A Study of Correlation between Anthropometric Measurements of FetalLimbs and Gestational Age of the Fetus

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Abstract

Introduction and Aims Determination of fetal age is of importance in the field of embryology and forensic sciences. Various methods and parameters have been used to calculate the same. The aim of the present study was to derive regression equations between anthropometric measurements of limbs of aborted fetuses and the gestational age of the fetuses.

Methods The study has been performed on 30 fetuses of gestational age varying from 13 to 32 weeks. The crown–rump length, length of the arm, forearm, hand, thigh, leg, and sole were measured with the help of manual sliding vernier caliper. Regression equations were derived using statistical methods.

Results The anthropometric measurements of the limbs showed a strong correlation with the crown–rump length and the gestational age.

Conclusions With the correlation demonstrated between anthropometric data and fetal age, and the regression equations derived using these data, would be helpful in determining the age of the fetus without availability of crown–rump length or using only fragments of mortal remains of the fetus.

Introduction

Fetal biometry is a methodology which is devoted to the measurement of several parts of fetal anatomy and their growth.¹

The fetal growth undergoes significant changes with advancement of pregnancy and must be evaluated against normal values specific to that age. The measurement of the fetal limbs can be used to date pregnancies. It can also form an important part of the assessment of fetal anatomy.²

Until recently, the study of intrauterine human growth was largely the concern of embryologists and obstetricians; today, however, it is actively pursued by anatomists and forensic experts. Their findings have attracted the interest of pediatricians for clinical reasons. Traditionally, anthropometric measurements were devised solely to describe human variation in body size, shape, the pattern of body growth, ethnic origin, and other parameters of interest mainly to anthropologists.³

The estimation of gestational age (GA) in fetal human remains is important to assess fetal viability, in addition to often being the only biological profile parameter that can be assessed with some accuracy for non adults. The length of the long bones is one of the most frequently used methods for fetal age estimation.⁴

The most accurate fetal age estimates are from crown–rump length (CRL) measurements in early pregnancy. Late pregnancy age estimates are less accurate, but the use of multiple body measurements provides a composite age estimate generally accurate to within 7% of actual age.⁵

Embryologically, at the end of the fourth week of development, limb buds become visible as outpocketings from the ventrolateral body wall. The forelimb appears first followed by the hindlimb 1 to 2 days later.⁶

The present study was performed to measure the physical parameters by gross anthropometric, non-imaging methods with the help of anthropometric instruments using a collection of aborted fetuses devoid of deformities.
These data were used to derive regression equations between the lengths of segments of fetal limbs with the GA.

Materials and Methods

A total of 30 fetuses were used for the present study. These fetuses were obtained after taking written consent from the concerned families and permission from the ethical committee of the Himalayan Institute of Medical Sciences. These fetuses included those obtained from spontaneous abortions. Fetuses with limb defects or any other gross anomalies were excluded.

The fetuses were embalmed by injecting 10% formalin locally in the abdominal cavity, cranial cavity, thoracic cavity, and also subcutaneously in the upper and the lower limb. The fetuses were then preserved in 10% formalin solution in jars.

The following measurements were taken by the help of a manual sliding vernier caliper (►Figs. 1 and 2):

1. The arm length (A) was measured as the distance between the cartilaginous prominence at tip of the shoulder (corresponding to acromion process) and distal (corresponding to the lateral epicondyle) most cartilaginous prominence of humerus (►Fig. 3).

2. The forearm length (B) was measured of the right side, between the proximal (corresponding to olecranon process) and distal (lower end) most cartilaginous prominence of the ulna (►Fig. 3).

Fig. 1  Graph showing relation between the length of the arm (mm), length of the forearm (mm), and length of the hand (mm) with the crown–rump length (crl) (mm).
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Fig. 2  Graph showing relation between the length of the thigh (mm), length of the leg (mm), and length of the sole (mm) with the crown–rump length (crl) (mm).

Table 1  Details of the fetuses according to CRL and gestational age

<table>
<thead>
<tr>
<th>Age (mo)</th>
<th>CRL (mm)</th>
<th>No. of fetuses</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>61–100</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>101–150</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>151–200</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>201–260</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>261–320</td>
<td>1</td>
</tr>
</tbody>
</table>

Abbreviation: CRL, crown–rump length.

3. The length of the right hand (E) was measured from the midpoint of flexor crease to the tip of the middle finger by keeping the wrist and fingers extended (►Fig. 4).

4. Similarly, the length of the right thigh (C) was measured between the proximal (corresponding to the greater trochanter) and distal (corresponding to the lateral condyle) most cartilaginous prominence of the femur (►Fig. 3).

5. The length of the right leg (D) was measured between the proximal (corresponding to the tibial tuberosity) and distal (corresponding to the lateral malleolus) most prominence of the tibia (►Fig. 3).

6. The sole length (F) was measured of the right side from highest point on the posterior end of heel to tip of the great toe (►Fig. 4).

Statistical analysis was done using SPSS version 20 and simple linear regression equations were derived.
Discussion

In the present study on 30 fetuses, segments of the fetal limbs were measured by gross anthropometric method, without using imaging techniques. The regression equations were derived to find the correlation between the CRL and the gross anthropometric measurements of limb segments. The p-value was found to be highly significant in all the five equations derived.

A study performed by Chaithra et al on 152 antenatal cases revealed that the relationship between the GA and the diaphyseal length of the femur is linear and direct. It was also found that the diaphyseal length of the femur can be an important parameter for estimating GA. In the present study, the length of the thigh of the fetuses between 13 and 32 weeks of gestation was found to have a strong correlation with the CRL.

The study performed by Carneiro et al concluded that the GA can be accurately determined by regression equations derived from the diaphyseal length of the long bones, namely the femur, tibia, humerus, radius, and ulna. In our study, we found strong correlation of the CRL with the external measurements of the arm, forearm, thigh, and leg lengths.

Merz et al measured the length of the femur, tibia, humerus, radius, and ulna by ultrasonographic method and found a strong linear relationship between the biparietal diameter and bone length for each bone. In our study, we measured externally the length of the thigh, leg, arm, and forearm and found all of them to have a strong correlation with the CRL and hence the GA.

Mhaskar et al conducted an ultrasonographic study and measured the foot length. The comparison of GA and linear regression of the foot length demonstrated a strong correlation with a $r^2$ value of 0.84. In our study, the value of $r^2$ was 0.948 for the sole length.

In a study done by Kumar et al, it was concluded that the linear regression model for estimating fetal GA is the femur length. In our study, we found a strong correlation between the length of the thigh and GA.

Two separate studies done by Sharma et al and by Bardale and Sonar derived a statistically significant linear relationship between fetal hand length and GA, the $r^2$
value being 0.986 and 0.978, respectively. The p-value was < 0.0001 in both the studies. In our study, the $r^2$ value was 0.949 and the p-value was < 0.001.

**Conclusion**

To conclude, in the determination of the GA, the fetal limbs’ anthropometric measurements can play an important role. The parameters of the upper limb, i.e., lengths of the arm, forearm, hand, and that of the lower limb, i.e., the thigh, leg, foot length, increase significantly with increasing GA. The CRL can be measured by the equations derived and hence the GA, especially in forensic settings when the CRL is not known or cannot be measured or in cases where there are partial remains of the fetus. More anthropometric studies can be done on a higher number of sample sizes and on various other external measurements.

**Conflict of Interest**

The authors have no conflicts of interest to disclose.

**References**