there was poor or no correlation between the girth and length measurements, which supports similar findings (Gupta and Gangadhar, 2004; Beazley, 1998 and Kemsley, 1957). Gupta and Gangadhar (2004) observed that girth measurements tend to correlate well with each other and in the same way linear or vertical measurements tend to correlate well with each other. These authors further observed that, there is little or no correlation between the girth and vertical measurements.

3.2 Classification of population into age groups

The results from the anthropometric survey was classified into three different age groups namely 20-29 years, 30-39 years and 40-54 years in order to determine variability among the key dimensions of the mean values of the population. The results of the Univariate data of the key dimensions are presented in Table 2.

Table 2: Univariate data of key dimensions (cms) of 3 age groups

S. no	Dimensions	Mean	Min	Max	Range	SD
20-29 years						
1	Height	158	140	175	35	6.5
2	Bust Girth	88	72	113	41	8.6
3	Waist Girth	73	59	99	40	8.8
4	Hip Girth	97	76	126	50	9.4
5	Drop value	9				
30-39 years						
1	Height	159	146	177	31	5.7
2	Bust Girth	94	72	114	42	9.1
3	Waist Girth	82	61	103	42	10.5
4	Hip Girth	102	78	126	48	10.7
5	Drop value	8				
40-54 years						
1	Height	158	143	173	30	6.1
2	Bust Girth	97	73	114	41	9.1
3	Waist Girth	85	59	103	44	10.4
4	Hip Girth	104	78	126	48	10.9
5	Drop value	7				

It can be observed from the results that the girth measurements had a standard deviation (SD) ranging from 8.6 to 10.9 indicating the homogeneity of the population. It is interesting to note the height measurements on the other hand had lower SD values showing less variability among the different age groups. It can be seen from the results that the mean values of the girth measurements increased with age and indicates that the body becomes larger with increased age and also changes in proportion. The mean values are central in the development of sizing systems as this is normally used as the average size (12) from which other sizes are derived. The drop value is defined as the difference between the hip and bust girths

(Winks, 1997; Chun-Yoon and Jasper, 1993) for women, and this is important in determining the body shape of an individual. It is interesting to note that the drop value decreased with increased age and it is reasonable to conclude the waist girth of most women increase with age which may be attributed to reproduction. This is an important finding from the point of designing well-fitting garments for the various age groups taking into consideration changes in the body proportions of women.

3.3 Comparison of key dimensions

The mean key dimensions (bust, waist and hip) of the entire population are compared in Table 3 with those found in literature (Beazley, 1998; Gupta and Gangadhar, 2004: Aldrich, 2004; Vronti, 2005; Winks, 1997 and Zwane and Magagula, 2007). The findings indicated that the average measurements in this study are larger which implies that the average Ghanaian is larger. However, the measurements of the key dimensions in this study are similar to those found by Vronti (2005) in her study on Cyprus women. The size drop for average women varies from 2.5 to 8cm based on the size chart of different countries (Yu, 2004a). A comparison of the key dimensions and the drop value indicated that Beazley (1997) and Gupta and Gangadhar (2004) had the highest drop of 10cm and the lowest of 5cm was identified in Swaziland size 36 (Zwane and Magagula, 2007) and the average of size UK (Bougourd, 2004). The current study however has a drop value of 9cm and compares with Vronti (2005) study on Cyprus women. It is therefore reasonable to conclude that the key dimensions of the current study are similar to those found among Cyprus subjects by Vronti (2005). This supports the findings reported in SizeUSA that the girth measurements for black women were found to be larger than those of the whites and Hispanics (Bougourd, 2004). This may explain why plumpness and well curvy body shape is adored in the Ghanaian culture and perceived as the ideal figure type (Aghekyan et al., 2005).

Table 3: Comparison of Key Dimensions

Body Dimensions	Beazley (UK) Size 12	Gupta& Gangadhar Size 12 (India)	Swaziland Size 36	Vronti Size 12 (Cyprus)	UK Size 12	Aldrich (UK) Size 12	Current study 12 (Ghana)
Height	165	156	-	159	160	-	158
Bust Girth	88	86	88	91	88	88	92
Waist Girth	68	76	68	79	70	70	78
Lower Hip Girth	96	96	93	100	94	94	101
Drop	10	10	5	9	6	6	9

(Measurements in centimetres)

3.4 Classification of Population into Height Categories

The mean height for the entire population was 158cm and standard deviation of 6.1. The height of the population was classified into three different groups namely short, medium and tall following Gupta and Gangadhar's approach (2004) of classification given below.

1. Short = < Mean height – 1 SD; or <152 cm
2. Medium = Mean height ± 1 SD; or 152-164 cm
3. Tall was = > Mean height + 1 SD; or >164 cm

The results in Table 4 revealed that the majority of the subjects (69.9) percent in this study are in the average (medium) category with about (15) percent spread in the other categories respectively (refer to Table 2 for the mean and standard deviation). The mean height of short Ghanaian women is 148cm, average is 158cm and tall is 168cm.

Table 4: Height Classification of subjects

Height Category	Mean	Minimum	Maximum	SD	Frequency/Percentage
Short	149	140	151	2.54	87 (14.4)
Average (medium)	158	152	164	3.29	419 (69.9)
Tall	168	165	177	2.75	94 (15.7)

A comparative table of the mean height for women in the various countries is shown in Table 5. It can be observed that Ghanaian women are among the shortest in the world which has practical implications for the design of length of garments and the height of other household as well as industrial products.

Table 5: Mean height of women in various countries

Country	Height (cm)
Philippines	152
India	156
Brazil	158
Ghana	**158**
South Africa	159
Japan	159
USA	160
Korea	161
Canada	161
France	163
UK	163
Spain	164
Netherlands	169

3.5 Development of size chart

The process of developing any size chart is based on anthropometric data of the target population (BS EN 13402-3, 2004). Winks (1997) and Beazley (1998) suggest that, in developing a sizing system three main aspects should be considered, namely:

1. The relationship (correlation) between one dimension and another;
2. The size of intervals by which one garment is larger than the next smaller garment;
3. How to identify the size.

According to Winks (1997) the arithmetic mean of a given set of measurements are mostly used which gives an indication of the central tendency which has been utilised in previous studies (Vronti, 2005; Gupta and Gangadhar, 2004; Otieno and Fairhurst, 2000; Otieno, 1999; Beazley, 1998). Size steps were then developed by

adding and subtracting the standard deviations from the means of all dimensions. To determine a size step, the average mean was identified and then increased or decreased by the standard deviation. However, the mean -2 ½ SD and +2 ½ SD were identified in order to determine the upper and lower limits for the size range. This approach was utilised by Vronti (2005) and Otieno (2008) to develop size charts for their target populations.

However, approach of utilising the standard deviation as the size step resulted in wide inter-size intervals which was not practicable in terms of garment sizing and fit for this study which had high SD for the key dimensions of the girth measurements. The size step (standard deviations) for the bust girth was 10cm, the waist girth 11cm and the lower hip girth 11cm respectively. The intersize intervals of the key dimensions of other countries ranged from 4cm-6cm for countries such UK, France, Portugal, Hungary, Australia and Canada among others (Winks, 1997). Therefore, it can be concluded that the method of using the standard deviation in determining the size step is not appropriate for the current study in practical terms of informing garments that are intended to fit the human form.

The method used to develop the size chart was originally used by Beazley (1998). As a result of the unrealistic size steps obtained from the high standard deviations, the data were normalised by determining the range from the 5th to the 95th percentiles for all the body dimensions to remove extreme outliers which could distort the size range. The resulting data was divided into seven sizes and used as the size step which resulted in a reasonable size step of 5cm for all the key dimensions.

In developing size codes, the mean is used as the equivalent of size 12 as in the UK garment industry or the average size. The size codes GH 8, GH 10, GH 12, GH 14, GH 16 and GH 18 referring to Ghanaian sizes are thus discerned as size for this study. Previous researchers have utilised this process in determining size codes (Vronti, 2005).

3.6 Fit testing

Fitting trials are an important aspect of the development of size charts as this involves verifying that the garment designed for the specific size dimensions does indeed fit (Le Pechoux and Ghosh, 2002; Pheasant, 1986). There are different methods of establishing fit of prototypes such as the use of dress forms and live models (Le Pechoux and Ghosh, 2002; Bougourd, 2007; Pheasant, 1986) or the calculation of aggregate loss of fit based on a formula (Gupta and Gangadhar, 2004). Basic garments or prototypes were constructed in calico (non-stretch fabric) for all the sizes using the graded patterns developed in the study. It was confirmed from the fitting trials that no adjustments were necessary as most of the fit problems experienced were mainly due to figure problems or deviations from the average such as broad and square shoulders, low true bust points, protruding abdomen and large waist lines

4 CONCLUSION

The development of a sizing system requires the use of anthropometric data from the target population and requires the number and size ranges that are needed. The selection of key dimensions is critical in the manufacture of well-fitting garments and good interface design of many household and industrial products. A critical analysis revealed that the measurements of the key dimensions (bust, waist and hip) were larger compared to measurements from other surveys. This implies that the key dimensions (bust, waist and hip girths) of the average Ghanaian size 12 are larger than those found in other studies. This supports the views found literature that plumpness in certain developing countries is linked to high social status, health and wealth. However, the height of the sample was found to be shorter when compared to other surveys which indicate that the average Ghanaian woman is shorter than the white ethnic populations examined in other studies. Thus, the suggestion that size charts should be local to cater for differences supports the findings of the current survey which was necessary to address the unique proportion needs of the Ghanaian woman. Also girth measurements tend to increase with age which should be considered in the design of garments for the different age groups.

5 IMPLICATIONS

From a theoretical point of view, this study is important in addressing the issues of fit and provides an expanded knowledge in terms of the categorisation of the body forms of Ghanaian women. Benefits and contributions from this study are in three aspects which include those to the manufacturer, the consumer and for academic and research purposes. The utilisation of the key dimensions by the manufacturers are expected to facilitate the production of garments thereby provide better fit and quality as many companies spend large amount of money on protective clothing for their employees and ensuring good fit is the basic requirement for the item to function correctly.

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