Anthropometric Data Collection of Portuguese Children with Overweight and Obesity

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Abstract. This paper presents an anthropometric data collection methodology to measure and identify the body measurements and shape of overweight and obese children, using 3D body scanning technology. The sample comprises of children residents in the North of Portugal between the ages of two and eleven, of both genders. The described procedure is part of an ongoing research linked to a project of the Doctoral Program in Textile Engineering at University of Minho, which aims to develop appropriate clothing, considering the anthropometrics and the ergonomics needs of the children from this specific population. The stages of data collection are presented. As a conclusion, considerations about the data collection points out some improvement opportunities and suggestions for similar studies.

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Keywords: Children's overweight · Children's obesity · 3D body scanning · Anthropometry

1 Introduction

Since the 1970 s, when the *World Health Organization* (*WHO*) defined obesity as a disease, the number of overweight children has increased. For Marchi-Alves et al. [1], the current moment is a period of epidemiological transition, from a scenario of malnutrition to one of obesity, which is becoming epidemic worldwide.

Childhood obesity is the result of several factors, from genetics to lifestyle, which includes a lack of physical activity and bad eating habits. Lima et al. and Gamba studies, cited by Faguntes [2], report that obesity is characterized by the accumulation of excess adipose tissue and overweight consists of a weight value above the growth patterns of the population as measured, according to gender, height, and age. In 2004, for the first time, the number of people with obesity surpassed the number of those suffering from malnutrition, reaching about one billion overweight and three hundred million clinically obese.

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Regarding childhood obesity, the *WHO* estimated that, in 1990, 18 million children under the age of five were classified as being overweight or obese worldwide [3]. Ribeiro [4], based on data from the *International Obesity Task Force* (*IOTF*), reports that about 150 million school-aged children are overweight and approximately 45 million are obese.

Taking into account the reality of childhood obesity in the *European Union* (*EU*), Sousa, Loureiro, and Carmo [5], estimate, also based on IOTF data, that one in five children is above the *Body Mass Index* (BMI), meaning that four million children are overweight, of which total three million are considered obese. In addition, Lobstein, as quoted by Venâncio, Aguilar, and Pinto [6], states that southern European countries have higher rates of overweight children than northern countries. As an example of a southern country, Portugal has more than 35% overweight children between 6 and 8 years, and another 14% are considered obese [7]. Nowadays, the steady increase in the number and the spread of overweight children in different age groups is an alert to the public health of Portugal [8].

According to Fisberg, cited by Soares and Petroski [9], being overweight cause non-acceptance and vulnerability feelings. For Solomon, cited by Winter and Moraes [10], overweight and obesity can lead to introspection, loneliness, difficulties of social interaction, anxiety, and depression. Abrantes, Lamounier, and Colosimo [11] mention that these problems interfere in their self-esteem and school performance. Regarding self-esteem, Assis and Avanci [12] affirm that it is not only a main indicator of mental health but also an important pointer to the sense of belonging to a certain social group. According to Dias [13], problems related to self-esteem raise other problems, such as anorexia and bulimia.

These problems that overweight children face affect other aspects, like purchasing and use of clothing. Currently, the children's clothing industry is not aware of such problems and not able to offer suitable products to this target market, as the standards of measurements used in clothing manufacturing are based on a normal *BMI*. In addition, from a market research, it is possible to note that available brands in Portugal do not respond to the needs of these children. The usability is poor: clothes are not adequate for corporal measurements of children, fabrics and styles cause discomfort, and have little aesthetic appeal for their ages. As a result, some children end up using clothing designed for adults.

To Heinrich, Carvalho, and Barroso [14] and Silveira [15], when clothing is not suitable for the user's body type and is not a good fit, can cause discomfort and affect the user's physical and emotional well-being. For Slater, cited by Broega [16] and Braga [17], comfort in clothing is associated with the harmony of ergonomic, psychological, sensorial, and thermos-physiological factors and includes the relationship with the environment. Clothing that offer comfort to the user take into account "the suitability of the raw material, the style of the model, the technique of pattern design applied in accordance to ergonomic criteria and anthropometric measurements" [15].

From this, it is possible to conclude that childhood overweight and obesity are worrisome and to note the key importance of studies that aim to minimize some of their consequences. Although there are some studies that investigate issues regarding overweight and childhood obesity, particularly in the area of health and nutrition, there is still a lack of research on anthropometry and ergonomics, especially in the development

of fashion products for these children. For this reason, the understanding of the needs of the overweight and obese Portuguese child population and the knowledge of their anthropometric characteristics are fundamental for the development of representative models of this age group.

The main outcome of this study is the development of garments that responds to these children's characteristics and needs, in particular its physical and psychological components. To achieve this, the development of the garments is going to be associated with the use of 3D body scanning technology, allowing accurate and representative models of this population, which is still in development phase. The results may also benefit the children's clothing industry, providing new parameters to an ergonomic pattern design methodology that fits the overweight and obese children. In this way, the comfort related to the clothing will increase and will contribute to the improvement of the children's self-esteem.

2 Methodology Stages

Sample Selection and Strategies for Gaining Access to Participants

Boueri [18] states that in order to obtain a reliable anthropometric database, the sample should have a variation of age and gender. According to Heinrich [19], the corporal difference between girls and boys will only happen near the age of twelve. Thus, the children target population was comprised of those between the ages of two and eleven years old, of both genders. The sample was also restricted to Portuguese children from the north of Portugal. To gain access to the children target population, groups working with child obesity, summer camps, and public and private elementary schools located in three cities in northern Portugal (Braga, Guimaraes, and Vila Nova de Famalicao) were contacted. Direct personal acquaintances helped in identifying the possible locations for data collection.

Subsequent to the initial contacts, meetings were held with each of the school's principals that accepted to host the study. These meetings aimed to demonstrate the importance of the research and of the support from the schools to its accomplishment. The meetings also clarified the study goal and data collection procedures, in order to make clear that the equipment would not affect the health and well-being of the children and to organize the data collection process.

Obtaining Parental Consent

It is important to emphasize that carrying out studies with this age group is not a simple task because parental consent is usually required. Letters were sent to parents and guardians, explaining the study and noting that the children would be asked to remains in underwear or bathing suits, and be barefoot.

In order to increase the number of participants, pictures of the equipment and of the resulting image were included in the letter, emphasizing that the image would not reveal children's identity. The number of parental consents in private schools was higher (95% to 100%) than in public schools (30% or less) (Fig. 1).

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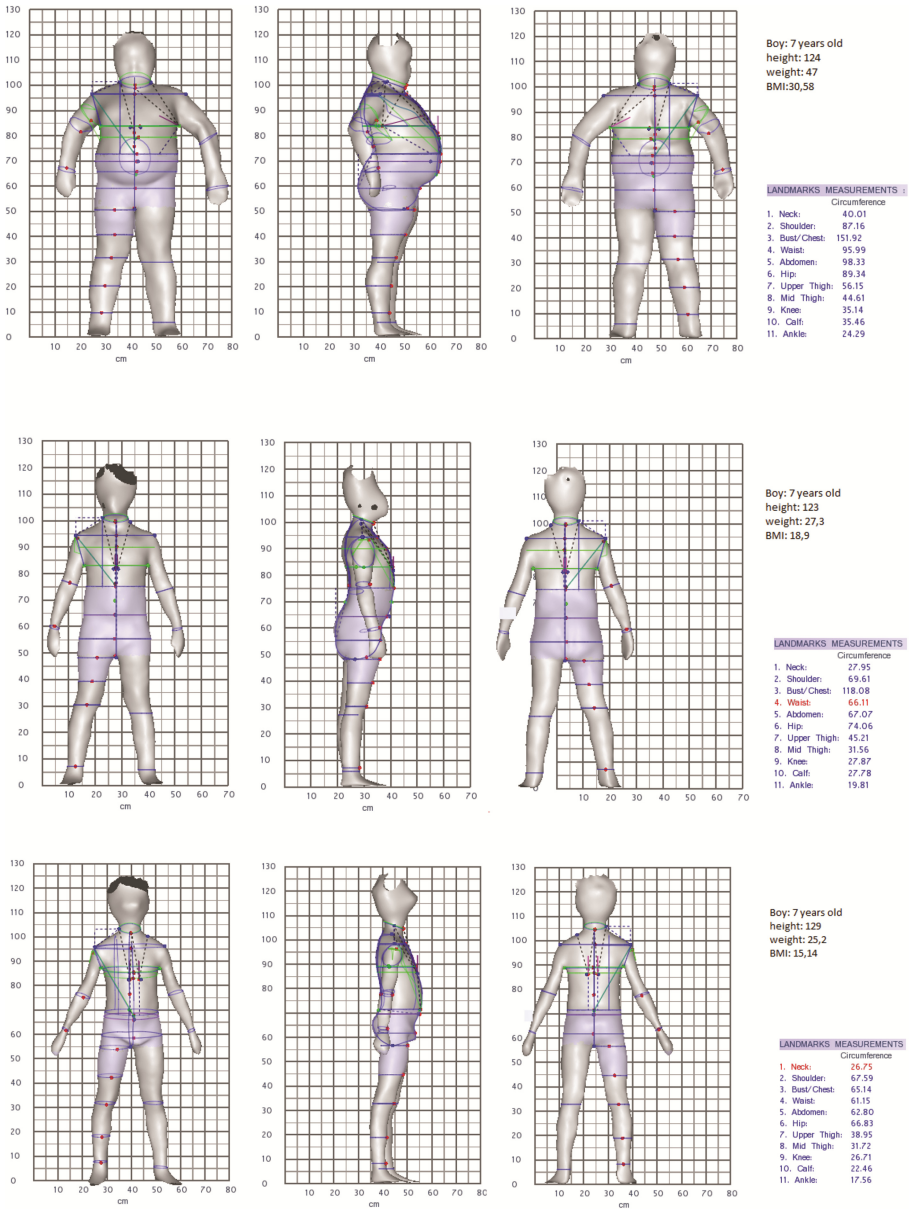

Fig. 1. Examples of 3D body scanner images.

The Body Scanning Equipment

The body scanning equipment used – Kinect Body Imaging (KBI, University of North Texas, USA), in order to respond to measurements needs of the garment industry. The equipment was chosen due to its availability at University of Minho and its greater precision and speed in obtaining measurements. Silveira [15] states that manual data

collection, "besides being delayed, is not structured as a precise database for the standardization of industrial measures".

The KBI equipment is comprised of a hardware and a software for image capture and visualization. Its scanning system is based on Kinect sensor. The KBI equipment is formed by four Kinect devices (Fig. 2). Each device has an infrared laser projector, an RGB camera and an infrared video camera that captures body movement within a 1/4 s time frame. The combination of the four devices allows a captured area of 4 m depth with an angular field of view of 30° to the right and to the left. Secondly, the pre-established measurements are transferred to the KBI software that is able to measure the anthropometric data in three dimensions (3D) and to displays the body image in a computer screen.

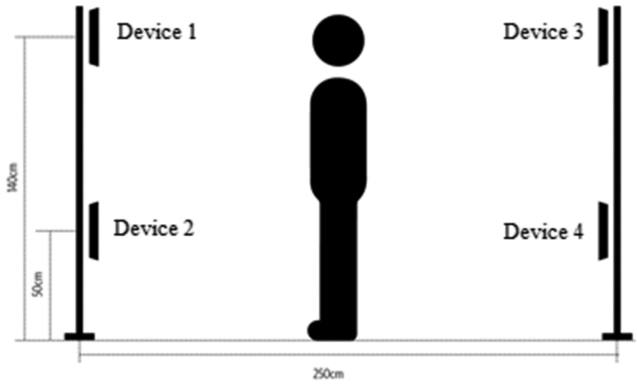

Fig. 2. KBI device set up scheme (adapted from Bragança et al. [20]).

Equipment Assembling and Calibration

The KBI equipment is considered relatively new, economical, portable, does not require much space to be installed, nor of markers in the body, which reduces the time of measurement [20]. However, due to the equipment structure and calibration need, and because children were asked to remain in underwear or bathing suits, a private room was requested to proceed with data collection.

A rigorous assembly and calibration of the equipment are required for accuracy in data collection. The four Kinect devices must be fixed on two metal structures, located at a 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 distance. In addition, it is important to note that the equipment must be set up in a suitable environment so that the anthropometric assessments are performed with privacy and comfort of the participants.

Due to the metal structures weight and assembling/disassembling needs, two persons are required to set up the equipment. The time spent for assembling was approximately 2:30 h while disassembly took approximately 1:30 h.

Calibration is essential for capturing images with proper quality.

It was noticed that the system did not work properly in contact with brightness and high temperatures. In cases where the room temperature reached around 35º C, the

software crashed and cameras presented errors. Additionally, imaging was not obtained when the equipment was exposed to sunlight.

Measuring Protocol and Children Anthropometric Data Collection

The measuring protocol was explained to children and examples of images generated were shown so that the information was the same as that given when parental consent for their participation was requested. The children participated in the collection of data only with this permission and their own willingness to participate. Aiming to avoid embarrassment and abuse by peers, the children were not informed about the study's focus on overweight and obesity. In this same sense, all individuals that had the parental consent were measured, regardless if they were in the target population or not.

Beyond the 3D image generated by the equipment, the following data were manually collected:

- height, measured with an inextensible tape measure, fixed on a smooth wall and without skirting. Children were asked to stand in an upright position with their arms stretched to their body side;
- body mass, measured with a digital scale (*Sanitas, model SBF 48*, a maximum capacity of 180 kg);
- head circumference, measured by an inextensible measuring tape.

Two researchers were involved in data collection. One was in charge of explaining the study to each child and the standing position required, to collect the measurements of body mass, height, and head circumference, and to help tying children's hair. The other researcher performed the imaging collection using the KBI. The presence of teachers or school staff was important to help keeping children quiet and reassured. Also, teachers were asked to help the children to undress and dress (specially the youngest ones).

The most appropriate way for performing data collection was having only two children in the room at a time. While one child was inside the structure where 3D images were collected, the other was being measured. Using this protocol, the order was kept and any kind of embarrassment by the other children was avoided.

According to Boueri [18] and Silveira [15], anthropometric measurements can be statically or dynamically collected. The first refers to the measurements of the motionless body, and the second with the body in various movement positions. For Silveira [15], the anatomical position of the body for an anthropometric study should be the orthostatic one, with the face forward – the Frankfurt plane [21] – looking at the horizon, arms extended and parallel to the trunk with palms facing forward and legs slightly apart, and with the feet forward [15]. To avoid scanning errors and facilitate the collection of the study's needed measurements, some adaptations were made in the orthostatic position: the hands were turned back and closed, with legs apart from one another, as shown in Fig. 3.

During scanning, children were asked to stand still, take a deep breath and remain in apnea for 2 s (to assure the reading would happen in that frame of time). In their study, Bragança et al. [20] repeated the scanning five times. However, in this study, the repetition varied from three to five times to capture a precise image, depending on the children's behavior. A total of 800 children from 11 elementary schools and summer camps were measured.

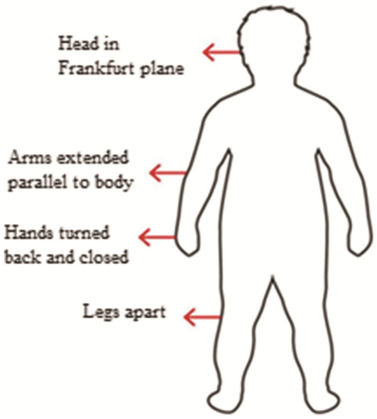

Fig. 3. Body position for 3D image capture (adapted from Norton and Olds [21]).

Relevant measurements

To proceed with the data analysis, only the significant measurements for children's clothing pattern design are going to be used. According to Bastos et al. [22], an anthropometric database is based on 115 measures. The KBI provides 110 measurements. Some authors have developed methodologies of industrial pattern design, and the methods and measurements needed for the clothing design vary according to authors. For example, Heinrich [19] uses 25 measurements for the pattern design process of clothing aimed to an adult audience, while using only 16 measurements for children: bust/chest girth, waist girth, neck girth, wrist girth, hip girth, hip length, pants length, back arc, front length, crotch depth, pleat, sleeve length, shoulder slope, across shoulders, and skirt length.

Among the 16 measurements used by Heinrich [19], 7 were not taken into account in this study. From the discarded measurements, 4 are related to the garment style and not to the body of the children (pants length, sleeve length, skirt length and pleat) and 3 were considered irrelevant: the neck circumference was replaced by head circumference, and back arc and shoulder slope do not need to be measured, as they are constant in children.

However, taking into account the need to prioritize anthropometric measurements in this study, 18 measurements (Fig. 4) were considered, 9 of which were used by Heinrich [19], except those already mentioned. To these, 9 more measurements were added:

- head circumference, because this part of the children's anatomy is usually proportionally larger in relation to the body, sometimes making it difficult to dress in the region of the collar;
- upper arm circumference, elbow circumference, thigh circumference, knee circumference, and ankle circumference, because these parts of the body have more adipose fat volume;
- arm length, knee height, and ankle height.

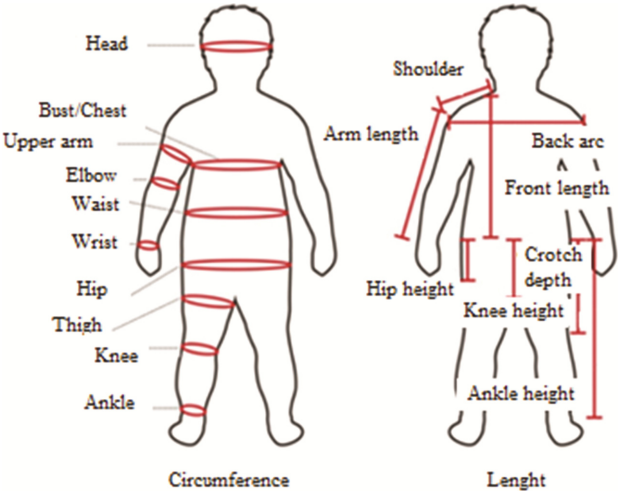

Fig. 4. Anthropometric measurements considered in the study.

Data Analysis Planning

As mentioned before, 800 children were measured. The next stage of this study is going to be the analysis of the collected data. Data analysis is going to start from the classification of overweight and obese children. The first step for data segregation will be the BMI calculation and classification of all children who participated in the study.

According to Soares and Petroski [9], there are indirect and precise methods for overweight and obesity classification as radiology, ultrasonography, magnetic resonance or computed tomography, laboratory methods such as hydrometry, bioelectric impedance (BIA), infrared (NIRI) and densitometry. However, all these methods require specialized equipment with high financial costs, so unviable for using in health centers, schools, and medical clinics. Such methods were also not viable for this study.

Marchi-Alves et al. [1] point out other methods for overweight and obesity classification, such as anthropometric indicators of "*body mass, height, skinfolds and circumferences*". One of these methods is the *BMI*, or *Body Mass Index*. *BMI* is calculated by dividing body mass by height squared [BMI = mass (kg)/height (m^2)]. The ranges are divided according to gender, age, and race.

According to Sotelo, Colugnati, and Taddei [23], the *BMI* is the anthropometric indicator most often used in public health to carry out an evaluation of adults and children. For Trichês and Costa [24], is the most recommended by *WHO* and *IOTF* as it is easy to apply and inexpensive. *BMI* has specific values for children population [5] and can be used in children from the age of two [6].

Also, in a subsequent step, the KBI images are going to be treated and data analyzed using the software *Statistical Package for the Social Sciences* (SPSS).

3 Conclusions

Anthropometric data collection performed in this study comprised 800 children from 11 elementary schools and summer camps located in Northern region of Portugal. The methodological steps followed evidence the need for a strategic plan to perform data collection.

The metal structure in which the Kinect devices are fixed can be improved in terms of size, weight and set up, aiming to minimize the time spent in assembling and disassembling, and to facilitate its transportation.

Regarding the participants, it is necessary to take into account the season and school calendar to carry out data collection. In winter period and during school evaluation period, children are usually more agitated and anxious, not willing to get undress in a cold environment and concerned about their studies.

In addition, it is important to mention that some obese and overweight children were reluctant to be weighted and/or to get undressed. It is possible to point out that they probably suffer social pressure from their peers and possibly their family. For reasons like this, data collection was performed with fewer participants each time. While in the beginning, a group from 5 to 7 children were measured in the same room, after this evidence only 2 children were allowed to be in the room at the same time.

Data collected is going to be used to build measurement tables for designing children's garment suitable for a high variation of biotypes, including overweight and obese children. Finally, from formulated tables, ergonomic pattern design bases are going to be developed, contributing to the improvement of the comfort and usability of clothing and children's self-esteem.

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References

1. Marchi-Alves, L.M., Yagui, C.M., Rodrigues, C.S., Mazzo, A., Rangel, E.M.L., Girão, F.B.: Obesidade infantil ontem e hoje: importância da avaliação antropométrica pelo enfermeiro. Escola Anna Nery **15**, 238–244 (2011)
2. Faguntes, A.L., Ribeiro, D.C., Naspitz, L., Garbelini, L.E.B., Vieira, J.K.P., Silva, A.P., Lima, V.O., Fagundes, D.J., Compri, P.M., Juliano, Y.: Prevalência de sobrepeso e obesidade em escolares da região de Parelheiros do município de São Paulo. Rev. Paul. de Pediatr. **26**, 212–217 (2008)
3. Fisberg, M.: Obesidade na Infância e Adolescência. Fundação BYK, São Paulo (1995)
4. Ribeiro, S.F.S.: Obesidade Infantil. Universidade da Beira Interior, Covilhã (2008)
5. Sousa, J., Loureiro, I., Carmo, I.: A obesidade infantil: um problema emergente. Saúde & Tecnologia. **2**, 5–15 (2008)
6. Venâncio, P., Aguilar, S., Pinto, G.: Obesidade infantil um problema cada vez mais actual. Rev. Port. Med. Geral Familiar **28**, 410–416 (2012)

7. Direção-Geral da Saúde (DGS): A Saúde dos Portugueses: Perspetiva 2015. Governo de Portugal, Lisboa (2015)
8. Ministério da Agricultura e do Mar, Ministério da Saúde, Ministério da Educação e Ciência: Regime de Frutas e Hortícolas nas Escolas. Governo de Portugal, Lisboa (2015)
9. Soares, L.D., Petroski, E.L: Prevalência, fatores etiológicos e tratamento da obesidade infantil. Rev. Bras. Cineantropometria Desempenho Humano 5, 63–74 (2003)
10. Winter, M.F.F., Moraes, S.G.: NEM 38, NEM 42: Vaidade, autoestima e autoconceito para a consumidora de moda plus size. In: Seminário de Iniciação da ESPM (2013)
11. Abrantes, M.M., Lamounier, J.A., Colosimo, E.A.: Prevalência de sobrepeso e obesidade nas regiões Nordeste e Sudeste do Brasil. Rev. Associação Médica Bras. **49**, 162–166 (2003)
12. Assis, S.G., Avanci, J.Q.: Labirinto de espelhos: formação da autoestima na infância e adolescência. Editora Fiocruz, Rio de Janeiro (2004)
13. Dias, A.J.S.: Vestuário inteligente e o interface no tratamento da obesidade infantil. Universidade da Beira Interior, Covilhã (2011)
14. Heinrich, D., Carvalho, M., Barroso, M.: Ergonomia e Antropometria aplicadas ao vestuário – discussão analítica acerca dos impactos sobre o conforto e a qualidade dos produtos. In: Diseño en Palermo. Universidad de Palermo, Buenos Aires (2008)
15. Silveira, I.: Usabilidade do vestuário: factores técnicos-funcionais. Modapalavra e-periódico **1**, 21–39 (2008)
16. Broega, A.C.L.: Contribuição para a Definição de Padrões de Conforto de Tecidos Finos de Lã. Universidade do Minho, Guimarães (2007)
17. Braga, I.M.S.: Optimização do design do vestuário cirúrgico através do estudo do conforto termofisiológico. Universidade do Minho, Guimarães (2008)
18. Boueri, J.J.: Sob Medida: antropometria, projeto e modelagem. In: Pires, D.B. (Org.). Design de Moda: olhares diversos, pp. 347–369. Estação das Letras e Cores, São Paulo (2008)
19. Heinrich, D.P.: Modelagem e técnica de interpretação para confecção industrial. Feevale, Novo Hamburgo (2005)
20. Bragança, S., Carvalho, M., Xu, B., Arezes, P., Ashdown, S.: A validation study of a kinect based body imaging (KBI) device system based on ISO 20685:2010. In: 5th International Conference on 3D Body Scanning Technologies, Lugano, pp. 372–377 (2014)
21. Norton, K., Olds, T.: Antropometria: um livro sobre medidas corporais para o esporte e cursos da área de saúde. Artmed, Porto Alegre (2005)
22. Bastos, S.F., Sabra, F., Rosa, R., Felipe, L.: SizeBR – The Brazilian study on anthropometric. In: 4th International Conference on 3D Body Scanning Technologies, Long Beach, pp. 243–257 (2013)
23. Sotelo, Y.O.M., Colugnatti, F.A.B., Taddei, J.A.A.C.: Prevalência de sobrepeso e obesidade entre escolares da rede pública segundo três critérios de diagnóstico antropométrico. Caderno de Saúde Pública. **20**, 233–240 (2004)
24. Trichês, P.B.M., Costa, R.F.: El índice de masa corporal como técnica de evaluación corporal y diagnóstico de la obesidad infantil. EFDeportes.com Revista Digital. 15/152 (2011)

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