Original Article

Humeral Length versus Femur Length for Estimating Fetal Age in the Third Trimester Using Ultrasound among Saudi Fetuses

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Abstract

Background: Ethnicity can influence organ measurements, so each ethnicity should provide normal references. The study was conducted to measure the normal ranges of humeral and femoral diaphysis lengths, to compare them during the third trimester of pregnancy in the Saudi population, and to identify their role in estimating fetal age. **Methods:** This cross-sectional study was conducted among 60 normal singleton pregnant females in the third trimester. The fetal humeral length (HL) and femur length (FL) were taken during ultrasound scanning for follow-up. The IBM Statistical Package for the Social Sciences Version 23 was used to summarize the data and to compare both the lengths with the last menstrual period (LMP) using Pearson's correlation. The comparison was considered statistically significant if $P < 0.05$. **Results:** The mean humeral and femoral diaphysis lengths ± standard deviations were 4.84 ± 1 cm and 5.54 ± 1.2 cm, respectively. A positive linear correlation was present between the length and LMP. The correlation of HL with LMP ($r = 0.828$) was higher than that of FL with LMP ($r = 0.770$). HL and FL were correlated. They showed a Pearson's coefficient of 0.941. The study revealed that gender does not affect fetal HL and FL. **Conclusion:** Normal reference ranges for femur and humeral diaphysis lengths during the third trimester were provided. The humerus can be used to assess fetal age. Humerus and femur were correlated to each other among Saudi fetuses. Another study with a larger sample size is recommended.

Keywords: Femur length, gestational age, humeral length, third trimester

Introduction

An accurate estimation of fetal age is critical[1] because it assesses fetal development and developmental disorders, such as intrauterine growth retardation.[2] Furthermore, accurate estimation of fetal age increases the accuracy of estimating the expected delivery date, reduces postdate labor induction, and improves obstetric care.[3] Ultrasound is the modality used to assess fetal growth.[2]

In ultrasound departments, the last menstrual period (LMP) and the first ultrasound examination were recorded. Determining fetal age with the help of ultrasound by measuring fetal organs is more accurate than relying on LMP.[4]

In the third trimester, a combination of multiple biometric parameters, including biparietal diameter, head circumference, abdominal circumference, and femur length (FL), is used for estimating gestational age (GA), rather than a single parameter.[3] The study "Estimation of Gestational Age from Measurements of Fetal Long Bones" found that the standard deviation (SD) does not increase with increasing FL. Therefore, these data can be useful in predicting GA in the second half of pregnancy.[5]

Different studies have confirmed the accuracy of estimating GA by humeral length (HL). Patre *et al*. found that HL is an accurate parameter compared to FL in assessing GA. The accuracy increases with the use of a combination of multiple biometric parameters in predicting GA in the third trimester of pregnancy.[6]

There are differences in the growth of the limbs between different ethnic groups, which should be considered.[7] For example, a previous study found significant differences

Received: 15-03-2022 **Revised:** 20-04-2022 **Accepted:** 06-05-2022 **Available Online:** 19-07-2022

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jmut

DOI: 10.4103/jmu.jmu_26_22

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How to cite this article: Hassan MG. Humeral length versus femur length for estimating fetal age in the third trimester using ultrasound among Saudi fetuses. J Med Ultrasound 2023;31:133-6.

in fetal growth among different ethnic groups: Hispanics, non-Hispanic, and Asians.[8]

Despite the significant correlation between the humerus and LMP, the measurement of HL is not used in general practice for estimating GA. Many sonographers sometimes find problems with the scanning of the femur due to fetal position. Determining a significant correlation of HL with LMP will solve the problem and give another parameter that can be combined with another fetal biometry during the third trimester for more accuracy. The study was conducted to find references for estimating GA using the femur and humerus among Saudi fetuses.

Methods

Subject selection, place, and equipment

The study included 60 healthy Saudi females with normal singleton pregnancies in the third trimester who came to the ultrasound departments for follow-up at different hospitals in Riyadh. The study excluded any pregnancy with multiple gestations, diabetic pregnant females, pregnancy-induced hypertension, fetal congenital anomaly, or pregnancy with oligohydramnios or polyhydramnios. For this examination, a convex US transducer with frequency ranging between 2 and 5 MHz was used.

Study design and data collection

This cross-sectional study obtained measurements during routine US scanning. A designed data collection sheet that included all the study variables was used. The variables included LMP and HL and FL.

The transducer was moved to the shoulder girdle, and the scapular spine was imaged to obtain the humerus's full length. Then, the transducer was rotated until the entire length of the humerus was shown. Measurement was taken between the two ends of the humeral diaphysis. After the fetal iliac crest was visualized, the transducer was rotated to obtain an image of the whole length of the femur. Again, measurement was taken between the two ends of the femoral diaphysis.

Statistical analysis

The IBM Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) Version 23 for Windows was used. The data were summarized as mean ± SD. Then, Pearson's correlation tests were used to compare the variables and analyze the significance of the results. The comparison was considered statistically significant if $P < 0.05$.

Ethical considerations

Ethical approval was obtained from the research center at Princess Nourah Bint Abdulrahman University before the data collection (IRB number: 22-0078). The patient informed consent was obtained.

Results

The study included 60 fetuses in the third trimester. Table 1 demonstrates the basic characteristics of the study population (number of fetuses measured at each GA [weeks] and fetal gender). 40% of fetuses were in the 30th week of pregnancy, and 60% were male. The mean ± SD of the study's parameters was calculated. HL ranged between 3.32 and 6.36 cm, and FL ranged between 3.34 and 7.74 cm [Table 2]. Pearson's correlation was used to assess the difference between the parameters. The study revealed a significant correlation between LMP and HL, LMP and FL, and FL and HL ($P < 0.001$) [Table 3]. Because of these positive linear correlations, fetal age can be estimated using HL and FL [Figures 1 and 2]. HL can be predicted if FL is known [Figure 3]. An independent samples *t*-test was used to compare the means of HL and FL classified by fetal gender. The difference was not significant ($P > 0.001$), as shown in Table 4.

Table 1: The basic characteristics of the study population

	Number (frequency)	Percentage
Gestational age (weeks)		
28	2	3.3
30	24	40
31	2	3.3
33	10	16.7
34	8	13.3
35	4	6.7
36	4	6.7
37	2	3.3
39	4	6.7
Total	60	100
Fetal gender		
Male	36	60
Female	24	40
Total	60	100

Table 2: Mean±standard deviation, minimum and maximum of the last menstrual period (weeks), humeral length, and femur length (cm)

Parameters	Mean±SD	Minimum	Maximum
LMP	32.57±2.9	28	39
HL	4.84±1	3.32	6.36
FL	5.54±1.2	3.34	7.74

LMP: Last menstrual period, HL: Humeral length, FL: Femur length, SD: Standard deviation

Table 3: Pearson's correlation between the variables of the study

Correlations	HL	FL
LMP		
Pearson correlation	0.828**	0.770**
P	0.000	0.000
HL		
Pearson's correlation		0.941**
P		0.000

**Correlation is significant at the 0.01 level. LMP: Last menstrual period, HL: Humeral length, FL: Femur length

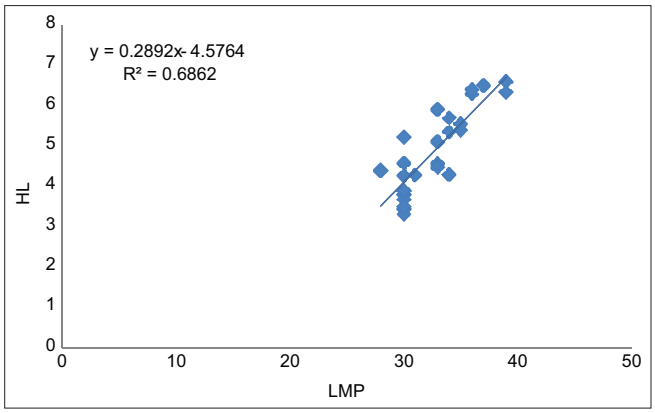

Figure 1: Scatter plot showing a positive linear correlation of LMP with HL. HL increases by 0.2892 cm when LMP increases by 1 cm. Fetal age (LMP) can be predicted using the following equation: Fetal age = HL + 4.5764/0.2892. LMP: Last menstrual period, HL: Humeral length

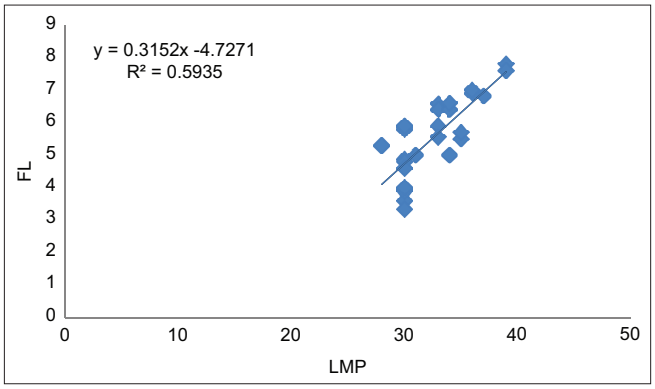

Figure 2: Scatter plot showing a positive linear correlation of LMP with FL. FL increases by 0.3152 cm when LMP increases by 1 cm. Fetal age (LMP) can be predicted using the following equation: Fetal age = FL + 4.7271/0.3152. LMP: Last menstrual period, FL: Femur length

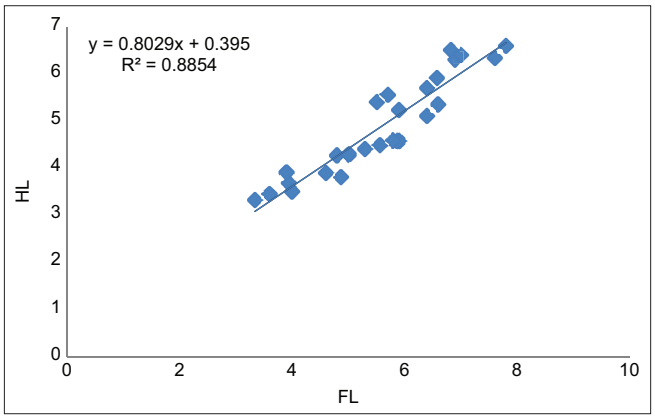

Figure 3: Scatter plot showing a positive linear correlation of HL with FL. FL increases by 0.8029 cm when LMP HL increases by 1 cm, where FL can be predicted using the following equation: FL = 0.8029HL + 0.395. HL: Humeral length, FL: Femur length

Discussion

The length of the long bone diaphysis is used to estimate fetal age with some accuracy. Accurate fetal age estimates the estimated due date and normal fetal growth. These long bones are also important for forensic settings to assess fetal viability.[9,10] Because each race or population has its own measurements, this cross-sectional study was conducted to assess the measurements of the femur and humerus among Saudi fetuses in the third trimester.

Table 4: Distribution of humeral and femur lengths means classified by fetal gender

Gender	Mean±SD	*P*	Mean difference	95% CI of the difference	
				Lower	Upper
FL					
Males	5.5±1.4	0.838	−0.065	−0.697	0.567
Female	5.6±0.71				
HL					
Males	4.9±1.2	0.732	0.927	−0.446	0.632
Female	4.8±0.76				

CI: Confidence interval, SD: Standard deviation, HL: Humeral length, FL: Femur length

All 60 pregnant females with a normal pregnancy in the third trimester came to the ultrasound department for follow-up. The mean ± SD of fetal age estimated by LMP is 32.57 ± 2.9 weeks. This study used LMP to estimate GA and not crown–rump length (CRL), which is more accurate. This is because those pregnant females who came for follow-up were within the advanced weeks of pregnancy, and there was no data about CRL in their records.

Among Saudi fetuses, the humeral diaphysis mean length ± SD was 4.84 ± 1 cm, and the femoral diaphysis was 5.54 ± 1.2 cm. This study revealed a significant difference between the study variables ($P < 0.001$). A strong positive linear correlation was found between LMP and HL ($r = 0.828$), LMP and FL ($r = 0.770$), and HL and FL ($r = 0.941$). The coefficient of these correlations can be used in a regression equation to predict fetal age and fetal femoral and humeral diaphyses.

This study's minimum HL and FL were too short for the normal fetus (GA: 20–21 weeks). It may be due to inaccurate estimation of LMP by those females or the effect of different factors such as maternal BMI and age.

This result implies that fetal age can be determined through an equation using the fetal humeral diaphysis as fetal age = HL + 4.5764/0.2892 and fetal femoral length as fetal age = FL + 4.7271/0.3152. Furthermore, the correlation of HL with LMP was stronger than the correlation of FL with LMP.

The femoral diaphysis length can be predicted through an equation using the fetal humeral length as FL = 0.8029 and HL + 0.395.

This result contradicts a previous study that disproved the correlation between HL and FL, such as Gameraddin *et al*.'s study, which proved the significant correlation of HL with LMP.[11] Another study revealed a significant difference between Saudi femoral lengths and GAs.[12]

These values are highly recommended for use by practitioners in Saudi Arabia for fetuses in the third trimester. HL measurement can be combined with other measurements because the accuracy of estimating fetal age decreases in the third trimester.[13]

Different studies proved the effect of gender on fetal growth. However, in this study, HL and FL were not statistically significantly different in gender; this may be due to the small sample size compared to other studies.

Conclusion and Recommendation

The study proved the correlation between LMP, HL, and FL among Saudi fetuses in the third trimester. Therefore, standard reference values have been provided for fetal humerus and femur measurements and recommended to predict GA. Fetal gender does not affect fetal growth, according to this study.

Another study with a larger sample size is recommended. The sample should include fetal age in all third trimester weeks, different factors (e.g., maternal age, maternal BMI, and reproductive history) and the calculation of the FL and HL percentile (10^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th}) at each GA. In addition, the sample size should include females with records from early pregnancy in the new study, and CRL can be used instead of LMP.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Acknowledgment

Special thanks are extended to my student, Nahlaa Khudair, for her help and assistance with data collection.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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