Forensic Science International 252 (2015) 188.e1–188.e10

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Forensic Anthropology Population Data

Soft tissue thickness values for black and coloured South African children aged 6–13 years

N. Briers [a,*], T.M. Briers [b], P.J. Becker [c,d], M. Steyn [a]

[a] Forensic Anthropology Research Centre, Department Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria, South Africa
[b] Victim Identification Unit, Forensic Science Laboratory, South African Police Service, South Africa
[c] Biostatistics Unit, Medical Research Council, South Africa
[d] Research Office, Faculty of Health Sciences, University of Pretoria, South Africa

ARTICLE INFO

Article history:
Received 12 February 2015
Accepted 15 April 2015
Available online 21 April 2015

Keywords:
Craniofacial reconstruction
Craniofacial approximation
Tissue thickness
Children
South African population
Forensic anthropology population data

ABSTRACT

In children, craniofacial changes due to facial growth complicate facial approximations and require specific knowledge of soft tissue thicknesses (STT). The lack of South African juvenile STT standards of particular age groups, sex and ancestry is problematic. According to forensic artists in the South African Police Service the use of African–American values to reconstruct faces of Black South African children yields poor results. In order to perform a facial approximation that presents a true reflection of the child in question, information regarding differences in facial soft tissue at different ages, sexes and ancestry groups is needed. The aims of this study were to provide data on STT of South African Black and Coloured children and to assess differences in STT with respect to age, sex and ancestry. STT was measured using cephalograms of South African children ($n = 388$), aged 6–13 years. After digitizing the images, STT measurements were taken at ten mid-facial landmarks from each image using the iTEM measuring program. STT comparisons between groups per age, sex and ancestry were statistically analyzed. The results showed that STT differences at lower face landmarks are more pronounced in age groups per ancestry as opposed to differences per age and sex. Generally, an increase in STT was seen between 6–10 year old groups and 11–13 year old groups, regardless of ancestry and sex, at the midphiltrum, labiale inferius, pogonion, and beneath chin landmarks. This research created a reference dataset for STT of South African children of Black and Coloured ancestry per age and sex that will be useful for facial reconstruction/approximation of juvenile remains.

1. Introduction

Craniofacial identification, whether it is used in the context of adults or children, requires intimate knowledge of human craniofacial anatomy and soft tissue thickness (STT). The South African Police Services (SAPS) annual crime statistics of the last 5 years have shown that the greatest frequency of cases regarding neglect and ill treatment of children had occurred in Gauteng (26.7%) and the Western Cape provinces of South Africa (18.3%) [1,2]. The Medical Research Council of South Africa determined that fatal child abuse, abandonment of babies and violence among teenage boys were the main causes for murder among children between the ages of 0 and 17 years. In terms of age specific murders, it was found that in the category of 0–4 years, girls were more often murdered than boys. After age 4, the murder rate among boys increased [3]. Statistics obtained from the Forensic Anthropology Research Centre, situated in the Gauteng Province of South Africa, showed that 56 skeletons/decomposed bodies of sub-adults were analyzed in the past 10 years.

Facial approximation/reconstruction of South African children from European ancestry can be based on European STT standards as a study on White British children by Wilkinson [4] showed good correlation to results from Manhein et al. [5] on White North American children. The same may not be true for Black South African children. In a study by Cavanagh and Steyn [6], clear differences were found between STT's of South African and North American black females.

Coloured children also pose a problem as Philips and Smuts [7] found significant differences when they compared STT of adult Black South Africans to a Coloured adult sample. Coloured people in the Western Cape are descendants of the Khoesan, Malaysian slaves brought in by the Dutch, and local African and European

* Corresponding author at: Department Anatomy, School of Medicine, Faculty of Health Sciences, University of Pretoria, Private Bag x323, Arcadia, Pretoria 0007, South Africa. Tel.: +27 123192631; fax: +27 123192240.
E-mail address: nanette.briers@up.ac.za (N. Briers).

http://dx.doi.org/10.1016/j.forsciint.2015.04.015
0379-0738/

people, while the Black people in Gauteng are descendants of the people who migrated and dispersed from the northern parts of Africa [8–10].

Data on STT of children are on the increase in the literature, but it mainly involves American children of European [5,11,12] and African [5,13] descent. Three studies on children from countries other than the USA were found and included Hispanic [5], White British [4] and female Japanese children [14,15]. Data on STT for South African children are still absent in the scientific literature and adult data cannot be used as studies have shown that STT changes with age, especially between the ages of 6 and 13 [4,16].

A variety of methods have been used in order to obtain STT data, each with its own strengths and shortcomings. In terms of ultrasound, an experienced ultrasonographer or radiologist is required and children may not be as compliant as adults [17–19]. It is also time consuming, as it needs to be ascertained that there is no compression of the soft tissue overlying the bony landmark which can cause inaccurate measurements. CT/MRI scans are said to be more accurate for the measurement of STT when compared to needle puncture of cadaver material [6,7,20,21]. The advantages of the imaging methods include the ability to work on living individuals with minimal distortion of STT and high resolution of soft tissue with CT scanning [4]. The disadvantages include some exposure to radiation when using the radiographic method; inaccurate or improper positioning of the transducer due to inexperience when using ultrasound; and both high cost and radiation involved in CT and MR scanning [22]. During scanning patients are also usually in a supine position, whereas an upright position is preferable. In using images already available in a database at a radiology department or the local academic hospital, researchers can circumvent radiation and cost issues of cephalograms, CT scans and MR imaging.

According to Smith and Throckmorton [17], different methods can render different measurements. These authors used ultrasound and radiographs obtained at three locations to compare three sets of STT measurements. They found that the correlation between measurements from the radiographs and ultrasound ranged from poor to excellent and the difference between measured STT ranged from −5.0 mm to +3.0 mm, which they attributed to difficulty in location of specific landmarks and in position of the head [17]. A further analysis of different methods used to collect the STT data showed that data from cephalograms produced larger values for mid-facial landmarks. The second and third largest values were found in studies that used ultrasound on living individuals and needle puncture on cadaver material, respectively. Both the latter two methods produced comparable results, except at some bilateral landmarks which may be due to positioning of the individual (supine *vs* upright). CT and MRI values produced the lowest discrepancies [18]. Stephan and Simpson [18] have shown that even though differences in methodology render different values, these values often do not differ significantly in terms of statistical or practical application. In a review, they compared a pooled set of STT data from different authors and with different methods, such as needle puncture, ultrasound, cephalograms, CT and MRI, to ascertain practical differences. None of these methods, when used by different authors, were shown to produce a consistent result. They concluded that, regardless of the strengths and weaknesses of each method, one method was not superior to the other. They suggested that STT data be pooled without considering the different methodologies [18,23–25]. Recent studies favoured either ultrasound [16] or CT [20,21].

The aim of this study was to provide STT data for South African children aged 6–13 years as a means to improve the reliability and validity of craniofacial approximations/reconstruction for children. Specifically, differences in STT with respect to age, sex and population of origin were assessed. We also tried to determine if there was a way in which data for different age groups could be sensibly combined, as we may not know the exact age of a child skull which needs reconstruction.

2. Materials and methods

For this study, a cross-sectional, descriptive study design was used, in order to collect data from South African children of different ancestry (African/Black and Coloured). Although a variety of different techniques and methods are available for measurement of STT and facial dimensions as explained above, this study made use of cephalograms for measuring midline facial STT as not enough CT scans of children were available at the local academic hospital to meet the sample size criteria. A cephalogram is a specific type of lateral radiograph of the face that shows both the skeletal profile and soft tissue outline of dental patients. Cephalograms are routinely used to determine dental occlusion in order to plan orthodontic treatment. Therefore cephalograms are taken by an experienced radiographer with the head in a standardized position to avoid rotation. Unfortunately cephalograms only enables visualization of midline STT and as a result, only midline STTs were measured in cephalograms.

The communities where the children were sampled from were selected based on three criteria: Relethford's geographical cluster axiom [26] which was developed from work by Cavalli-Sforza [27] and Lieberman and Kirk [28]; communities most affected from crime that involved children; and compliance of oral and dental hospitals.

Relethford's [26] axiom dictates that geographical clusters express the correlation between genetics and geography and that the geographical distances between clusters should exceed the geographical distance within a cluster. In practical terms, schools within the Western Cape and Gauteng provinces were identified to participate in the project as the geographical distance between these two provinces is 1200 km. However, homogeneous groups, consisting only of one ancestral group, could not be guaranteed as the researchers had to rely on data from files. Therefore, some coloured children may inadvertently be contained within the black group and *vice versa*.

Ethical clearance was obtained from the Main Ethics and Research Committee, Faculty of Health Science, University of Pretoria (85/2007) prior to commencement of this study.

Only patient images and data already on file were reviewed and captured. The STT data were collected retrospectively from these files which did not contain information regarding the weight and height of the children. Therefore, the effect of BMI on STT could not be assessed. A total of 388 cephalograms from children aged 6–13 years of Black and Coloured ancestry were obtained from oral and dental hospitals in the Western Cape and Gauteng. STT measurements were taken at 10 mid-facial landmarks using the iTEM morphometry software (iTEM Analyses imaging program; Olympus Soft Imaging Solutions, 48149 Münster, Germany) (Fig. 1).

Landmarks on the skull were located and digitally marked. Table 1 shows a list of homologous landmarks. The method for measuring STT is similar to methods described by Aulsebrook et al. [29] and Cavanagh and Steyn [6]. First, a tangential line was placed on the curvature of the bony landmark's outer surface on the skull. Another line was then drawn perpendicularly to the tangential line. This line was extended to the point where the outline facial profile was visible. This distance was measured as the STT. The orientation of the line was standardized based on the descriptions provided in Table 1. The distance was automatically registered on a spreadsheet. As a means to calibrate the measuring programme, all cephalograms were first digitized with a scale. In order to test