Standard growth curves for achondroplasia

Standard growth curves for achondroplasia, the most common form of short-limbed dwarfism, have been constructed based on measurements of height, growth velocity, upper and lower segment, and head circumference in 400 achondroplastic dwarfs. These standard curves provide the basis to assess normal growth in these individuals, to aid in the determination of superimposed disorders, and to assess any growth accelerating therapy.

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ACHONDROPLASIA is the most common form of short-limbed dwarfism. Although the clinical and radiologic features have been well characterized, surprisingly little attention has been given to the study of growth patterns in this disorder.[1] Nehme et al[2] have recently published height and skeletal growth curves for achondroplasia, but their data were based on only 18 patients; thus they were able to report only average values, without any measure of variance. Because of the need for this type of information in the management of individual patients and in the evaluation of potential growth acceleration therapy, we have measured height, growth velocity, upper and lower segment, and head circumference in over 400 classical achondroplastic dwarfs. Using these data, standard growth curves have been constructed. (Preliminary curves based on measurements on 140 individuals were presented at the 1976 Birth Defects Conference, Vancouver, Canada.[3])

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METHODS

Measurements of total height, upper and lower segment, and head circumference were obtained on 403 patients with achondroplasia ascertained through short stature clinics at UCLA-Harbor General Hospital, Torrance, Calif., the University of Washington School of Medicine, Seattle, Wash., the University of Texas Medical School at Houston, and the 1976 National Convention of the Little People of America. The sample included 189 males and 214 females. Patients treated with potential growth acceleration drugs, such as fluoxymesterone, were excluded from the study for the period during and after such treatment. Head circumference measurements from patients known to have had previous shunt procedures for hydrocephalus were also excluded.

Achondroplasia is a specific chondrodystrophic disorder with characteristic and specific clinical and radiographic features.[1] Only those individuals satisfying the strict diagnostic criteria for achondroplasia were included in this study by the three participating bone dysplasia centers. Measurements were made as part of ongoing evaluation in the Short Stature Clinics and by one of us (W. A. H.) at the Little People of America National meeting. Most of the measurements were casual and retrospective, but were done in clinics specializing in the evaluation of short stature, which expend a great deal of effort in standardizing their measurement techniques.

Graphic methods were used to construct preliminary growth distance curves for height, upper and lower segment, head circumference, and growth velocity curves for height.[4] A combination of cross-sectional and longitu-

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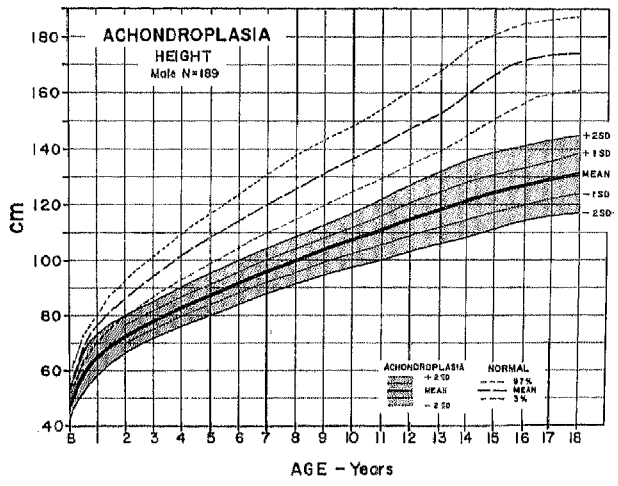

Fig. 1. Height (mean ±SD) for males with achondroplasia (stippled area) compared to normal male standard height curve (third, fiftieth, and ninety-seventh percentile).

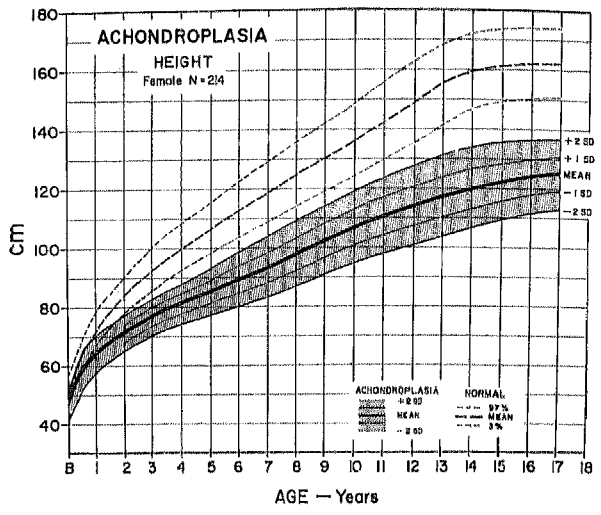

Fig. 2. Height (mean ±SD) for females with achondroplasia (stippled area) compared to normal female standard height curve.

dinal data was used for the distance curves, and longitudinal data for velocity curves. For all curves, the mean ±2 SD was plotted for achondroplasia and compared to standard curves showing the normal third, fiftieth, and ninety-seventh percentiles for height and height velocity, and mean ±2 SD for upper and lower segments and for head circumference. The normal height and height velocity curves were taken for Tanner and Whitehouse.[5] The estimates of normal upper and lower segment lengths were calculated from the upper/lower segment ratio standards derived by McKusick,[6] and the normal height curves of Tanner and Whitehouse.[5] The curves of Nellhaus[7] were used for head circumference standards. In the velocity curves, when mean velocity and standard deviations for achondroplasia could not be plotted because of insufficient longitudinal data, single velocity measurements were plotted and connected by a dotted line.

RESULTS*

As seen in Figs. 1 and 2, the male and female height distance curves are very similar. The range of birth length for achondroplasia overlaps the lower range of normal, whereas height progressively falls below normal with time. The mean adult height (taken at 18 years) is 7 cm greater for males than for females with achondroplasia.

Mean growth velocity appears to be normal during the first year in achondroplasia (Figs. 3 and 4). Beyond infancy, however, the growth rate drops to approximately the third percentile for normal, where it remains throughout the first decade. (This is distinctly abnormal when one considers that in normal individuals the growth rate varies consistently above and below the mean during this period of time, rather than following a certain velocity percentile as is usual for distance percentiles. For example, a normal individual growing consistently at the third velocity percentile would reach a final height of less than four feet [120 cm] compared to an individual following the ninety-seventh velocity percentile whose adult height would be near seven feet [210 cm].) Unfortunately, beyond age 10 years, the number of measurements is small and we cannot be certain if there is a pubertal growth spurt, although the few longitudinal observations suggest that such a spurt occurs. In addition, the increased variability in velocity that is normally seen during adolescence was also seen in the achondroplastic subjects, suggesting that some individuals were undergoing a growth spurt while others were not during each measurement period. Further observations during this age period will be required to clarify this matter. Otherwise, the shape of the height velocity curves appears entirely normal for both males and females with achondroplasia.

Upper and lower segment lengths in achondroplasia are plotted in Figs. 5 and 6. As expected, since achondroplasia is a form of short-limbed dwarfism, their upper segment lengths are normal and the lower segment lengths much below the normal range for both males and females. In contrast to our earlier observations based on 140 individuals, in whom the lower segment length was apparently similar in the two sexes, but the upper segment length greater for males,[8] both upper and lower segments are slightly greater in the male in this expanded sample.

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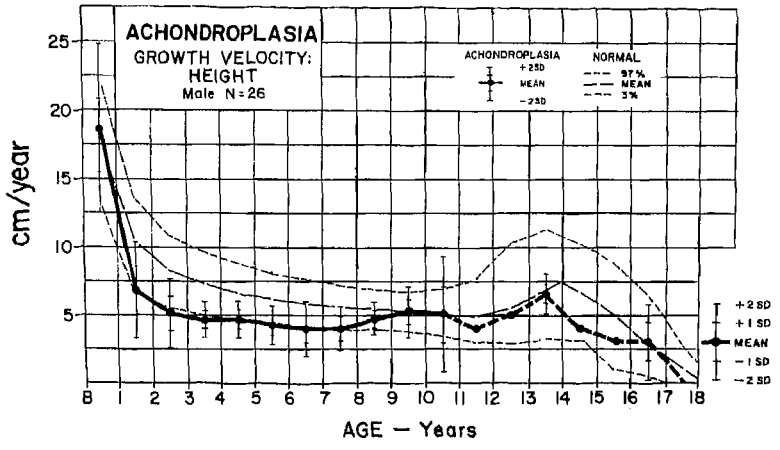

Fig. 3. Height velocity (mean [heavy line] ±2 SD) for males with achondroplasia compared to the normal male standard growth velocity curve.

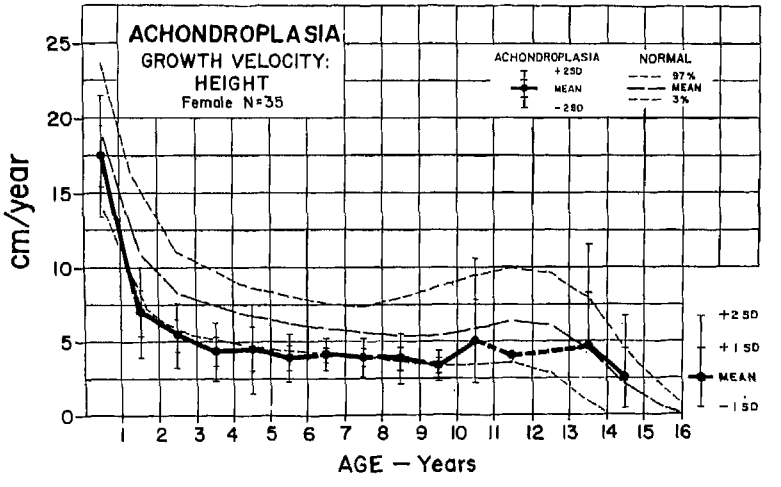

Fig. 4. Height velocity (mean [heavy line] ± 2 SD) for females with achondroplasia compared to normal female standard velocity curve.

At birth, the mean head circumference for achondroplasia is slightly more than 2 SD above the normal (Figs. 7 and 8). During the first year, when rapid head growth occurs, this mean rises further above the normal range, after which a relatively constant relationship is maintained between achondroplastic and normal head circumference into adulthood. There is, however, considerable overlap between the head circumference in achondroplasia and in the normal population. As in normal individuals, head circumference is slightly greater at all ages for males compared to females with achondroplasia. It is the clinical impression of one of us (J. H.) that there are three different head circumference growth curves in achondroplasia: one in which the head is large at birth and grows parallel to but above the ninety-seventh percentile; a second in which the head is normal, or slightly large at birth, but grows dramatically, crossing the ninety-seventh percentile and then leveling off; and a third, depicted by Figs. 7 and 8, with gradually increasing head size during the first year. More individual longitudinal data will be needed to confirm or refute this impression.

DISCUSSION

Standard growth curves for height, height velocity, upper and lower segments, and head circumference have been derived from measurements of over 400 individuals with classic achondroplastic dwarfism. These curves should prove useful in following the individual patient with achondroplasia. The plotting of an affected child within the "normal range" for achondroplasia may comfort the anxious patient or his parents. Growth measurements differing notably from those expected from the curves might indicate that some factor in addition to achondroplasia is interfering with growth, or alternative-

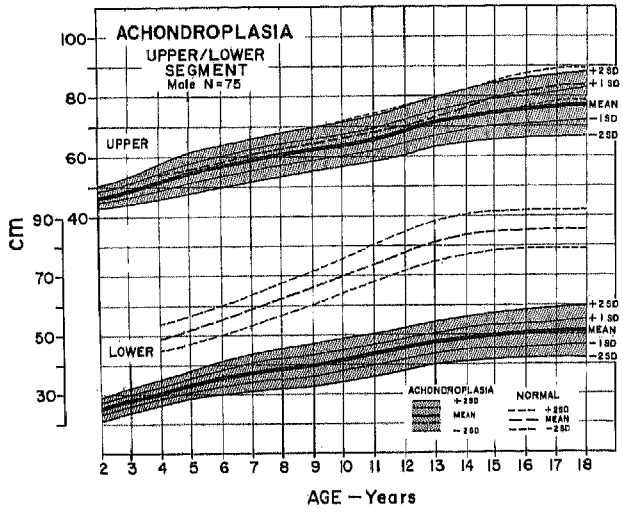

Fig. 5. Upper and lower segment lengths (mean ± 2 SD) for males with achondroplasia (stippled area) compared to normal upper and lower segments (mean ± 2 SD).

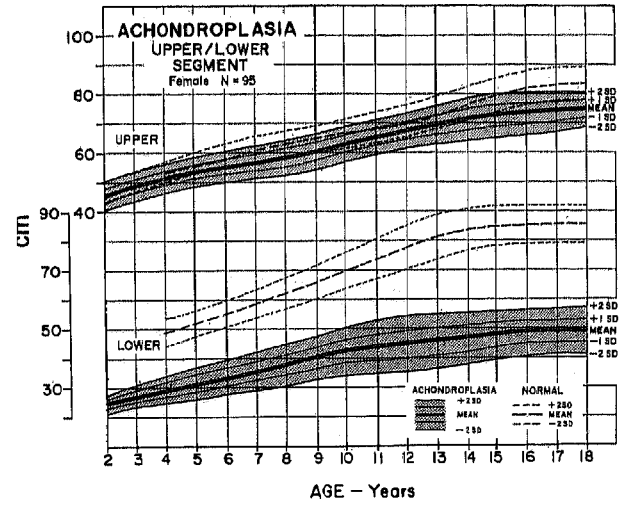

Fig. 6. Upper and lower segment lengths (mean ± 2 SD) for females with achondroplasia (stippled area) compared to normal upper and lower segments (mean ± 2 SD).

ly, that the patient does not have achondroplasia. Furthermore, such standard curves for achondroplasia must be used to assess properly any potential growth accelerating treatment.

Hydrocephalus is frequently suspected in the achondroplastic infant due to his unusual head shape, relatively large head circumference and delayed motor development. Plotting the child's head circumference on these head circumference curves may demonstrate the normality of his head size for his basic disease and thus prevent unnecessary diagnostic or even therapeutic measures. Similar growth curves would be useful for each of the skeletal dysplasias.

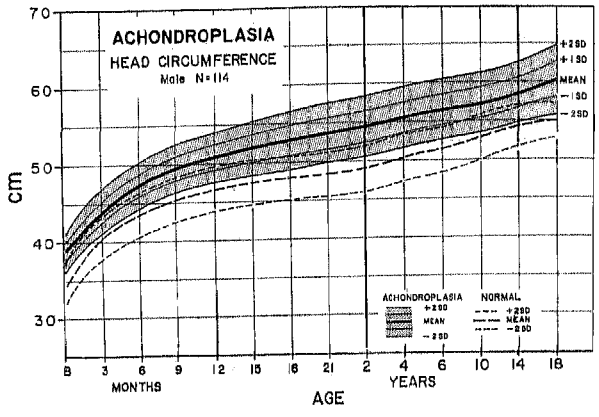

Fig. 7. Head circumference (mean ± 2 SD) for males with achondroplasia (stippled area) compared to normal male head circumference (mean ± 2 SD).

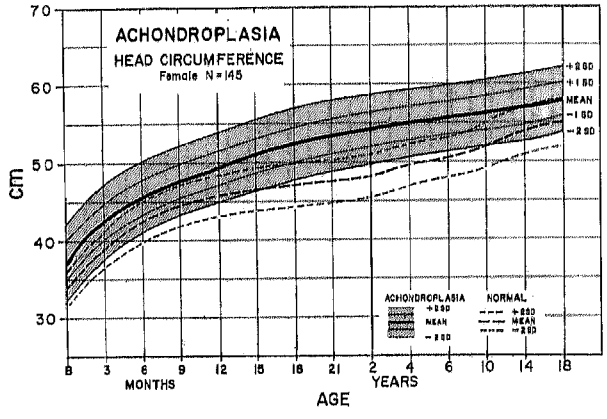

Fig. 8. Head circumference (mean ± 2 SD) for females with achondroplasia (stippled area) compared to normal female head circumference (mean ± SD).

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