

# Centiles for adult head circumference

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## Abstract

**Reference range for head circumference on the Tanner charts do not go beyond age 16. In this study the head circumference and heights of 354 adults in two British centres were measured. The centile charts constructed from these measurements show that adult head circumference is related to height. The mean head circumference of a male of average height is above the 97th centile for a 16 year old on the Tanner charts. The paediatric charts are therefore inappropriate for use in adult males.**

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Measurement of the occipitofrontal head circumference is an integral part of most paediatric and many medical examinations. It is often of particular importance in making a diagnosis in the dysmorphic child with developmental delay. The London dysmorphology database lists 250 syndromes associated with microcephaly and 114 with macrocephaly.<sup>1</sup> Many of these conditions are inherited and therefore accurate assessment and counselling of relatives should include measurement of head circumference. In the investigation of a child with an apparently isolated abnormality of head circumference examination should also include parental head circumference as studies have shown that up to 50% of normal variation in head size is familial.<sup>2</sup> The centile charts used routinely in Britain have data only up to age 16 years.<sup>3</sup> We have produced centile charts appropriate for use in adults.

## Data collection

Data were collected on the head circumference, height, and age of 354 white adult volunteers attending the outpatient clinics of dental hospitals in Newcastle upon Tyne and Cardiff. Care was taken to exclude patients attending for conditions that might affect cranial anatomy. Two hundred and seven patients were measured in Newcastle (93 males and 114 females) and 147 in Cardiff (66 males and 81 females). The median age was 40 years (range 17 to 83). The subjects in Cardiff were measured by a single observer, whereas in Newcastle two observers measured approximately equal numbers.

## Analysis

The approach was guided by the assumption that the head circumferences are normally distributed, a feature which was checked in the course of the analysis. Under this assumption the centiles were set using estimates of the

mean and SD. So, for example, the 97th centile was calculated to be mean  $+1.88 \times \text{SD}$ . A further concern was that the mean and SD might depend on various recorded variables such as age and height. Thus the method for the simultaneous modelling of means and variances described by Aitkin was used.<sup>4</sup>

The use of this methodology also enabled a check to be made for evidence of a systematic effect of the centre (or observer) on the means (a bias) or on the variance (different precisions).

## Results

Following Aitkin's recommendation a model was assumed for the means which allowed for all the factors mentioned above and some of their second order interactions and different models for the variance were considered.<sup>4</sup> There was no evidence that age, height, or sex had any effect

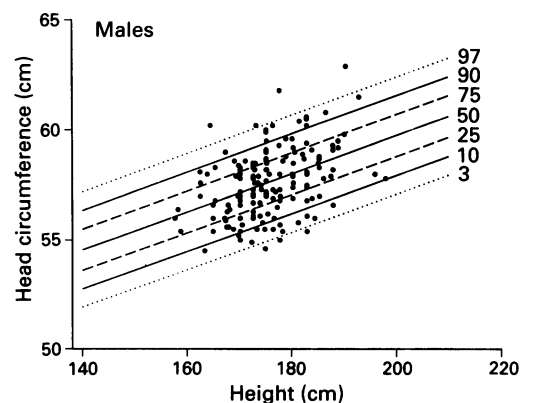


Figure 1 Head circumference plotted against height in 159 adult males. The line describing the mean of the distribution is  $42.4 + 0.08673 \times \text{height}$ .

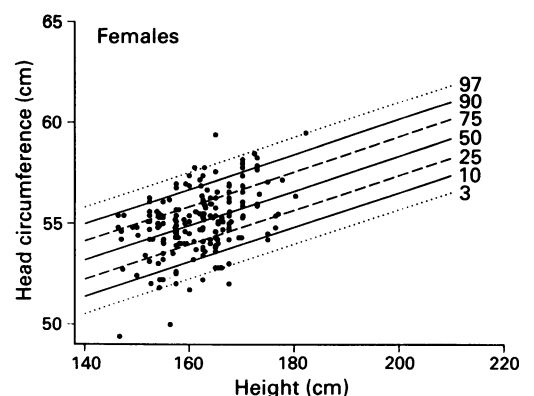


Figure 2 Head circumference plotted against height in 195 adult females. The line describing the mean of the distribution is  $41.02 + 0.08673 \times \text{height}$ .

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on the spread of the measurements. Moreover, there was no indication that the different observers had different precisions. (In a small sample, 20 subjects were measured twice: the SD of the intraobserver measurement error was 0.133 cm.)

As there was no need to include any variables in the model for the variance, Aitkin's approach reduces to ordinary multiple regression,<sup>4</sup> which was then used to examine the effect of age, height, and centre on the mean head circumference. No evidence was found of any effect of age nor of centre.

Figures 1 and 2 shows the data collected with the calculated centiles for males and females. There was clear evidence that mean head circumference increased with increasing height

(slope 0.08673 cm/cm, SE 0.01031 cm/cm,  $p < 0.0001$ ) and that a male would have a head circumference that was on average 1.38 cm larger than that of a female of equal height (mean difference 1.378 cm, SE 0.211 cm,  $p < 0.0001$ ).

The relations given in the figures are reasonable for heights between 140 and 190 cm (females) and 150 to 200 cm (males). The SD about the line is 1.41 cm.

The centiles were constructed assuming the normality of the head circumference measurements, and this was confirmed by the normal probability plot of the jack-knife residuals. The Shapiro-Wilk test<sup>5</sup> did not discredit the hypothesis of normality ( $W = 0.986$ ,  $p = 0.69$ , using Royston's approximation<sup>6</sup>).

## Discussion

We have produced centile charts for adult head circumference based on measurements from two British centres (figs 3 and 4). From our measurements it is apparent that it could be quite misleading to make an assessment of an individual's centile for head circumference without taking height into account. This is in agreement with the data of Bale *et al* who showed a correlation between head circumference and height in a small number of normal subjects.<sup>7</sup> A relationship between brain weight and height has also been demonstrated in adult life as well as during childhood.<sup>8</sup>

Most importantly, we have shown that in adult males especially it is quite misleading to use the end of the paediatric charts to plot parental head circumference, as the mean head circumference of a male of average height is above the 97th centile at age 16 on the Tanner charts. This discrepancy is not so marked in females, probably reflecting the fact that the adolescent growth spurt occurs earlier in females than in males and that head circumference in males continues to grow into early adulthood. These charts provide a more accurate reference range to detect abnormal head circumference in adults.

We would like to thank Dr Susan Huson, whose comments on patients with neurofibromatosis type 1 indirectly stimulated this study. We would also like to thank Professor Barnes in the department of operative dentistry, University of Newcastle upon Tyne, and Dr Edmunds in the oral health clinic of the dental hospital in Cardiff for allowing access to their patients and staff. The values from the Tanner charts are reproduced by permission of Castlemead publications. KMDB is an MRC Training Fellow. Reprints and copies of the centile charts are available from Dr Bushby.

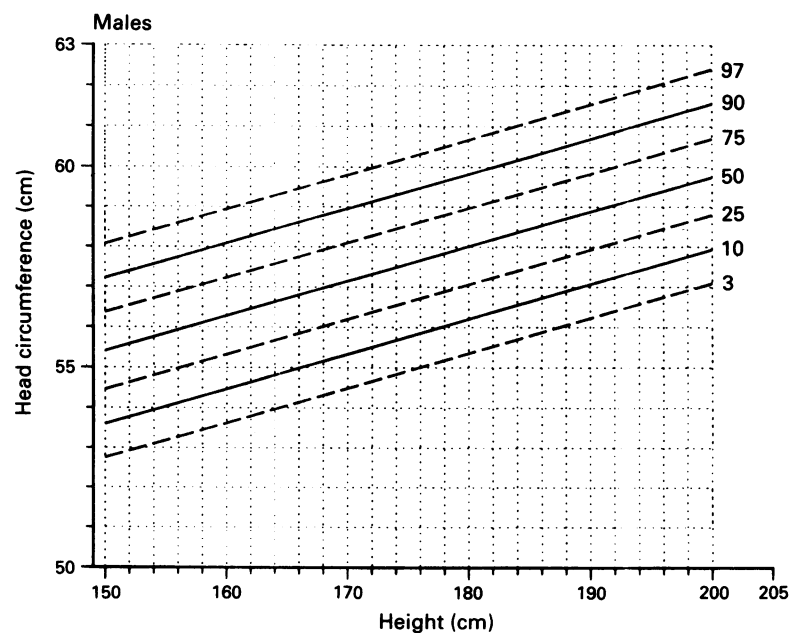


Figure 3 Centile chart for head circumference against height constructed from our data for use in adult males. For comparison, on the Tanner charts the 97th centile for head circumference for a boy of 16 years is 57.7 cm and the 50th centile 55 cm.

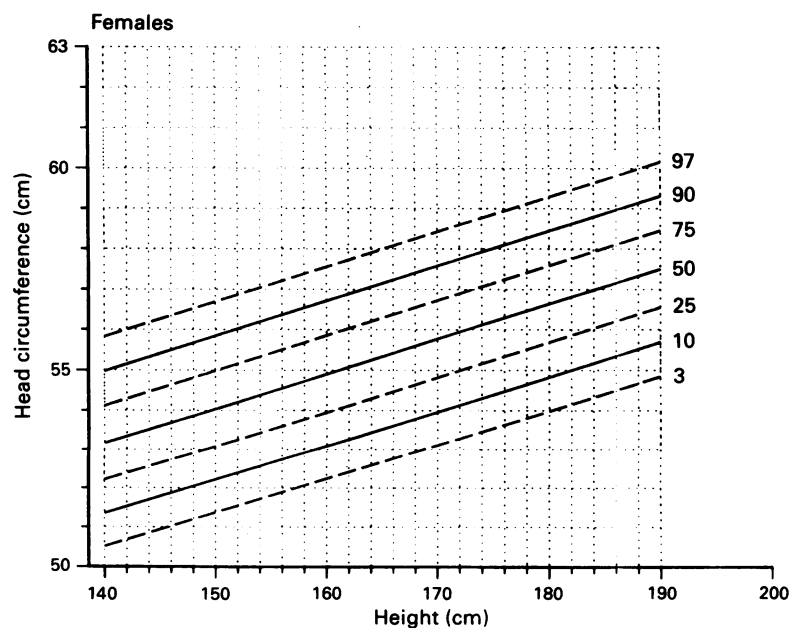


Figure 4 Centile chart for head circumference against height constructed from our data for use in adult females. For comparison, on the Tanner charts the 97th centile for a girl of 16 years is 56.4 cm and the 50th centile 54.2 cm.

- Baraitser M, Winter R. *London dysmorphology database*. Oxford: Oxford Medical Databases, 1990.
- Weaver DD, Christian JC. Familial variation of head size and adjustment for parental head circumference. *J Pediatr* 1980;96:990-4.
- Physical growth and development. In Forfar JO, Arneil GC, eds. *Textbook of paediatrics*. 3rd Ed. Edinburgh: Churchill Livingstone, 1984:315-7.
- Aitkin M. Modelling variance heterogeneity in normal regression using GLIM. *Applied Statistics* 1987;36:332-9.
- Shapiro SS, Wilk MB. An analysis of variance test for normality (complete samples). *Biometrika* 1965;52:591-611.
- Royston JP. Algorithm AS 181. The W test for normality. *Applied Statistics* 1982;31:176-80.
- Bale SJ, Amos CI, Parry DM, Bale AE. Relationship between head circumference and height in normal adults and in the nevoid basal cell carcinoma syndrome and neurofibromatosis type I. *Am J Med Genet* 1991;40:206-10.
- Minckler TM, Boyd E. Physical growth of the nervous system and its coverings. In: Minckler J, ed. *Pathology of the nervous system*. Vol 1. New York: McGraw Hill, 1968: 120-37.