TESTING STANDARD METHODS OF DENTAL AGE ESTIMATION BY MOORREES, FANNING AND HUNT AND DEMIRJIAN, GOLDSTEIN AND TANNER ON THREE SOUTH AFRICAN CHILDREN SAMPLES

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ABSTRACT

Dental age estimation of juvenile skeletal remains has utilized the methods of Moorrees, Fanning and Hunt (1963) [MFH] and Demirjian, Goldstein and Tanner (1973) [DGT] for many years with various results. The Demirjian *et al* method has been tested by several authors on their population groups with varying results. The use of these methods to age the skeletal remains of South African children by the author has not been successful. The aim of this study was to test the accuracy of the dental age estimation methods of MFH and DGT on samples of children of different ethnic groups. The study showed that the MFH method consistently under-estimates the age and the method of Demirjian *et al* over-estimates the ages.
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INTRODUCTION

Charts prepared from population surveys have been used to determine the age of individuals for orthodontic and forensic purposes for many years and have been regarded as sufficiently accurate to estimate chronological age of a juvenile. Standard charts show the bone age, dental age, height and weight, sexual development and secondary growth patterns of children and juveniles. These charts have become the standard references for age assessment used throughout the world.[1] Subsequent studies have used radiographs of the jaws to determine the state of development of the entire mandibular dentition; the maxillary teeth are not easily seen on pantomographic radiographs and little data is available for these teeth. These charts are based on dental surveys of cross sections of various populations and show the progressive states of dental development for each year of age.[2] Tanner (1962) suggested that the rate of skeletal growth had increased over the first half of the 20th century therefore creating the difference between the earlier age estimation charts and the recent ones.[5]

Moorrees, Fanning and Hunt (1963)[3] published charts based on a radiographic survey of the development of both the deciduous and permanent dentition. These charts indicate the average age and two standard deviations for the various developmental stages of the teeth. The range between ± two standard deviations represents an age range in which 95% of the population would be expected to reach the appropriate developmental landmark. These charts have proved useful for the assessment of a child's dental development with regard to the skeletal developmental stage and for planning orthodontic treatment. They have also been used for age estimation of skeletal remains.

A study of dental maturity by Demirjian, Goldstein and Tanner (1973)[4] using the pantomographic radiographs of 2928 boys and girls of French-Canadian ancestry between the ages of two and 20 was undertaken. The progressive developmental stages of the seven left mandibular teeth were allocated labels A to H. The various stages of dental development were recorded for each of the age groups. Maturity scores, based on

the work of Tanner, Whitehouse and Healy (1962)[5] were developed and allotted to each tooth during its developmental stages. The total of the maturity scores of the seven teeth was then converted to tables for both boys and girls to obtain an estimated chronological age. Several authors have tested the Demirjian *et al* method against their child population groups with varying success.[6-11]

The aim of this study was to test the accuracy of the dental age estimation methods of Moorrees, Fanning and Hunt [MFH] (1963) and Demirjian, Goldstein and Tanner [DGT] (1973) against population samples of children of known chronological age from the Western Cape (Tygerberg sample), Black (Zulu) and Indian from Kwa-Zulu Natal.

MATERIALS AND METHODS

The data used for this study consisted of 914 pantomographic radiographs of children between the ages of three years to 16 years that had routine dental treatment at the Dental Faculty at Tygerberg. These were recorded as the Tygerberg sample and consisted of 472 males and 442 females of White and Coloured* origin. The pantomographic radiographs of 91 Black (Zulu) children (44 females and 47 males) with an age range of between seven and 15 years were obtained from an orthodontic practice in Durban. A sample of 153 Indian children (82 females and 71 males) with an age range of six to 16 years was obtained from two orthodontic practices in Durban. Only radiographs showing normal development and no pathological lesions were used. Each radiograph was numbered for further reference together with the name, sex, date of birth and the date on which the radiograph was taken. The chronological age of each individual was calculated by subtracting the date of birth from the date when the radiograph was taken. Each radiograph was then examined and the stages of development of each of the permanent mandibular teeth in the left mandibular quadrant were recorded. The age of each child was estimated firstly using the method of MFH (1963) and then that of DGT (1973). The estimated ages of the Tygerberg sample were then compared to their chronological ages. The data from the Indian and Zulu samples were analyzed in a similar manner. The

data from each of the sample groups was used to analyze the error between the chronological age (real age) of each child with the age estimations of MFH and DGT methods respectively.

One examiner undertook all the observations.

RESULTS

The data from the Tygerberg sample was used to compare the real age (chronological age) to the estimated age by both MFH (1963) and DGT (1973) methods. Graph 1 shows a scatter diagram of the estimated ages using MFH method and compared to the real age; it was found that in the Tygerberg sample, this method under-estimated the ages in 89.2% of the sample on average by 0.91 years; the DGT method over-estimated the ages of these children on average by 0.89 years in 85.7% of the sample (Graph 2).

The data for each of the three sample groups i.e. Tygerberg, Indian and Zulu, were used to test the degree of error between the estimated age and the chronological age. The estimation error [EE] was represented graphically by comparing the real age [RA] to the difference between the estimated age [EA] minus the real age [RA] for both MFH and DGT methods (Graphs 3, 4, 6, 7, 8 & 9).

Graph 3 shows the estimation error compared to the chronological age of the Tygerberg sample of children by the MFH method. This graph shows that 96% of the sample lies below the chronological age. The error increases with age from 13 to 16 years. Graph 4 shows the estimation error compared to the chronological age of the Tygerberg sample by the DGT method. This graph shows that 86.3% of the sample lies above the chronological age. Graph 5 shows the degree of under-estimation of the ages of the Tygerberg

*Coloured people of South Africa.** The Coloured people were descended largely from Cape slaves, the indigenous Khoisan population, and other black people who had been assimilated to Cape colonial society by the late nineteenth century. Since they are also partly descended from European settlers, Coloureds are popularly regarded as being of "mixed race" although the amount of admixture from the parental populations is highly variable (Adhikari, 2006).[12]

sample by the MFH and DGT methods in age intervals. This graph indicates that the MFH method under-estimates 81% of

individuals who are under 5 years of age; 94% between 5 and 7 years; 93% between 7 and 9 years; 97% between 9 and 11 years and 100% between 11 and 15 years. The DGT method therefore over-estimates 62% of individuals under the age of 5 years; 83% between 5 and 7 years; 86% between 7 and 9 years; 81% between 9 and 11 years; 94% between 11 and 13 years and 91% between 13 and 15 years (Table 2).

Graph 6 shows the under-estimation of the ages of the Indian children by the MFH method; 93.7% of the sample lies below the chronological age.

Graph 7 shows the over-estimation of the ages of 79.2% of the Indian children by the DGT method. Graph 8 shows the under-estimation of the ages of 96.7% of the Zulu children by the MFH method. Graph 9 shows the over-estimation of the ages of 90% of the Zulu children by the DGT method.

Table 1 shows that the average age under-estimation of the Tygerberg sample by the MFH method was 0.91 years in 89.2% of the sample; the average age over-estimation by the DGT method of this sample was 0.89 years in 85.7% of the sample.

Table 2 shows the percentage of the Tygerberg sample in which the ages have been under-estimated by the Moorrees *et al* method and the percentage that have been over-estimated by the Demirjian *et al* method in age intervals.

Table 3 shows the percentage of the 3 samples in which there was under-estimation and over-estimation of the chronological ages by the methods of MFH and DGT respectively. The method of MFH under-estimated the ages of 96% of the Tygerberg sample, 93.7% of the Indian sample and 96.7% of the Zulu sample. The DGT method over-estimated the ages of 86.3% of the Tygerberg sample, 79.2% of the Indian sample and 90% of the Zulu sample.

Table 1: Average age estimation of the Tygerberg sample in years

Moorrees *et al*	Demirjian *et al*
-0.91 (in 89.2%)	0.89 (in 85.7%)

Table 1 shows that in the Tygerberg sample the Moorrees *et al* method under-estimated the chronological age of 89.2% of the sample by 0.91 years. The Demirjian *et al* method over-estimated the chronological age of 85.7% of the sample by 0.89 years.

Table 2: The percentage under-estimation of the ages of the Tygerberg sample in age intervals by Moorrees et al and over-estimation by Demirjian et al methods

Demirjian						
Age Interval	<5	5-7	7-9	9-11	11-13	13-15
% Over Est.	62%	83%	86%	81%	94%	91%
Moorrees						
Age Interval	<5	5-7	7-9	9-11	11-13	13-15
% Under Est.	81%	94%	93%	97%	100%	100%

Table 2 shows the percentage of the Tygerberg sample in which the ages have been under-estimated by the Moorrees *et al* method and the percentage that have been over-estimated by the Demirjian *et al* method in age intervals.

Table 3: *The percentage of samples where age is over-estimated and under-estimated*

	Under-estimation by Moorrees *et al*	Over-estimation by Demirjian *et al*
Tygerberg (n = 914)	96%	86.3%
Indian (n = 153)	93.7%	79.2%
Zulu (n = 91)	96.7%	90.0%

Table 3 shows the percentage under-estimation of the chronological ages of all 3 sample groups by Moorrees *et al* and the percentage over-estimation by Demirjian *et al* for the Tygerberg, Indian and Zulu children.

DISCUSSION

The method of Moorrees, Fanning and Hunt (1963) was used extensively for dental age estimation until Demirjian, Goldstein and Tanner (1973) published their new dental age estimation method. The MFH method was used to predict the stage of development of the teeth at a certain age whereas the DGT method was originally regarded as a better method of dental age estimation. Several authors have however shown that the use of DGT method was not accurate when applied to their population sample.[6-9] This study limited the age range of the samples to individuals between the ages of six and 16 years. The study showed that the method of MFH under-estimated the ages of the three South African sample groups and the method of DGT over-estimated the ages of these groups. The under-estimation of the ages of all three samples by MFH was over 90% in each sample group. The over-estimation of the ages of the samples varied from 79.2% for Indians, 86.3% for the Tygerberg children and 90% for the Black children.

The isolated individuals in the graphs where the age estimation by MFH (Graph 3) and that of DGT (Graph 4) are severely under-estimated or over-estimated respectively are either due to incorrect documentation of the date of birth on the radiograph or individuals that are genetically very advanced or retarded in their growth patterns. An increase in error with age was also noted especially with the DGT method. This could be due to the construction of the weighted tables in which a small change in weighted value is applied to the ages between 13 and 16 years.

CONCLUSION

The Moorrees *et al* method consistently under-estimated the ages of the three samples of South African children. The Demirjian *et al* method over-estimated the ages of these samples. These methods are not applicable to accurately estimate the ages of South African juveniles. It therefore follows that dental age related tables for the different ethnic groups in South Africa are necessary for age estimation of these children.

Graph 1: *Comparison between chronological age and the average estimated age of the Tygerberg sample by Moorrees, Fanning and Hunt (1963)*
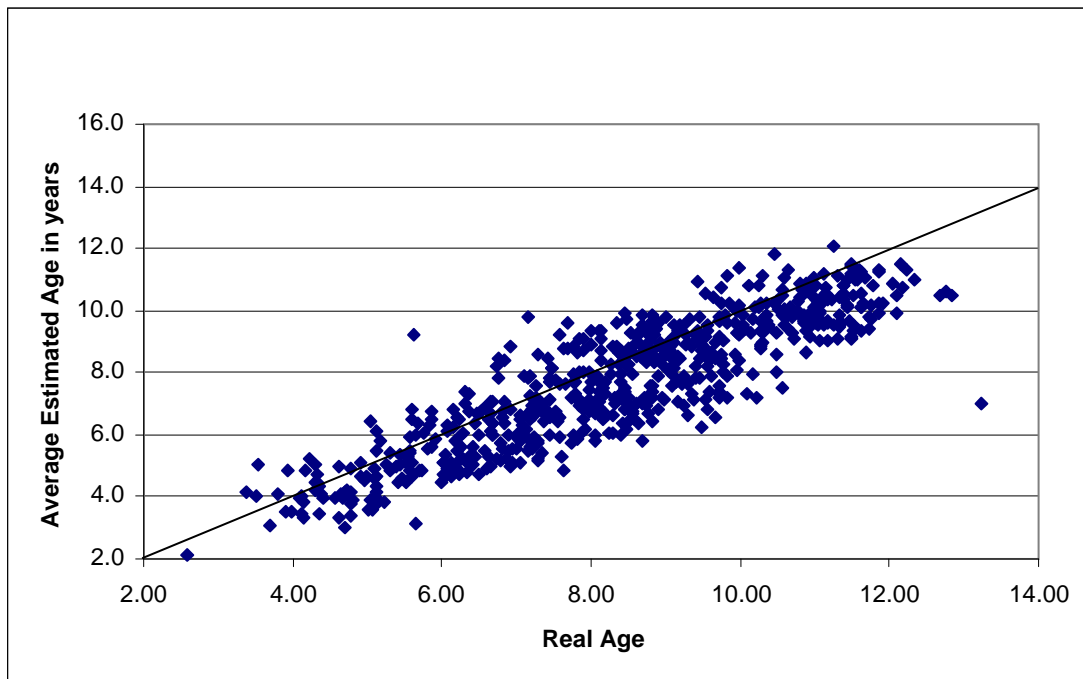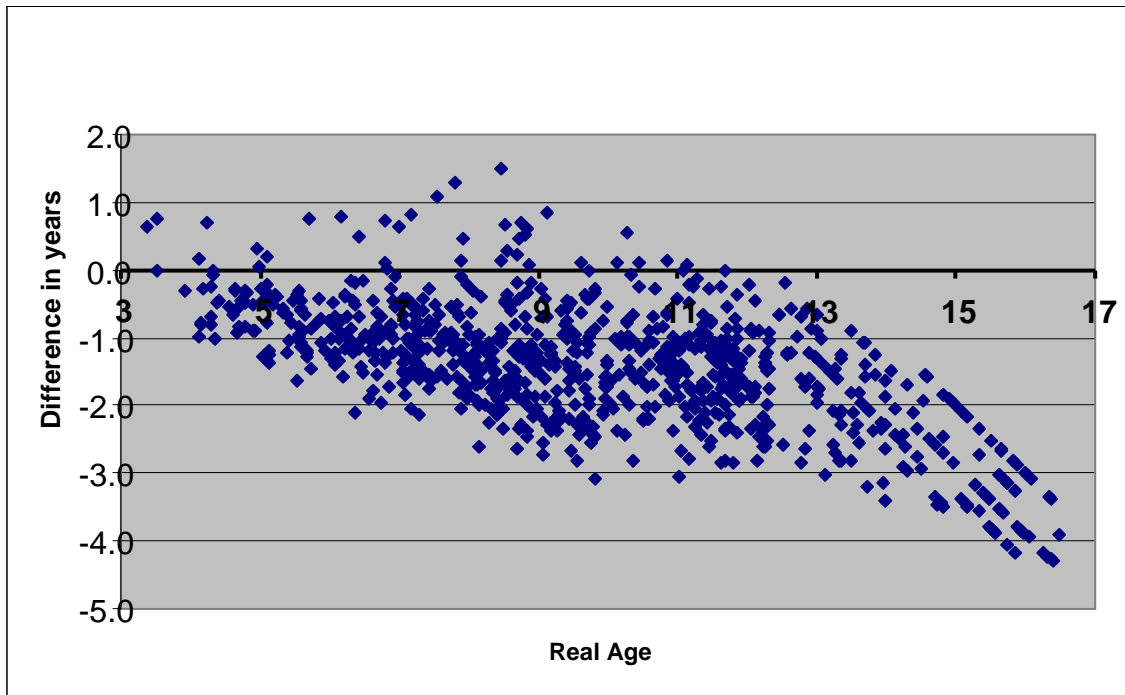

This graph shows the estimated ages using MFH method and compared to the real age; in the Tygerberg children this method under-estimated the ages in 89.2% of the sample on average by 0.91 years. The ages are in years

Graph 2: *Comparison between the chronological age and the average estimated   age of the Tygerberg sample by Demirjian, Goldstein and Tanner (1973)*
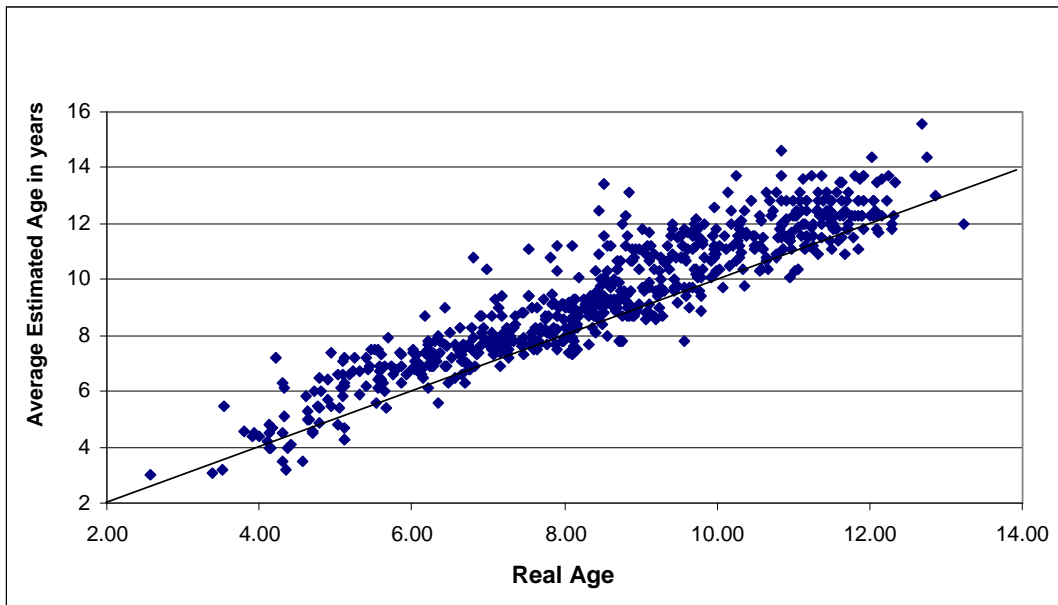
This graph shows the DGT method over-estimated the ages of the Tygerberg children on average by 0.89 years in 85.7% of the sample. The ages are in years.

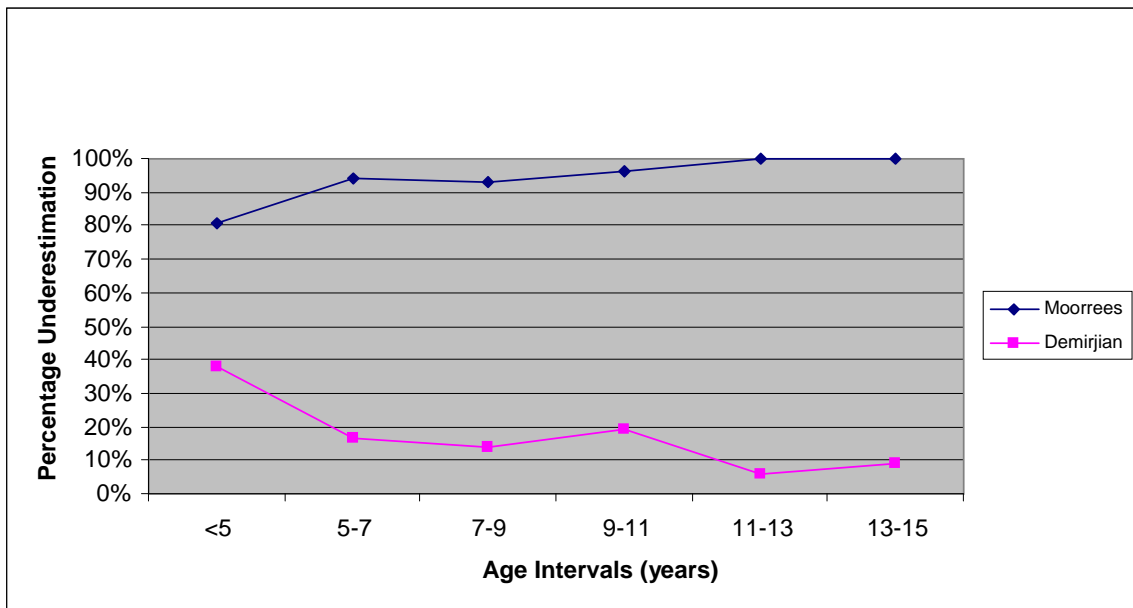*Graph 3: Tygerberg children. Age estimation error using the MFH method*

This graph shows the estimation error compared to the chronological age of the Tygerberg sample of children by the MFH method. It shows that 96% of the sample lies below the chronological age. The error increases from 13 to 16 years.

Graph 4: Tygerberg children. Age estimation error using the DGT method
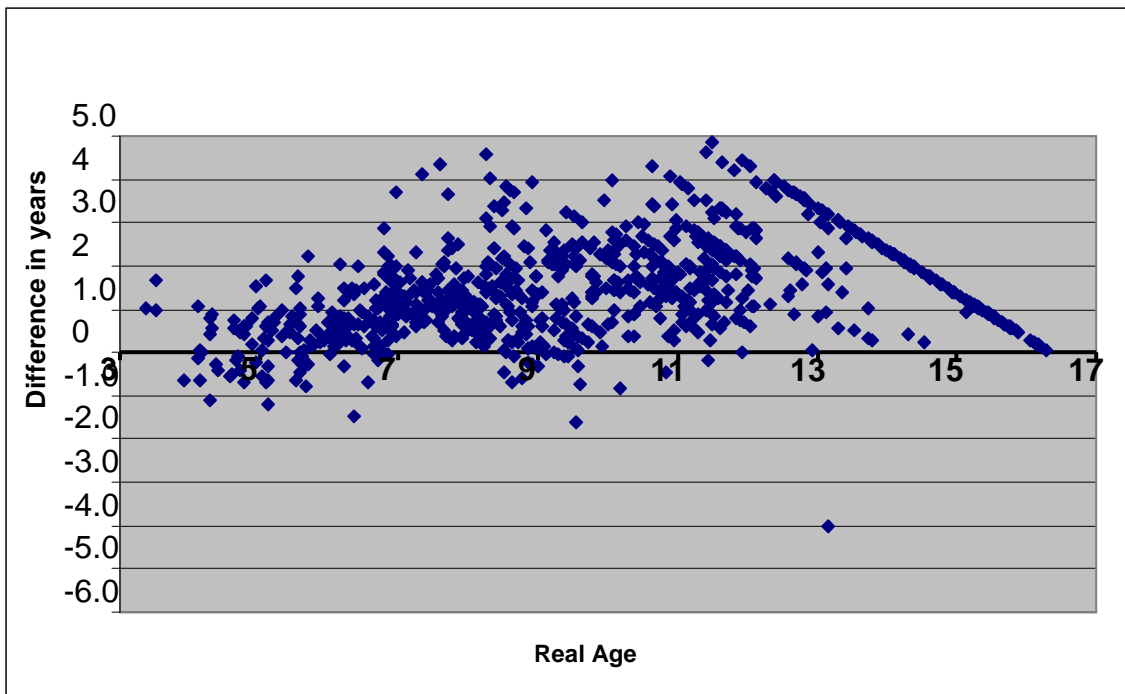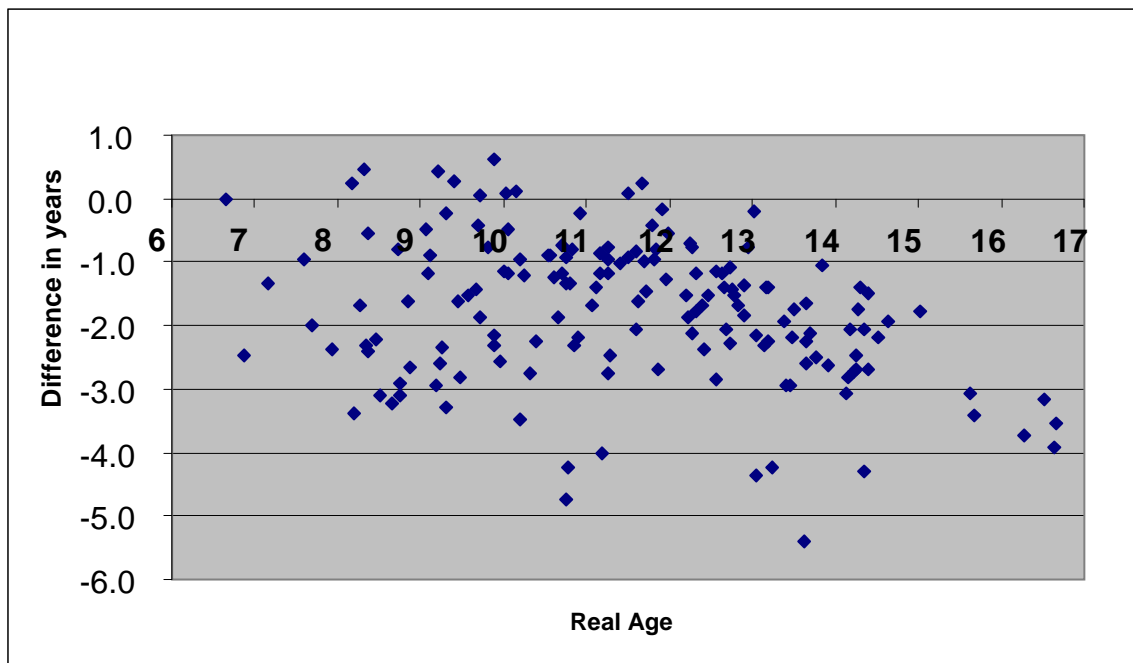

This graph shows the estimation error compared to the chronological age of the Tygerberg sample by the DGT method. This graph shows that 86.3% of the sample lies above the chronological age. The ages are in years.

Graph 5: The percentage of under-estimation of the ages of the Tygerberg sample by the MFH and DGT methods in age intervals
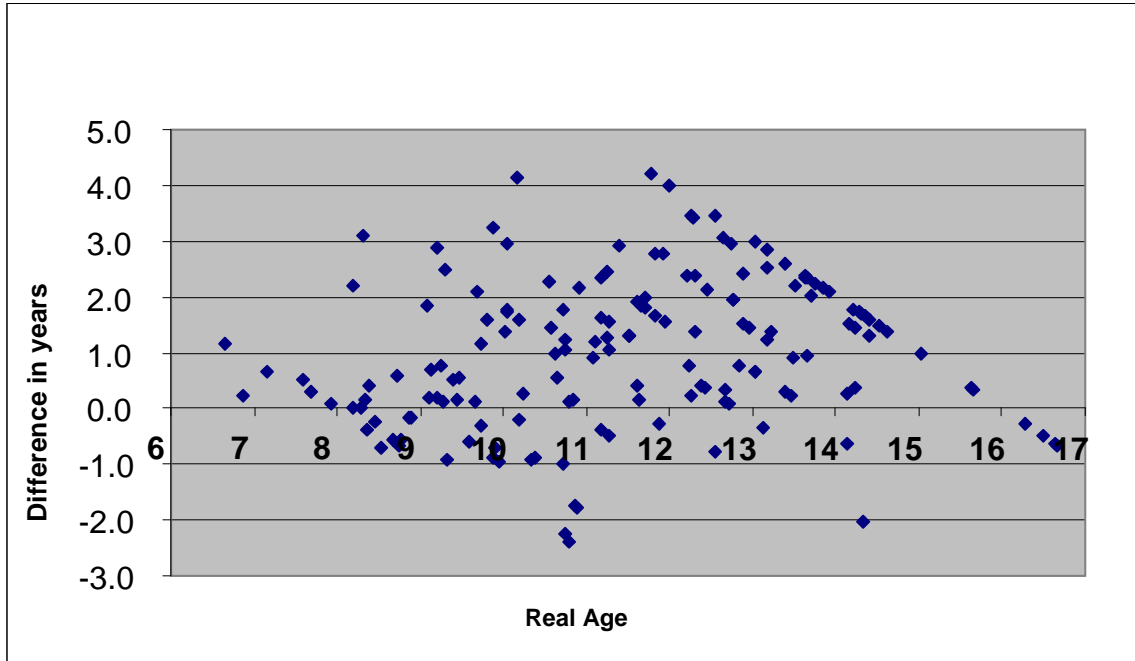

This graph shows the degree of under-estimation of the ages of the Tygerberg sample by the MFH and DGT methods in age intervals. This graph indicates that the MFH method under-estimates 81% of individuals who are under 5 years of age; 94% between 5 and 7 years; 93% between 7 and 9 years; 97% between 9 and 11 years and 100% between 11 and 15 years. The DGT method therefore over-estimates 62% of individuals under the age of 5 years; 83% between 5 and 7 years; 86% between 7 and 9 years; 81% between 9 and 11 years; 94% between 11 and 13 years and 91% between 13 and 15 years.

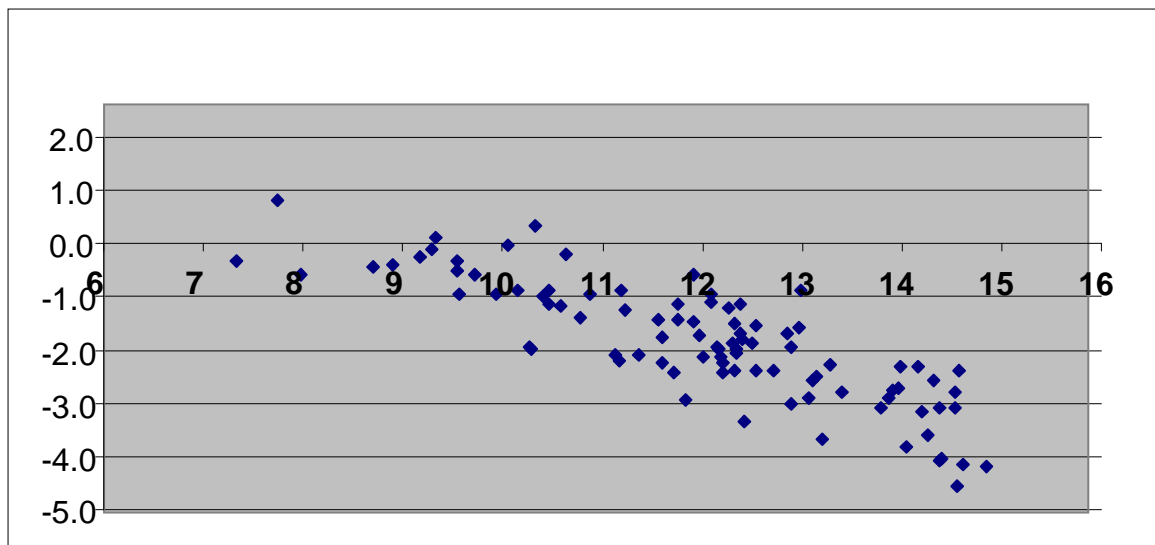*Graph 6: Indian children. Age estimation error using the MFH method*

This graph shows the under-estimation of the ages of the Indian children by the MFH method; 93.7% of the sample lies below the chronological age. The ages are in years.

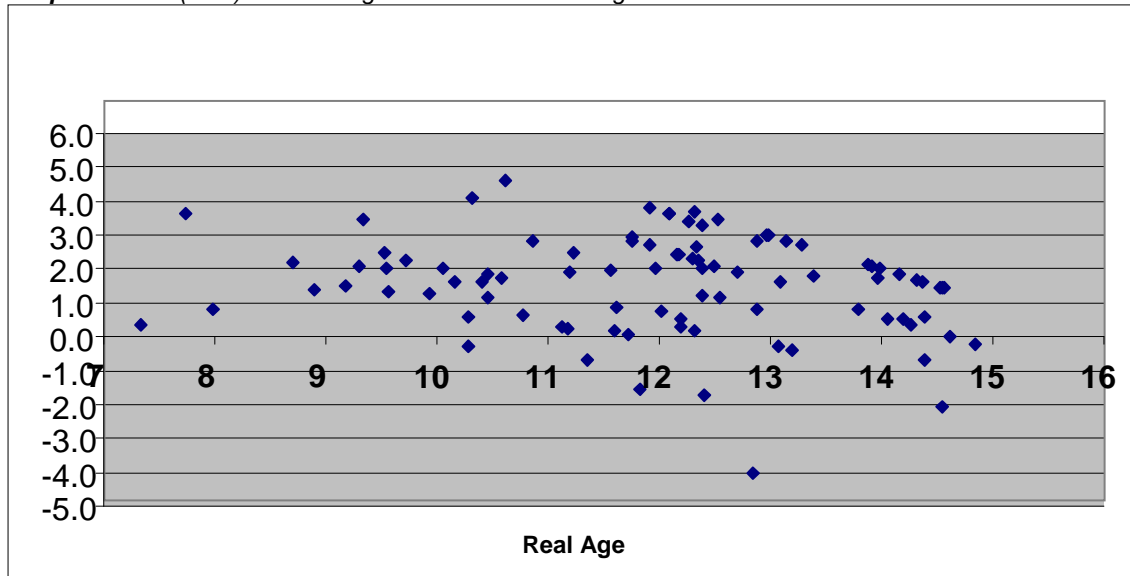*Graph 7: Indian children. Age estimation error using the DGT method*

This graph shows the over-estimation of the ages of 79.2% of the Indian children by the DGT method. The ages are in years.

Graph 8: Black (Zulu) children. Age estimation error using the MFH method

This graph shows the under-estimation of the ages of 96.7% of the Zulu children by the MFH method. The ages are in years

Graph 9: Black (Zulu) children. Age estimation error using the DGT method

This graph shows the over-estimation of the ages of 90% of the Zulu children by the DGT method. The ages are in years.

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