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Corresponding Author	Family Name	**Capelassi**
	Particle	
	Given Name	**Carla**
	Prefix	
	Suffix	
	Division	Fashion Design Department
	Organization	Federal University of Technology – Parana (UTFPR)
	Address	Campus Apucarana, Apucarana, Brazil
	Division	Textile Engineering Department, School of Engineering
	Organization	University of Minho
	Address	Campus Azurem, Guimaraes, 4800-058, Portugal
	Email	carlacapelassi@hotmail.com
Author	Family Name	**Carvalho**
	Particle	
	Given Name	**Miguel**
	Prefix	
	Suffix	
	Division	Textile Engineering Department, School of Engineering
	Organization	University of Minho
	Address	Campus Azurem, Guimaraes, 4800-058, Portugal
	Email	migcar@det.uminho.pt
Author	Family Name	**Campos**
	Particle	
	Given Name	**Raquel**
	Prefix	
	Suffix	
	Division	Textile Engineering Department, School of Engineering
	Organization	University of Minho
	Address	Campus Azurem, Guimaraes, 4800-058, Portugal
	Email	raquel.campos@erechim.ifrs.edu.br
Author	Family Name	**Kattel**
	Particle	
	Given Name	**Cristina**
	Prefix	
	Suffix	

	Division	Department of Design and Fashion
	Organization	State University of Maringa
	Address	Campus Maringa, Maringa, Brazil
	Email	cristinaclucio@gmail.com
Author	Family Name	**Xu**
	Particle	
	Given Name	**Bugao**
	Prefix	
	Suffix	
	Division	
	Organization	University of North Texas
	Address	Denton, TX, USA
	Email	Bugao.Xu@unt.edu

Abstract	The researches concerning the measurements of the human body in Brazil are still very few and the anthropometric data related with the Brazilian women is widely diversified due to some aspects such as the vastness of the country and a huge miscegenation of races. The results obtained through the utilization of a 3D body scanner were segmented into four categories, namely: age, region of origin, race and shape. The aim of this study is to provide more accurate and reliable measurements and information concerning the different types of body shapes for the clothing sizing systems directed to the industry specialized in the mass production of clothing, and, therefore, allow clothing to fit appropriately on the wearer's body in such a way as to make her more confident and satisfied with the clothing available in the market but also access higher levels of comfort.

Keywords (separated by '-')	Anthropometry - Body measurement - Body shape - Clothing fit - 3D body scanning

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Segmentation of Anthropometric Data of the Brazilian' Female Population

Carla Capelassi[1,2(✉)], Miguel Carvalho[2], Raquel Campos[2], Cristina Kattel[3], and Bugao Xu[4]

[1] Fashion Design Department,
Federal University of Technology – Parana (UTFPR),
Campus Apucarana, Apucarana, Brazil
carlacapelassi@hotmail.com
[2] Textile Engineering Department, School of Engineering,
University of Minho, Campus Azurem, Guimaraes 4800-058, Portugal
migcar@det.uminho.pt,
raquel.campos@erechim.ifrs.edu.br
[3] Department of Design and Fashion, State University of Maringa,
Campus Maringa, Maringa, Brazil
cristinaclucio@gmail.com
[4] University of North Texas, Denton, TX, USA
Bugao.Xu@unt.edu

Abstract. The researches concerning the measurements of the human body in Brazil are still very few and the anthropometric data related with the Brazilian women is widely diversified due to some aspects such as the vastness of the country and a huge miscegenation of races. The results obtained through the utilization of a 3D body scanner were segmented into four categories, namely: age, region of origin, race and shape. The aim of this study is to provide more accurate and reliable measurements and information concerning the different types of body shapes for the clothing sizing systems directed to the industry specialized in the mass production of clothing, and, therefore, allow clothing to fit appropriately on the wearer's body in such a way as to make her more confident and satisfied with the clothing available in the market but also access higher levels of comfort.

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Keywords: Anthropometry · Body measurement · Body shape · Clothing fit · 3D body scanning

1 Introduction

Until the present time, it is not available in Brazil a database reflecting the different types of body shapes and measurements of the main types of Brazilian female bodies, to establish a correct sizing system for the clothing production industry. The data currently available to the Brazilian fashion design industry is not enough, presenting divergences between the sizes currently in use in the industrial production and the real measurements of the average female body.

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Some aspects make difficult the standardization of sizes in Brazil. One of them is the fact that Brazil has a vast territory, which is divided into five regions, each one composed of states. Those regions were already inhabited by local people, the indigenous, when the Europeans arrived and colonized it and, later, the diversity increased with the arrival of the Africans and Asians. That great diversity of people gave rise to the mestizos, people of mixed ancestry whose physical characteristics have received several influences.

Besides that, the clothing manufacturers have their own sizing systems based on their target markets [1]. Since they consider their sizing systems as an important commercial marketing tool, they are not willing to disclose them [2] and are reluctant to accept a standard sizing system, which could have the potential to provide consumers with a standard size on all brands. Therefore, as a consequence of the lack of that standard size, arises an insecurity in the consumer, which ends up in having doubts about their size, feeling insecurity when buying clothes online.

In opposition to the difficulties mentioned, technology is facilitating the anthropometric studies through the use of equipment for body scanning in three dimensions, through which it is possible to obtain instantaneously and very accurately the measurements of different parts of the body and, consequently, optimizing the research time with increased reliability.

2 Methodology

The body scanner used in this study was the *KBI - Kinect Body Imaging*, composed of hardware and software, capture a 3D image of the body and, automatically, generates the most important body measurements and volumes. The system was developed by the School of Human Ecology, University of Texas – Austin (USA).

In her study, Wenping [3], describes in the detail how the scanning process performed by the KBI works. When the 3D model of the body is captured by the system, the landmarks and the measurements of the body are extracted automatically. The method of extracting the landmarks and measurements of the body was the same used by Xu *et al.* [4], once the key landmarks were located, the body was segmented into the torso, head, arms, and legs. Then various measures such as circumferences and lengths were extracted.

The sample was composed of Brazilian women who study at University of Minho and live in Portugal. The data regarding these 101 women was collected between June and September of 2016 in the cities of Braga and Guimaraes.

The study involved, in a first moment, filling out a sociodemographic questionnaire and, afterwards, the collection of the body measurements. The body scanner collected instantaneously and accurately 105 body measurements, including girths, heights, widths and lengths of the main body parts, as well as the volumes of the main body segments. It was also recorded for each participant the body mass and height for later analyses.

The volunteers were instructed to stand in the proper position according to the standard [5], wearing only their own underwear during the procedure, thereby ensuring that the measurements were reliable and could be used in the study. The data collected by the KBI system was treated afterwards in a *Microsoft Excel* spreadsheet and in the *SPSS* software for statistical calculations.

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3 Results

The results collected from the sample composed of 101 women that participated in the study was segmented in four categories, consisting of homogenous groups with similar characteristics, taking in consideration aspects such as age group, region of origin in Brazil, race and body shape.

Five variables were selected for the segmentation, namely, body mass in kilograms, height in centimeters and the girths of bust, waist and hip in centimeters. It is important to emphasize that the five variables selected are important for the development of clothing products. The analyses of the results was performed using simple statistical techniques.

3.1 Segmentation by Age Group

Regarding the total sample of 101 women, the ages ranged from 19 to 62 years. Since there was a great variation of ages, it was necessary to group them in age groups within intervals of ten years on average, to better understand the results. Table 1 presents the average of the five variables selected.

Table 1. Average of the five variables regarding the segmentation by age group.

Age ranges (years)	% sample	Body mass (kg)	Height (cm)	Bust girth	Waist girth	Hip girth
19–29	34%	60.2	163	93.6	73.4	101.6
30–39	32%	64.0	165	98.1	77.5	103.5
40–49	24%	67.6	163	100.9	83.2	107.8
50–62	10%	62.3	162	98.4	81.5	102.1
Total sample	100%	63.5	163	97.7	78.9	103.7

Analyzing the results, it can be seen an expressive increase in the average of the body mass as well as in the averages of the girths of the bust, waist and hip in the group comprising ages between 40 and 49 years. In this group, the values of those variables are above the average of the total sample results. In the other age groups, the variations were not significant.

3.2 Segmentation by Region of Origin in Brazil

Due to the vastness of its territory, Brazil is divided in five regions, each one of them composed of states. In order to group states in a region, are used the criteria defined by the Brazilian Institute of Geography and Statistics (IBGE) [6], such as similarities in physical, human, cultural, social and economic aspects. In the total sample of the study participated woman born in all the regions, as shown in Table 2.

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Table 2. Average of the five variables regarding the segmentation by region of origin in Brazil.

Regions of Brazil	% sample	Body mass (kg)	Height (cm)	Bust girth	Waist girth	Hip girth
Northeast	34%	63.6	164	97.3	77.9	103.8
Southeast	27%	63.5	164	97.2	77.9	103.8
South	26%	63.9	164	97.9	78.3	104.0
North	7%	63.3	163	97.2	77.9	103.7
West Central	6%	59.7	163	94.4	74.7	101.3
Total sample	100%	62.8	163	96.8	77.3	103.3

The Northeast is the region with the largest number of representatives, being that 34% of the participants are from that region, whereas the West Central region has the lowest representation, with only 6%. Through the analysis of these results, it was concluded that the Northeastern, Southeastern, Southern and Northern regions present homogeneous averages concerning the variables studied. Only the West Central region has lower scores than the averages regarding the variables body mass and girths of bust, waist and hip.

3.3 Segmentation by Race

The distribution of the population in the Brazilian territory according to the race reflects the migratory processes of the country during the last 500 years. The migratory movement that had Brazil as destination was enormous [7], beginning, initially, with the arrival of the Europeans and, subsequently, the sub-Saharan Africans.

The Brazilian population is characterized as being largely composed of mestizos due to the combination of the three predominant races in the country, specifically, the white, black and indigenous races. The blending of these races gave origin to the term mixed race, which is the miscegenation of different races.

Since there is in Brazil the combination of European and Asian immigrants, people from Africa and indigenous people, the amount of anthropometric variations has increased as a consequence of so many different possibilities of miscegenation between different peoples with different body constitutions and different physical characteristics. The results are shown in Table 3.

Table 3. Average of the five variables regarding the segmentation by race.

Race	% sample	Body mass (kg)	Height (cm)	Bust girth	Waist girth	Hip girth
White	62%	63.4	163	97.3	77.9	103.7
Mixed race	28%	63.5	164	97.2	77.9	103.8
Black	9%	65.0	164	98.9	79.6	104.6
Indigenous	1%	72.0	162	101.3	82.7	113.4
Total sample	100%	66.0	163	98.7	79.5	106.4

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Regarding the analysis of the results segmented by race, it can be observed that the white and mixed races present similar results. Concerning the group of black people, the results are higher than the average, however, it is in the group of the indigenous that the results differ more from the others. Nevertheless, since this group represents only 1% of the total sample, it cannot be considered as being representative of that race.

3.4 Segmentation by Shape

The shapes of the female body are classified using some classifications related to figures that have similarities with them, such as geometric shapes (oval, triangle, inverted triangle, rectangle), types of fruits or vegetables (apple, pear), letters of the alphabet (H, O, A, X, R, I, S, V) and some other objects with well-defined shapes (hourglass, bean, heart, spoon and diamond) [8–10].

In the study of Karla Simmons [8], it was developed a software called *Female Figure Identification Technique* (FFIT) for apparel, based on the studies for the development of a methodology to characterize the diverse types of bodies of the American population. The research for the development of FFIT made use of mathematical criteria and the tacit knowledge of experts on product design, development and clothing adjustment.

In the methodology developed for the FFIT, the hourglass shape was the basis from which many of the other categories were created. The body measurements used to define the hourglass category were the bust, waist and hip. The person with an hourglass shape has the appearance of being proportional in the bust and hip and with a defined waist.

The measurements of bust, waist, high hip and hip girths are the main measurements defined for the evaluation parameters. The most common shapes found in this study, using the KBY system and following the same methodology used by Karla Simmons, are listed in Table 4.

Table 4. Most common shapes found in the research with Brazilian women living in Portugal.

Shape	Total
Rectangle	40.0%
Hourglass	28.0%
Bottom hourglass	18.0%
Spoon	11.0%
Top hourglass	3.0%
Triangle	0.0%
Inverted triangle	0.0%
Total	100.0%

The most common shapes found were the *Rectangle, Hourglass, Bottom hourglass, Spoon* and *Top hourglass*. The *Triangle* and *Inverted triangle* shapes had no representatives in the sample. Each shape presents specific body characteristics to determine in which classification each woman is represented.

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Although the *Rectangular* shape is characterized as being a straight body shape with little waist definition, is the one with the largest number of representatives, with 40% of the participants. The sum of the number of women who are included in the categories *Hourglass, Bottom hourglass* and *Top* hourglass got a total value of 49%. The shape *Hourglass* and its derivations characterize a body with a more defined waist.

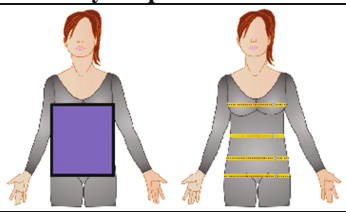
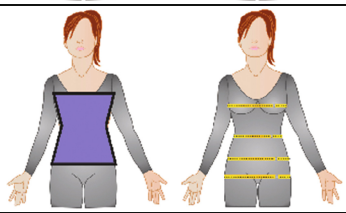
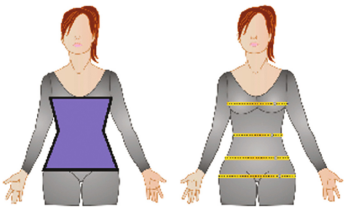
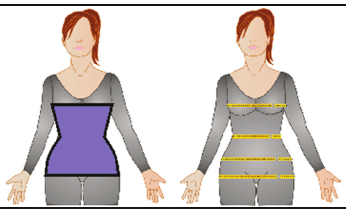
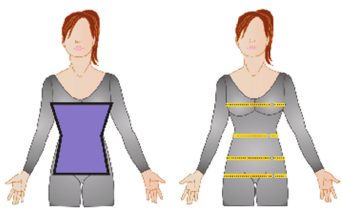
Body shape illustration	Description
	*Rectangle*: A rectangular subject would have the bust and hip measurement fairly equal and the bust-to-waist and hip-to-waist ratios low. The subject would not possess a clearly discernible waistline.
	*Hourglass*: A subject would fall into this shape category when there is a very small difference in the comparison of the circumferences of the bust and hips and if the ratios of the bust-to-waist and hips-to-waist are about equal and significant.
	*Bottom Hourglass*: A subject would fall into this shape category if has a larger hip 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.
	*Spoon*: This shape is based on the criteria that if a subject has a larger circumferential difference in the hips and bust and if the bust-to-waist ratio is lower than the *Hourglass* shape and the high hip-to-waist ratio is great, then the shape would be *Spoon*.
	*Top Hourglass*: When a subject has a larger bust circumference than hip circumference and if the ratios of the bust-to-waist and hips-to-waist measurements are significant enough to produce a definite waistline, then would be classified into the *Top hourglass* shape. This subject would appear to be heavy in the bust as compared to the hips but still would have a defined waistline.

Fig. 1. Description of the five most commonly found shapes and their illustrations based on the publications of Bastos *et al.* and Lee *et al.* [11, 12].

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Therefore, there is a part of the population with a straight body and, almost in the same proportion, women with more defined waist formats.

Figure 1 illustrates and describes the five most commonly found shapes based on the publications of Bastos *et al.* and e Lee *et al.* [11, 12].

4 Discussion

This anthropometric study was shown that the measured sample of Brazilian women living in Portugal was segmented into four main categories. Analyzing the obtained results, it is possible to visualize the difficulty of defining a unique standard sizing system directed to the manufacture of women's clothing in a country like Brazil, with such a large extent of territory and with an enormous variation of physical types as a result of the miscegenation of races.

Nevertheless, it is important that the Brazilian industry is aware of this reality and that can define the type of their target clients, in order to redefine their size tables according to accurate anthropometric studies. Only with the knowledge of the body of their users and use of the sizing system that represents the average body of their clients, they will be able to mass produce their collections. It is also important that they understand the standardization of sizes as a factor of competitiveness, as it already happens in other countries that benefit from this way of selling clothing online.

Each consumer wishes to have clothes that fit to their body type, which goes through changes over the years due to external influences, and this encourages a constant update of the anthropometric researches, with the help of technology, aiming to define a clothing sizing system for the current market. As a result of the knowledge of the woman's body in Brazil, greater satisfaction will be generated due to the possibility of having clothes with the appropriate adjustment to the different body shapes. Regardless of the age, race or region in which they live, all women want to have the product design appropriate for their body profile.

Although this study was limited by the size of its sample, it is a major contribution to the clothing industry in Brazil because the country has few researches using accurate measuring systems, like using 3D body scanner technology for body measurements, being also a source of research and comparison for future studies in the fields of anthropometry aiming the design and production of clothing.

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