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Anthropometric data collection of Portuguese children using 3D body scanning: considerations about the scanning booth

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Abstract. This paper presents some considerations regarding the scanning booth used in an anthropometric study done with a 3D body scanning technology. The data collected is part of a Ph.D. study conducted in Textile Engineering at University of Minho in Portugal, which aims to develop clothing for overweight and obese Portuguese children aged 2-11 years, of both genders. The challenges faced during data collection are described, and modifications of the scanning booth are proposed. It is possible to conclude that the importance of the scanning booth is key to an efficient anthropometric data collection, including the growth of this technology in the garment industry, Universities Research Institutes involved with anthropometric studies.

1. Introduction

In Portugal, as in many countries, children's clothing design does not consider the characteristics and needs of those who are overweight or obese. Individuals' specific restrictions are not accommodated, as standards used in garment production are based on the average population body measurements. In the case of overweight and obese children, the measurement tables are not appropriate to their needs, leading to a limited product offer in the market. This results in children wearing inappropriate clothing according to their age, which do not have an appropriate fit to their bodies, causing discomfort, exclusion and even limiting their movements and quality of life.

According to Heinrich, Carvalho, and Barroso [1] and Silveira [2], when clothing does not suit to user's body type and fit, it can cause discomfort and affect the user's physical and emotional well-being. From this perspective, users' comfort is related to the adequacy of the raw materials, the styling, and the technique of pattern design applied according to the ergonomic criteria and the anthropometric measurements [2]. In the studies of Iida [3], Heinrich, Carvalho, and Barroso [1], Silveira [2], and Dias [4], it is stated that the apparel industry success and the increase of ergonomic clothing rely on the development of appropriate anthropometric studies of the targeted users, and the development of specific measurement tables. This would result in a better product quality as functionality, comfort, and usability are improved.

Anthropometric studies aim to evaluate the body measurements of individuals [3] according to scientific standards and procedures [2]. In the garment sector, such studies are made through static or structural measurements, in the case of casual clothing; and dynamic and functional, in the case of sportswear [5], [2]. According to Nacif and Viebig, 2007, quoted by Capelassi [6], body measurements can be single evaluated or related with weight, height, skinfolds and different body circumferences. Also, studies can be performed in two ways: mechanically (manual), using anthropometers, scales, body calipers, measuring tapes, etc., or by computer systems, which provide three-dimensional measurements [2].

A manual anthropometric data collection, besides being time-consuming, does not guarantee a precise database for the standardization of industrial measurements [2]. However, the development of 3D body scanners has facilitated such studies, as they allow a quick data collection and a greater measurement precision [7], [2], [8]. Currently, there is a considerable selection of 3D body scanners in the market, presenting different characteristics and advantages. The optical devices vary from light projectors, CCDs, and halogen, infrared or laser light [9].

Among several anthropometric studies carried out using 3D body scanners for clothing, it is possible to highlight the CAESAR (*Civilian American and European Surface Anthropometry Resource*) study, conducted between 1998 and 2000, in a partnership with government, industry and the Air Force of the United States. Abreu, 2008 quoted by Braga [9] notes that in such study, body measurements of men and women of different ages and ethnicities were used for developing ergonomic military uniforms. Data were collected from three different body positions, using a 3D scanner, measuring tapes, and body calipers [1].

The German system *Human Solutions* was also a pioneer company in using 3D body scanners for anthropometric studies. The company is known for collecting anthropometric data from nine countries, aiming to validate the European standard for labeling clothes sizes (EN 13402:2006) [1]. Another company specialized in apparel studies is *Alvanon*, a mannequin manufacturer which has a database of more than 300,000 bodies scanned with *AlvaScan* laser technology. Also, Chun [7] describes other companies' initiatives in using body scanning technologies, like SizeUSA, SizeUK, French National Size Survey and Size Korea.

2. Data collection

Aiming to contribute to the development of clothing for overweight and obese children, a Ph.D. research is being conducted in Textile Engineering Department at University of Minho (Portugal). This undergoing study comprises Portuguese overweight and obese child population, ages 2-11 years, of both genders. Data collection was already concluded, and are currently being analyzed.

A total of eight hundred children from eleven elementary schools and summer camps located in three cities in Northern Portugal (Braga, Guimaraes, and Vila Nova de Famalicao) were measured. It is important to highlight that not all of the eight hundred children measured are in the study target population, i.e., not all are overweight and obese. When gaining access to a school or a summer camp, all children were invited to participate. This was done aiming to avoid embarrassment and abuse by peers. The data collection protocol used is better described in Campos et al. [10].

3. The Kinect Body Imaging System

The 3D body scanning technology used for the anthropometric data collection was *KBI-Kinect Body Imaging* system, developed by researchers from University of Texas, at Austin, and University of North Texas, in Danton, (USA), in order to respond to measurements needs of the apparel industry.

The KBI system is comprised of a hardware and a software for image capture and visualization. Its scanning system makes use of *Kinect* sensor technology, launched in 2010 by *Microsoft* for *Xbox 360* console games.

The KBI hardware is formed by four *Kinect* devices. Each device has an inbuilt infrared laser projector, an RGB camera, and an infrared video camera. The combination of the four devices allows an acquiring area of 4 m depth with an angular field of view of 30° to the right and to the left. The devices capture the image in three dimensions, identifying automatically body landmarks, providing the most important body measurements to the software for data analysis and body image visualization on a computer screen. The KBI system provides automatically 110 body measurements and body image is captured within a 1/4 seconds time frame.

3.1. The KBI system set-up

A proper assembly and calibration of the KBI system is required for accuracy in data collection. The four devices are divided into two groups and the devices of each group are positioned one over another. The groups must be fixed at a minimum distance of 250 cm from one another. The lower two devices should be at a distance of 50 cm from the floor and the upper two at 140 cm.

3.2. The scanning booth
As the hardware is not provided together with the KBI system, the user of the software must built the hardware, selecting the best designing of the scanning booth, yet respecting the distances mentioned before.
The scanning booth used in this study was designed at University of Minho. Its structure is formed by aluminium metal bars, fixed to each other using braces. As the brightness can interfere in measurements, a black textile curtain is fixed around the structure, providing also privacy for the participants in the study. The scanning booth is shown in Figure 1.

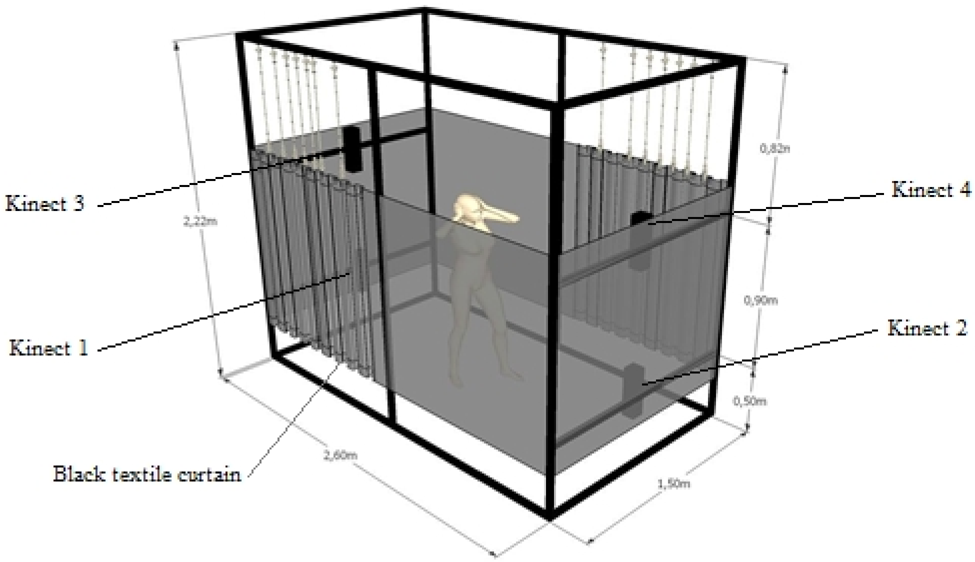

Figure 1. KBI devices' set-up and booth structure used.

4. Discussion
For the undergoing study with children, the KBI system was chosen due to its availability at University of Minho and its greater precision and speed in obtaining measurements. Among many advantages of the KBI system, Braganca et al. [8] affirm that it is relatively new, economical, and portable. Also, it does not require much space to be installed and eliminates the need of markers on the body of the participants, which greatly reduces the measurement time required [8].
However, some challenges were faced during the data collection performed.

Firstly, due to the metal structure size and weight, it was relatively difficult to transport between school locations. At each school, an appropriate room was requested for assembling the structure, being dedicated to it during the data collection period, which took in average two or three days at each school/summer camp. Also, due to its size and weight, the assembly process would be easier if two people were involved. Furthermore, it is important to note that the booth was over dimensioned (2.2 meters' height) for this study, as it was designed for adult body dimensions.

Secondly, each assembly and calibration required approximately 2,5 hours to be performed. The time spent in disassembling was approximately 1,5 hours. The structure is fixed by braces that must be screwed (Figure 2), requiring time and precision. The time required for assembling and calibration obstructed a fast data collection process that was also restricted due to regular school activities, e.g. exams, lunch break, etc.

Figure 2. Structure braces.

Furthermore, the structure has a metal bar, close to the floor, including the entrance, requiring the children to pass over it to be scanned. In many occasions, even though being warned, the children stepped on it, unbalancing the structure and requiring the devices' recalibration.

Another issue, relevant for children, was the use of black curtains. These were not attractive to the children, causing a feeling of fear, especially to the youngest. Some of the children, when brought to the room, refused to enter inside the scanning booth.

In many situations, the KBI system did not functioned properly when exposed to high temperatures. In cases where the room temperature reached 35ºC, the software crashed and cameras presented errors. Also, image was not obtained when the equipment was exposed to direct sunlight. The equipment must therefore be preferably installed under a controlled room temperature.

Based on the exposed faced difficulties, a lighter, smaller and portable scanning booth design is proposed to be used in children's studies. The aim of this proposal is to reduce the transportation, assembly/disassembly and calibration time required, and to be more attractive/acceptable by the children.

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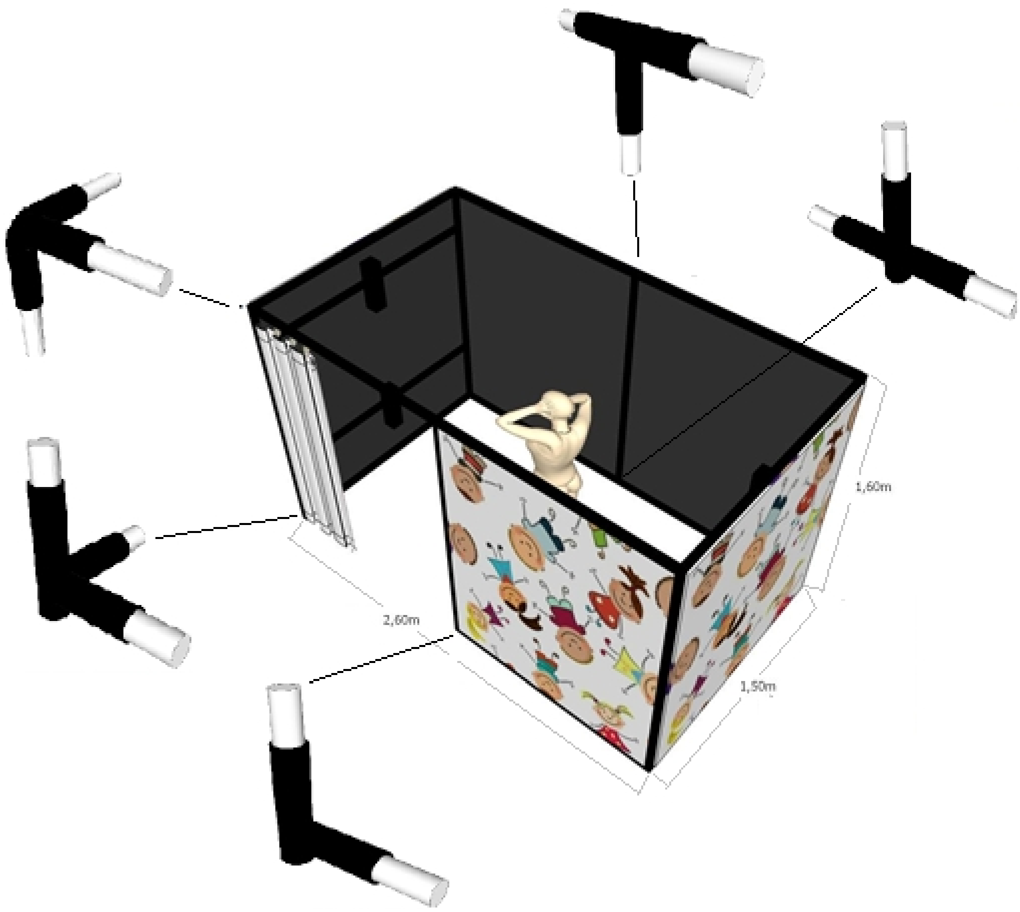

Figure 3. Scanning booth proposed.

The following amendments are proposed:

- decrease the height of the structure, or use a modular structure in order to meet other study specific needs;
- replace the structure profiles used by tubular structures, easier to assembly;
- remove the metal bar located at the entrance of the booth, reducing the risk of unbalancing;
- replace or cover the exterior part of the black fabric curtain with a more attractive fabric design for the children.

5. Conclusions

Anthropometric studies are not, *per se*, simplistic tasks. However, the 3D body scanning technologies have been assisting in overcoming many difficulties of such studies. In recent decades, 3D body scanning technologies are being applied worldwide for clothing design.

The undergoing study aims to contribute to the design of appropriate clothing for overweight and obese children. To achieve that, a sample of 800 individual children, sourced from the North of Portugal, was measured using the KBI body scanning system. Some limitations of the hardware were discussed and a new proposal for the design of the booth was proposed. The following phase of the study will be the data analyses, aiming to identify the percentage of overweight and obese children and to group them according to biotypes. Additionally, measurement tables and prototypes will be developed.

It is possible to emphasize many advantages of the KBI system. It is economical, portable, flexible, and images are sufficiently accurate for apparel studies. However, some challenges faced during the data collection evidence how the system could be optimized if some aspects of the scanning booth were taken into consideration. The proposed scanning booth aims to facilitate the transportation, assembly, calibration, and to be more attractive to the children, increasing the number of participants.

As a conclusion, recommendations regarding the scanning booth structure must be provided by the 3D body scanning systems developers, in order to make the systems more efficient and to facilitate their use. The scanning booth is of paramount importance for an efficient anthropometric data collection and for the growth of such technologies within the industry and the scientific community.

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