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Neonatometer: A New Infant Length Measurer

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Davies, D. P., and Holding, R. E. (1972). *Archives of Disease in Childhood*, **47**, 938. **Neonatometer: a new infant length measurer.** A new instrument for measuring crown-heel length in infancy is described. Reproducibility data show it to be capable of detecting the small increments in linear growth that might be expected at this age, with an accuracy and reliability certainly adequate for any conceivable purpose at the present time.

The diagnosis of impaired fetal growth in newborn infants continues to rely at the present time on two main parameters—birthweight and estimated gestational age (Miller and Hassanein, 1971). Likewise, the routine clinical appraisal of growth in infancy also depends mainly upon the parameter of weight gain. Comparatively little attention, however, seems to have been given to growth of body length (linear growth) in either the fetus or infant, and in many ways this is surprising, for not only must physical growth be considered an integrated increase in both weight and length (Babson and Bramhall, 1969), but in the older child and adolescent the evaluation of growth relies as much, if not more, upon the measurement of body length than it does upon weight gain. One of the principal reasons underlying this reluctance to use body length in the assessment of fetal and infant growth relates to the various conventional methods that are at present available for measuring crown-heel length, since none is able to provide measurements with any high degree of accuracy and reliability.

The purpose of this communication is to introduce a new infant length measurer, the Neonatometer, for the precise measurement of crown-heel length in infants up to the age of 6 to 9 months. (After this age the 'Harpenden Infant Table' is the instrument widely used for the accurate measurement of body length in later infancy and early childhood.)

Design

The Neonatometer* (Fig. 1) is a hollow aluminium frame on which is mounted a freely moving carriage.

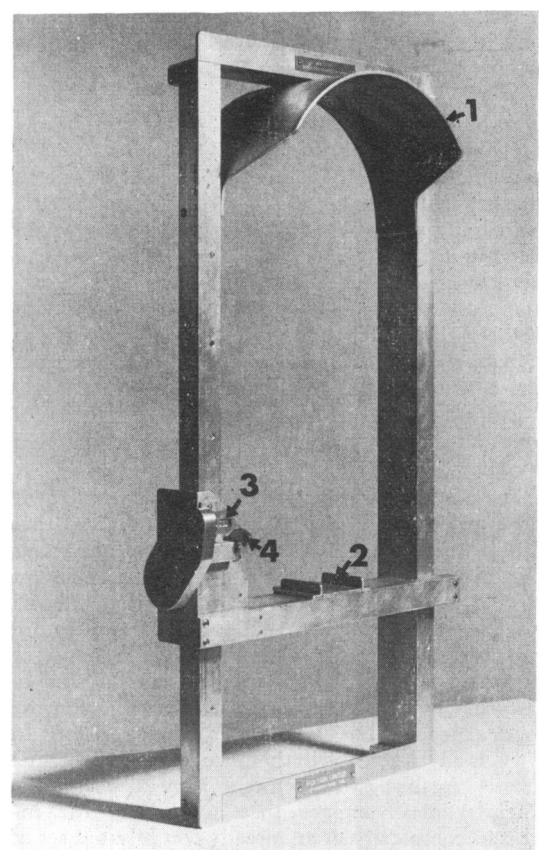

FIG. 1.—*The Neonatometer. 1: curved head-piece; 2: foot plate; 3: number counter; 4: constant pressure catch.*

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*Now available from R. E. Holding, Holtain Lrd., Crosswell, Crymmych, Pembs.

Two frame sizes are available: (a) 30×64 cm for use with the newborn infant, and (b) 30×76 cm for the infant up to the age of 6 to 9 months. This hollow frame has advantages over a solid or table-topped frame since it is easily portable and can be placed over and around the infant thereby enabling measurements to be accomplished with a minimum of handling or disturbance, and it is also easily cleaned with an antiseptic solution, therefore minimizing the potential risk of cross-infection.

To detect the small growth increments which might be expected during infancy, a highly sensitive measuring system is needed. The first requirement is for the infant to be correctly positioned within the instrument. This is facilitated (a) by a *curved head-piece* at one end of the instrument, which serves to locate accurately the position of the baby's head, and (b) a *foot plate* which is mounted centrally on the carriage. The second requirement is an accurate and unbiased read-out system. As with other anthropometric instruments of the 'Harpenden' range, this is provided by a *number counter* mounted on the carriage which gives direct readings in millimetres. Measurements made in this way are more reliable and far less susceptible to reader error than those taken from a linear scale.

Early field studies with the instrument, nevertheless, showed that, despite careful positioning of the infant, repeated measurements carried out by one observer on a given subject according to a specified method (see below) resulted in a large and unacceptable spread of values. The factor found to have the most influence on this spread was the variation in pressure which was exerted by the foot plate on the infant's heel at the moment of counter read-out. To overcome this difficulty a *constant pressure catch* was fitted to the number counter to lock automatically the carriage at a measured point when a force of one pound is exerted by the foot plate. This device, therefore, eliminated an important operator variable and ensured a constant end-point measurement.

Technique of Measurement

The infant to be measured is placed within the instrument frame on a smooth table-top covered by a thin, warm cotton sheet (Fig. 2). An assistant holds the head firmly against the centre of the curved head piece so that the lower borders of the orbits lie in the same verical plane as the external auditory meati. At the same time the infant's shoulders are firmly fixed to the table by the assistant's index fingers. After ensuring that the infant's body lies parallel with the long axis of the instrument, the operator then fully extends the infant's right leg with his left hand and holds the foot at a right angle to the table top. The carriage is then moved towards the infant by the index finger of the operator's right hand on the constant pressure catch until the foot plate touches the infant's heel (Fig. 3). When a pressure of one pound is exerted by the foot plate on the heel the carriage becomes automatically locked, and the crown-heel length is read from the number counter.

Reproducibility Studies

To determine the precision with which crown-heel length could be measured with the Neonatometer the following experiment was undertaken: 10 infants between the ages of 0 and 3 months were measured by 4 observers, all of whom had been carefully taught the technique of measurement. 5 measurements were made consecutively on each of the 10 infants by each observer and care was taken to ensure that after each measurement the individual infants were removed from the frame and repositioned before the subsequent

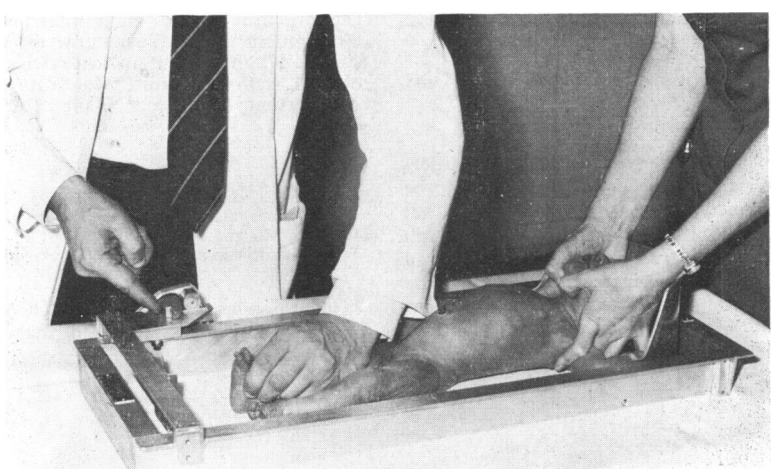

FIG. 2.—*The correct alignment of the infant within the instrument, with the head firmly held against the curved head-piece and the right leg fully extended. Observe the index finger of the operator's right hand on the constant pressure catch ready to move the carriage towards the infant.*

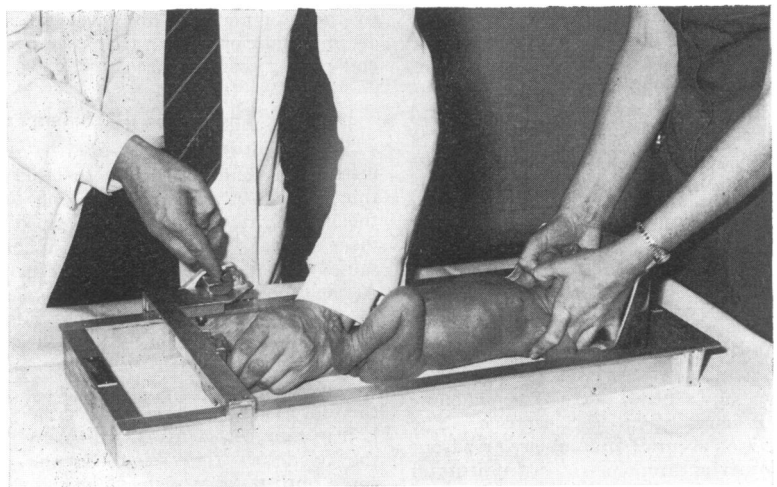

FIG. 3.—*The moment of measurement when the foot plate comes into contact with the infant's right heel. Note how the constant pressure catch has moved forward thereby locking the carriage.*

measurement. An analysis of variance was applied to the results (Table).

TABLE

Sources of Variation	Degree of Freedom	Sums of Squares	Variances	'F'
Observer	3	1·21	0·40	4·13*
Infant	9	284·49	31·61	1033·00†
Observers × infants	27	2·61	0·10	3·15†
Residual	160	4·90	0·03	
Total	199	293·21	—	—

*Significant at P <0·01.
†Significant at P <0·001.
Standard deviation of the differences between replicates 0·17 mm. Coefficient of variation 0·35%.

From this analysis the standard deviation of differences between replicate measurements was found to be 1·7 mm with a coefficient of variation of 0·35%. That is to say, only 1 in 20 observations of crown-heel length would have an error greater than 3·4 mm. There was a significant subject-observer interaction, with the differences found by the 4 observers being inconsistent with the various infants. However, with a standard deviation of differences between replicates of only 1·7 mm this interaction is interpreted as being of little practical importance.

Conclusion

Every skeletal anthropometric method requires careful attention to be given to the technique and training of observers if a high degree of accuracy and consistency is to be achieved. If these requirements are met with this new infant measurer, 95% of all observations of crown-heel length are likely to lie between ±3·4 mm of the true value.

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