Prenatal age-specific reference intervals for measuring all five digits of the fetal hand

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ABSTRACT

Objective To construct prenatal age-specific reference intervals for measurement of five digits in normal fetuses.

Patients and Methods Prospective cross-sectional study of fetuses assessed at an antenatal ultrasound unit in a university-affiliated general hospital. The study cohort comprised 302 pregnant women attending our clinic for routine fetal biometry or anomaly scan between December 1997 and June 2000. They all fulfilled the study inclusion criteria: singleton fetuses with normal anatomy, accurate gestational age and no medical complications of pregnancy. Each fetus was scanned once only and the finger measurements of one hand were obtained. Electronic calipers were placed on the outer margin of the proximal phalanx to the outer margin of the distal phalanx level. Those measurements and the relevant gestational age were registered in a computerized database.

Results The linear increase of size of each of the five fingers was plotted across the evaluated range of gestation (P < 0.001; r² between 0.85 and 0.86 for fingers I to V). Tables showing the 5th, 50th and 95th centiles of finger lengths between 14 and 27 weeks’ gestation were created based on the reference interval charts.

Conclusions Second-trimester measurement of all five digits of the fetal hand is feasible. This may assist in the evaluation of fetuses that are primarily suspected of having genetic abnormalities that might be expressed by deviation in finger length.

INTRODUCTION

The construction of reference charts for fetal limb growth has enabled the identification of a variety of genetic syndromes, in particular skeletal dysplasias1. Abnormal finger length may also be an important feature of genetic anomalies. Both extremely long fingers (arachnodactyly) and extremely short fingers (brachydactyly) may be associated with many genetic syndromes2–5, metabolic diseases6, in-utero exposure to teratogenic substances7, as well as other miscellaneous conditions8. Categorization of digit nomograms is based on radiological findings derived from neonates and infants. Sivan et al9 published postnatal reference ranges for the middle finger of infants born between 27 and 41 weeks of gestation. However, their nomograms may not be applicable for prenatal diagnoses, especially those carried out in the second trimester of gestation. Goldstein et al10 measured the length of the fifth digit in 173 euploid fetuses between 15 and 23 weeks’ gestation and constructed reference charts for this finger. They proposed incorporating this parameter with other known sonographic markers into the prenatal screening for Down syndrome10.

To the best of our knowledge, no prenatal age-specific reference intervals for all five fingers of the fetal hand have been reported previously. In light of the potential diagnostic implications of this kind of biometric measurement, the present study aimed to construct reference centile charts based on the normal population.

MATERIALS AND METHODS

This prospective cross-sectional study was conducted between December 1997 and June 2000. Pregnant women who underwent routine fetal biometry or anomaly scanning at our antenatal sonographic unit were enrolled. All of them volunteered to participate and agreed to undergo the measurements.

All measurements were performed by two experienced sonologists (J.T. and A.H.) using an ATL-3000 (Advanced Technology Laboratories, HDI-3000, Seattle, WA, USA) machine. Scans were performed with either a 2–4-MHz curvilinear abdominal transducer or a 5–9-MHz vaginal probe.

The study group included only singleton fetuses with normal anatomy and adequate amniotic fluid. This was a prospective cross-sectional study in which each fetus was
scanned during one visit, and only the fingers of one hand were measured. Exclusion criteria, similar to those utilized by Kurmanavicius et al.\textsuperscript{11,12} for fetal biometry assessment, included cases with uncertain gestational age, those missing a first-trimester scan, multiple gestation, fetal malformations and chromosomal abnormalities, and various medical complications of pregnancy. Fetuses with a difference of 10 days or more between gestational age and sonographic biometry were also excluded.

Although identification of the fetal digit may be feasible at as early as 12 weeks’ gestation, we chose to initiate our measurements at 14 weeks’ gestation because measurements seem to be more accurate at this age. This is in accordance with Goldstein et al.\textsuperscript{10}, who measured the fifth digit from 15 weeks’ gestation. The current study was limited to 27 weeks’ gestation because the fists are usually closed and evaluation of the fingers is more difficult and might be inaccurate as well as excessively time-consuming at a more advanced stage of gestation.

The gestational age was calculated from the first day of the last menstrual period and later confirmed by both a first-trimester crown–rump length scan and by second-trimester biometric measurements (biparietal diameter, head circumference, abdominal circumference and femur length). Data were rounded off to whole gestational weeks.

Earlier studies among Israeli newborns showed that there were no statistical differences between body size in relation to maternal ethnic origin\textsuperscript{13} or limb standards in relation to infant sex\textsuperscript{9}. Therefore, those parameters were not considered in the present study.

After sonographic visualization of the open hand, the location of the thumb (finger 1) was first identified and then all three phalanges of fingers 2–5 and the two phalanges of finger 1 were delineated. Based on previous recommendations by Goldstein et al.\textsuperscript{10}, whose methodology we used, we only measured the total length of each finger rather than any ratios between the phalanges. The images were magnified to two-thirds of the screen and the calipers were placed at the proximal end of the proximal phalanx and at the distal end of the distal phalanx of each finger (Figure 1). Special care was taken to perform the measurements with the fetal fingers in an extended position. This was achieved by only including cases with stretched fingers and visualization of interphalangeal space. The views and measurements were printed on a thermal hard copy for recording and only images of sufficient quality (similar to the one in Figure 1) were included for data processing and the rest excluded.

**Statistical analysis**

Fetal measurements including gestational age, fetal biometry, and each of the five digits’ measurements were registered on a computerized database. Data are presented as mean ± standard deviation (SD), or 5%, 50% and 95%, where appropriate. Gestational age-related reference ranges were constructed using linear regression analysis according to a previously published model by Royston and Wright\textsuperscript{14}. The calculations were performed in the Statistical Department of the Tel Aviv University using SPSS software (Chicago, IL, USA). A P-value < 0.05 was considered significant.

**RESULTS**

The study originally comprised 376 fetuses scanned between 14 and 27 gestational weeks. However, after reviewing the images, only 302 met the strict criteria previously mentioned and the rest were not included. Of those cases, 16 fetuses (5%) were scanned by a transvaginal approach.

Sonographic visualization and measurements of all five fingers were obtained in all 302 cases without exception. However, it was possible to obtain a coronal section of all five fingers in a single plane in only 22% of the cases (mainly in weeks 14–19) (Figure 1). Two separate planes were needed in 57% of the examined fetuses, one sectioning fingers 2–5 and the other for the thumb. Three or more frames were needed for the remaining 21% of cases. The average time needed for an accurate measurement of all five fingers was 9.0 ± 2.0 min.

Linear growth of each of the five fingers was observed across the evaluated range of gestation ($r^2 = 0.86$ for digits 1 and 2, $r^2 = 0.87$ for digits 3 and 4 and $r^2 = 0.85$ for digit 5, $P < 0.001$). The following equations for the measurement of the individual digits was applied:

\[
\begin{align*}
\text{mean length of digit 1} &= -5.471 + 0.729 \times \text{gestational week;}
\end{align*}
\]

\[
\begin{align*}
\text{mean length of digit 2} &= -8.463 + 1.026 \times \text{gestational week;}
\end{align*}
\]

\[
\begin{align*}
\text{mean length of digit 3} &= -9.276 + 1.122 \times \text{gestational week;}
\end{align*}
\]

\[
\begin{align*}
\text{mean length of digit 4} &= -8.912 + 1.086 \times \text{gestational week;}
\end{align*}
\]

\[
\begin{align*}
\text{mean length of digit 5} &= -6.238 + 0.835 \times \text{gestational week.}
\end{align*}
\]

Charts which depict the distribution across the gestational weeks of the measurements for each separate finger, are presented in Figure 2. The gestational age-specific reference interval of the 5th, 50th and 95th percentiles for each of the five finger lengths throughout 14–27 gestational weeks are presented in Table 1.

The method for calculating Z-score of a measurement is presented in the Appendix. For each separate digit, the

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![Figure 1](image.png)

*Figure 1* Coronal view of a fetal hand showing five digits. Measurements are as follows: digit 1 = 0.62 mm, digit 2 = 0.77 mm, digit 3 = 0.80 mm, digit 4 = 0.77 mm and digit 5 = 0.39 mm.
Figure 2. The distribution across the gestational weeks of the measurements for each separate finger. Diagonal lines represent 5th, 50th and 95th centiles.
variations of SD throughout 14–27 weeks’ gestation were around 0.1 mm. Therefore, for practical reasons, the values were rounded so that for each digit one figure was set, as follows: SD digit 1 = 1.0 (range, 1.018–1.027) mm, SD digit 2 = 1.4 (range, 1.439–1.450) mm, SD digit 3 = 1.5 (range, 1.537–1.551) mm, SD digit 4 = 1.4 (range, 1.444–1.456) mm and SD digit 5 = 1.2 (range, 1.220–1.224) mm.

### DISCUSSION

Results of the current study enabled us to show that between 14 and 27 weeks’ gestation all five digits of the fetal hand grow in a linear fashion and allowed us to construct normative data for the prenatal growth of all five fingers throughout the second trimester. Such data has not been reported yet. Our findings, concerning nomograms of the fifth digit, are in agreement with Goldstein et al.\(^\text{10}\). They reported a reasonable interobserver variation of about 8% and because the same methodology was used for measuring the other four digits, another repeatability test was not required.

We do not propose that digit measurement is incorporated into routine detailed anomaly scans. Nevertheless, in cases that require ‘genetic sonography’\(^\text{15}\), the integration of a fetal digit measurement into the antenatal assessment may be of real value. The data presented in this study may be applicable for the performance of a comprehensive work-up when there is a suspicion of fetal anomalies that may also include digital length variation. This is especially true for those cases in which abnormal finger length is part of the condition and a definitive prenatal diagnostic test is not yet available. However, clinical use of the nomograms presented in this study is of limited value. Whereas measurements located inside the 90% reference interval are regarded as normal, measurements falling outside are not necessarily abnormal. Antenatal measurements, throughout pregnancy, of cases defined after birth as having brachydactyly or arachnodactyly are not a definition of abnormality.

In conclusion, second-trimester measurement of the fetal digits is feasible. The presentation of prenatal age-specific reference intervals of all five fetal fingers may assist in the evaluation of fetuses investigated for having genetic abnormalities that might be expressed by deviation in finger length. We believe that this is an important addition to a target anomaly scan when deviation in length from that of the normal digit is suspected\(^\text{15}\). Insofar as the current data were retrieved from a normal population, the implementation of the current information for the identification of abnormal fetuses awaits further experience.

### ACKNOWLEDGMENT

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Z-score = (measurement − mean)/SD, where the mean is obtained from Table 1, for each digit, according to gestational age and SD is the standard deviation of the digits, between 14 and 27 weeks’ gestation, as follows: digit 1 = 1.0 mm, digit 2 = 1.4 mm, digit 3 = 1.5 mm, digit 4 = 1.4 mm and digit 5 = 1.2 mm.

APPENDIX


