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Growth of Long-bones of Human Fetus as Illustrated by the Tibia.

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The growth in length of the human tibia in the latter part of pre-natal life has been studied quantitatively from observations, made chiefly by Corrado¹ and by Tamassia,² on a series of 152 fetuses. The data include the total body-length, the total length of the tibia, the length of the tibial diaphysis, and the combined lengths of the superior and inferior (cartilagenous) tibial epiphyses. Regression formulae have been computed for certain relationships between these values and are given, with other data, in Table I. Fig. 1 shows the distributions of these observations and their regressive lines.

These formulae indicate that, in the period under consideration, the growth in length of the tibia and the lineal growth of its various

TABLE I.
Correlations and Empirical Formulae for the Human Fetal Tibia and Total Body-Length.

Dimensions compared	Sex and number of cases	Coefficients of correlation	Regression formulae	Root mean square deviations of observed from computed values
				(mm.)
Length of proximal diaphysis(X) and length of both epiphyses (Y)	Males (73)	0.5296 ± 0.058	$Y = 0.1660X + 7.285 \text{ mm.}$	2.10
	Females (49)	0.5438 ± 0.068	$Y = 0.1335X + 8.991 \text{ mm.}$	2.10
Total body-length (X) and length of diaphyses (Y)	Males (73)	0.9494 ± 0.008	$Y = 0.1384X - 5.772 \text{ mm.}$	2.50
	Females (49)	0.9617 ± 0.007	$Y = 0.1543X - 13.650 \text{ mm.}$	2.45
Total body-length (X) and length of both epiphyses (Y)	Males (73)	0.5676 ± 0.005	$Y = 0.0249X + 5.850 \text{ mm.}$	2.04
	Females (49)	0.5835 ± 0.064	$Y = 0.0230 + 6.521 \text{ mm.}$	2.03
Total body-length (X) and total length of tibia (Y)	Males (73)	0.9556 ± 0.007	$Y = 0.1671X - 2.019 \text{ mm.}$	2.81
	Females (49)	0.9655 ± 0.008	$Y = 0.1743X - 5.443 \text{ mm.}$	2.64

¹ Corrado, *Gior. d. Ass. Napol. d. Med. e. Natural.*, 1899, ix, 220.

² Tamassia, *Atti. R. Inst. Veneto d. Sc., Lett. e. Arti.*, 1893, 7 ser., iv, 815.

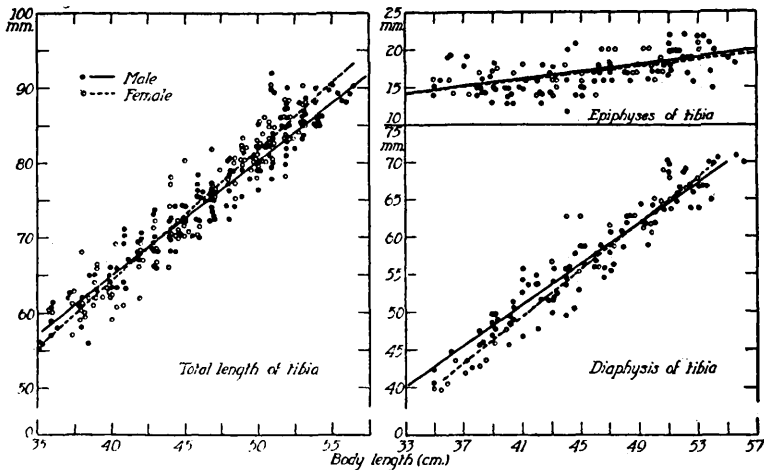


FIG. 1.

Field-graphs and regression lines representing the relation of the length of the tibia and its parts to the total body-length in the latter part of the fetal period.

parts are directly proportional to the growth in total or crown-heel length. The empirical formulae for the total length of the tibia and for the length of the tibial diaphysis, with respect to total body-length, are characterized by negative second constants, as are the various empirical formulae which have been developed for the external dimensions of the lower extremities (Calkins and Scammon³). The empirical formulae for the epiphyses, on the other hand, show positive second constants. Therefore, while the lengths of the tibia as a whole and of its diaphysis are becoming *relatively*, as well as *absolutely*, greater, the epiphyses are becoming *relatively* shorter, although *absolutely* longer.

Fig. 2 shows the calculated growth in length of the tibia and its several parts in the last trimester of prenatal life. The relation of the lengths of these structures to age, in fetal or lunar months, has been computed by the use of the empirical formula of Scammon and Calkins⁴ for the relation between time and total body-length in the fetal period.

Differentiating the expressions for the lengths of the tibial structures with respect to time in the fetal period, we find that all parts of the bone decline in absolute rates of lineal growth in the latter part of prenatal life. The rate of absolute lineal growth of the tibia as a whole drops from 7.7 mm. per month at 7 lunar months to 6.4 mm. per month at 10 lunar months or birth. The

³ Calkins and Scammon, *PROC. SOC. EXP. BIOL. AND MED.*, 1925, **xxi**, 353.

⁴ Scammon and Calkins, *PROC. SOC. EXP. BIOL. AND MED.*, 1923, **xx**, 353.

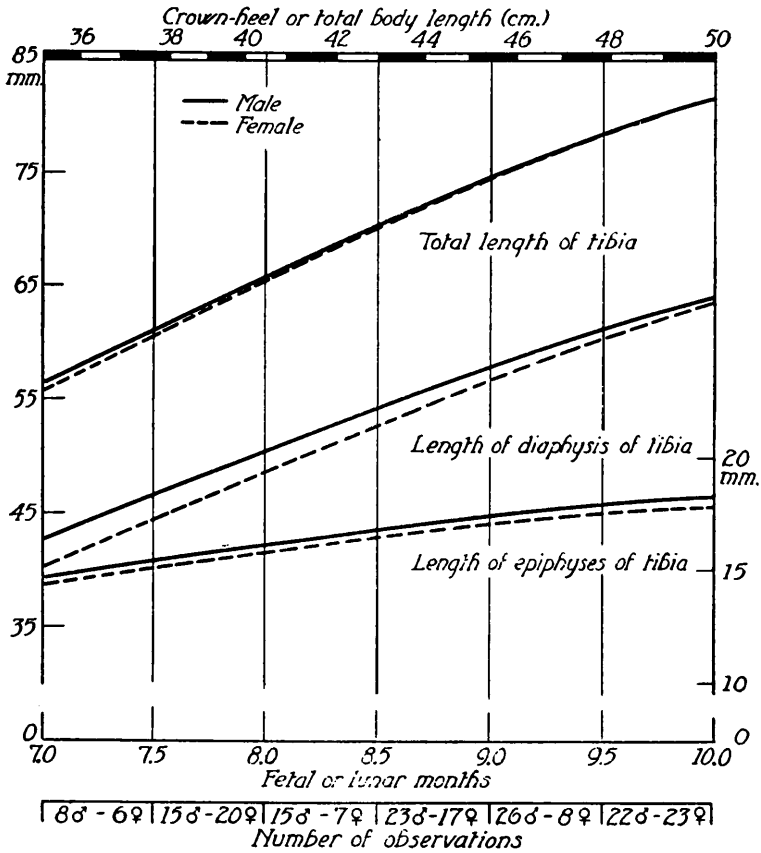


FIG. 2.

Curves, drawn from computed values, showing the growth in length of the tibia, the length of the tibial diaphysis and the combined lengths of the tibial diaphyses in the last 3 months of prenatal life.

rate of diaphyseal growth declines from 8.6 mm. per month at 7 lunar months to 7.1 mm. per month at birth, and the rate of lineal growth of both epiphyses drops in the same period from 1.4 mm. per month to 1.1 mm. per month. These figures are based upon formulae computed by the method of least squares, using individual cases of both sexes.

Relative velocity ratios were obtained by dividing the absolute velocities of lineal growth of the several tibial parts at various times by the attained lengths of these times. These ratios decline between one-third and one-half between 7 lunar months and birth.

Ossification takes place in the superior tibial epiphysis in the 9th and 10th lunar months,⁵ but the present data show no evidence that the appearance of this ossification center affects in any way the

rate of growth of the epiphyses, either with respect to body-length or with respect to age.

Although the tibia is said to ossify earlier in females than in males,⁵ ⁶ we find no significant sex differences in the rates of growth of the bone as a whole or in any of its parts, in the period under consideration.

⁵ Adair and Scammon, *Am. J. Obstet. and Gynecol.*, 1921, ii, 3.

⁶ Pryor, *Anat. Rec.*, 1923, xxv, 257.