A CHART OF ANTHROPOMETRIC VALUES

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A chart is presented to assist with the assessment and treatment of patients with growth-related deformities. It is based on anthropometric values from five published sources and relates sitting height to stature, limb length, the radiographic lengths of the leg bones and the lengths of the feet and hands. It has proved useful in the prediction of leg-length discrepancies, in the diagnosis of cases of short stature, and in the assessment of spinal shortening from scoliosis.

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In growing children the development of the skeletal apparatus takes place according to the limits and proportions established by the genetic heritage of each individual. If balanced growth is maintained, there are constant ratios between stature, the lengths of the limbs and the dimensions of the various long bones. These relationships vary according to race.

In orthopaedic practice it is often necessary to compare the dimensions of the limbs and the spine with standard reference values, especially when dealing with limb-length discrepancy, size discrepancies of the hands and feet, short stature, and scoliosis.

THE BASIS FOR THE CHART

There is little information readily available in the literature on the anthropometry of the growing child. With this in mind we developed a 'Chart of Anthropometric Values'. It was prepared after a review of the literature and an analysis of the standard anthropometric values for the populations of Western European countries from five publications (Maresh 1955; Tanner and Whitehouse 1976; Snyder et al 1977; Hensinger 1986; Boscherini et al 1990).

The 50th centile of the lengths of the body segments in centimetres was chosen as the figure for analysis. The sitting height (SH) was established as the reference for the proportional analysis of the bones of the limbs. The percentage value of the standing height (H), and of the length of each bone segment were calculated in relation to SH.

The basic data, as published by Hensinger (1986), are calculated as follows: H from the tables of Tanner and Whitehouse (1976); SH and hand size from the tables of Snyder et al (1977); and upper and lower limb lengths from the tables of Maresh (1955).

The chart can be used to establish the ideal proportions between the trunk and the lengths of the upper and lower limbs, the lengths of the individual long bones of the limbs, and the length of the hand (measured from the tip of the middle finger to the radiocarpal joint) or the foot (measured from the tip of the hallux to the back of the heel).

DESCRIPTION OF THE CHART

There are two charts, one for girls and one for boys (Figs 1 and 2). The values are in centimetres or percentages and are given for each year from the age of two to 16 years. Each chart is divided vertically into three parts.

Trunk measurements. The left section of the chart gives the values for H and SH in centimetres and the ratio of SH to H, expressed as a percentage. For example, a two-year-old boy should be 86 cm tall (H) and have a sitting height (SH) of 55 cm, 64% of his standing height. This percentage changes during growth to the adult value of 52% in males and 53% in females.

Radiographic limb measurements. In the central section of the chart the radiographic lengths of the long bones are given as percentages of SH. The epiphyses are excluded from these calculations between the ages of two and nine years and included from ten years onwards. The values are for radiographs taken from a distance of at least 2 m to minimise magnification. The mean adult percentage values for each of the long bones are shown in bold print at the bottom of each column.

Hand and foot measurements. The right section of the chart gives the external measurements of the hand and

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GIRLS

AGE years	Height (H) cm	Sitting Height (SH) cm	Sitting Height (SH) % H	HUMERUS % SH	RADIUS % SH	ULNA % SH	FEMUR % SH	TIBIA % SH	FIBULA % SH		HAND % SH	FOOT % SH
2	84	53	63	24	18	20	31.5	26	25.5	EXCLUDING EPIPHYSIS	19.5	27
3	93	53	57	27.5	20.5	22.5	37	30	30		19.5	27
4	100	57	57	28	21	23.5	39	31.5	31.5		20	28
5	108	59.5	55	29.5	21.5	24	41	34	33		20	28
6	114	62.5	55	30	22	24.5	42.5	34.5	34		20	28
7	120	65	54	31	23	25	44.5	36	35.5		20	28.5
8	126	68	54	32	23.5	26	46	37.5	37		20	29
9	132	70	53	32.5	24	26.5	47.5	38.5	37.5		20.5	29.5
10	138	71.5	52	36	26.5	28.5	54	45	44	INCLUDING EPIPHYSIS	21	30
11	145	75.5	52	37	27	29.5	55	46.5	44		21	30
12	150	78	52	37.5	28	30	56	47	45		21	30
13	155	80.5	52	37.5	28	30	56	46.5	45		21	29
14	158	82	52	38	28.5	30	56.5	47	45.5		20.5	28.5
15	159	84.5	53	38	28	30	56	46.5	45		20.5	28
16	160	85	53	37.5	28	29.5	56	46	44.5		20	28
MEAN VALUES ▶				**37.5 %**	**27.5 %**	**29.5 %**	**55.5 %**	**46.5 %**	**44.5 %**		**20.5 %**	**28.5 %**

RADIUS/HUMERUS = 74.5 % ULNA/HUMERUS = 81 % TIBIA/FEMUR = 84 % FIBULA/FEMUR = 80%

Fig. 1

Anthropometric chart for girls.

BOYS

AGE years	Height (H) cm	Sitting Height (SH) cm	Sitting Height (SH) % H	HUMERUS % SH	RADIUS % SH	ULNA % SH	FEMUR % SH	TIBIA % SH	FIBULA % SH		HAND % SH	FOOT % SH
2	86	55	64	23.5	17.5	19.5	31	25.5	25	EXCLUDING EPIPHYSIS	19.5	27
3	94	55.5	59	26.5	20	22.5	36	29.5	29		19.5	27
4	102	58	57	28	21.5	23.5	39	32	31.5		19.5	28
5	110	60.5	55	29	22	24	40.5	33	33		19.5	28
6	116	64	55	30	22.5	25	42.5	34.5	34		20.5	28.5
7	122	66	54	31	23	25.5	44	35.5	35.5		20	29
8	128	69	54	31.5	23.5	26	45.5	37	36.5		20	29
9	133	70.5	53	32.5	24	26.5	47	38	37.5		20.5	30
10	138	71.5	52	36	26.5	28	53.5	44.5	43	INCLUDING EPIPHYSIS	21	30
11	144	73.5	51	35.5	27.5	29	54.5	45.5	44		21	30.5
12	150	76.5	51	37	28	29.5	56	47	45		21	30.5
13	156	79.5	51	38	28.5	30	57	48	46		21.5	31
14	163	83	51	38.5	29	30.5	57	48.5	46.5		21.5	31
15	168	85.5	51	39	29.5	31	57.5	48.5	47		21.5	30
16	172	89.5	52	38	28.5	30.5	55.5	47	45		22	29.5
17	174	90.5	52	38	29	30.5	55	47	45.5		20.5	29
18	176	91.5	52	38	28.5	30.5	54.5	46.5	45		21	29
MEAN VALUES ▶				**37.5 %**	**28.5 %**	**30 %**	**55.5 %**	**47 %**	**45%**		**20.5 %**	**29 %**

RADIUS/HUMERUS = 75.5 % ULNA/HUMERUS = 81 % TIBIA/FEMUR = 84.5 % FIBULA/FEMUR = 81%

Fig. 2

Anthropometric chart for boys.

foot as percentages of SH, again with the mean adult values in bold print at the bottom of the columns.

Finally, at the bottom of each chart are given the ideal proportions of the radius and ulna to the humerus, and of the tibia and fibula to the femur.

CLINICAL APPLICATION OF THE CHART

The chart has been in daily use for three years in the orthopaedic department at the University of Verona and its reliability and value have been confirmed. It can be used to forecast eventual leg-length discrepancies and the amount of lengthening or shortening required, to diagnose and classify cases of short stature, and to determine the amount of spinal shortening from vertebral deformities.

There follow some examples of how the chart can be used.

Short stature. A seven-year-old girl had a value for H of 105 cm and for SH of 65 cm. From the chart, the normal value of H is 120 cm and of SH 65 cm. Since SH is normal the deficit in height is entirely due to short lower limbs. The diagnosis is of disharmonic short stature with a 15 cm deficit in the lower limbs.

Using the chart again, the relative shortening of the femur and tibia is calculated. In this patient the femur was 20 cm long and the tibia 18 cm. If both bones were lengthened by 7.5 cm, the proportion between them would be altered to 93%, instead of the normal 84%.

It is therefore necessary to calculate the normal lengths of the femur and tibia at this age by using the known percentage of the bones to SH. At seven years the length of the femur is given as 44.5% of SH, and of the tibia as 36%. Since SH is 65 cm, the normal femoral length should be 29 cm, and the tibial length 23 cm. There is therefore 9 cm of shortening in the femur and 5 cm in the tibia, making a total deficit of 14 cm. These figures can be checked by calculating the ratio of the lengths of the two bones: in this case it is 83%, which is very close to the normal of 84%.

Lower-limb discrepancy. In a ten-year-old boy, H was 140 cm and SH 73 cm, and one femur was 7 cm shorter than the other. This is a mean shortening of 18% and has remained constant as calculated by three consecutive measurements at intervals of one year. To predict the leg-length discrepancy expected at the end of growth, the target height must be calculated. This figure is obtained by inserting the observed values of H at each of the three years into the curve given by Tanner and Whitehouse (1976) and plotting the final value by following the appropriate centile. This value can be compared with that obtained from the formula for the genetic inheritance for males: (H of father + H of mother + 13)/2. The formula for females is (H of father + H of mother − 13)/2 (Boscherini et al 1990).

For the patient in this example, the final predicted value of H was 180 cm. From the chart, the final value for SH will be 93.5 cm (SH:H = 52%). The final length of the healthy femur will be 55.5% of SH, or 52 cm. The final deficit in length of the short femur will therefore be 9.4 cm (18% of 52 cm), 2.5 cm more than the current deficit of 7 cm.

Scoliosis. The chart can be used in scoliosis to monitor the growth of the trunk in relation to overall stature. A ten-year-old girl has a value for H of 138 cm, and for SH of 71.5 cm. The SH:H ratio of 52% is the normal one and should be maintained during growth. If the ratio decreases it is an indication that growth in length of the spine has slowed, and that vertebral deformity may be increasing. In this case, when H was 155 cm SH was 78 cm and SH:H was 50%. For this ratio to be maintained at 52% SH should be 80.5 cm, and the vertebral height is therefore 2.5 cm less than expected.

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