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RESEARCH ARTICLE

Fetal Humerus Length Nomogram in Gestational Weeks 19-24: Clinical Significance, Gender and Turkish Ethnical Differences

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Abstract

Introduction: Objective To create a comprehensive fetal humerus length nomogram that is both gender- and ethnically relevant and applicable to the specified gestational weeks.

Methods: We conducted a retrospective cohort study that included singleton pregnancies between 19 and 24 weeks of gestation who were admitted to our clinic between 2021 and 2023. The study population comprised pregnant women who identified themselves as originating from the primary Turkish ethnic group and are between the age of 18 to 45. Ultrasonographic measurements were conducted by a single clinician using a General Electric Voluson E6 (USA) ultrasonography device with a transabdominal approach. Biometric evaluation of fetus was determined with measurements taken for Biparietal Diameter, Head circumference, Abdominal Circumference, Femur Lenght and Humerus Lenght.

Results: Gender-specific nomograms were constructed according to the gestational weeks. No significant differences were observed between the fetal genders,however, the humerus length of the fetuses was found to be greater than that documented in other populations, as evidenced in the WHO fetal growth charts.

Conclusion: The findings of our study demonstrate the necessity of ethnic-specific fetal HL nomograms. Furthermore, we anticipate that our results will contribute to the development of customised fetal nomograms for the Turkish population, in the future. In conclusion, by using a nomogram that accounts for ethnic differences, clinicians can better identify at-risk populations and provide targeted interventions, ultimately improving fetal outcomes.

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Introduction

The measurement of fetal humerus length (HL) during second trimester sonography provides essential insights into fetal growth and development. This period is particularly significant as it marks a phase of rapid skeletal development, where the accurate assessment of long bone lengths can serve as an important indicator of overall fetal health. The humerus becomes visible on ultrasound at 10 weeks of gestation. The optimal measurement of HL is taken between the two ends of the diaphysis.[1] Several studies have demonstrated that ultrasonographic measurement of HL can be employed to assess the fetal skeletal system and fetal growth and development in instances where conventional measurements such as Biparietal diameter (BPD) and Femur lenght (FL) cannot be obtained with sufficient accuracy. HL also plays an important role in the assessment of potential growth restriction, developmental abnormalities and aneuploidies, so it is very important to establish customised growth standards that incorporate maternal and fetal variables to improve the detection of abnormal conditions.[2]

The concept of a universal standard has been challenged on the grounds that a multitude of biological and cultural factors can exert an influence on fetal growth, including those pertaining to racial and ethnic backgrounds.[3] A cross-sectional study that compared fetal long-bone lengths across different populations, highlighting the necessity of considering demographic factors when interpreting fetal measurements.[4] It is therefore crucial to develop population and gender specific reference ranges in order to guarantee the precision of assessments.

The creation of HL nomograms for the evaluation of healty fetal development and the prediction of FGR and aneuploidy, with consideration of ethnic variations and fetal gender will enhance the clinical utility of these measurements. For this purpose, we created the HL nomograms of our patients evaluated at Selcuk Univercity Perinatology Clinic with the aim of contributing to the specific nomograms of the Turkish population.

Material and Methods

We conducted a retrospective cohort study that included singleton pregnancies between 19 and 24 weeks of gestation who were admitted to our clinic between 2021 and 2023. The study population comprised pregnant women who identified themselves as originating from the primary Turkish ethnic group and are between the age of 18 to 45. The last menstrual period was used to determine the gestational week. In pregnant women whose last menstrual period was not known, the gestational week was determined by first-trimester crown–rump length (CRL) measurement or second-trimester BPD. Pregnancies with structural and karyotype anomalies, preterm premature rupture of membranes, intrauterine growth retardation, maternal systemic diseases and multiple pregnancies were excluded from the study. The Local Ethics Committee of Selçuk University Rectorate gave permission to conduct the study with the document date and number 19.01.2023-E.440154.

Ultrasonographic measurements were conducted by a single clinician using a General Electric Voluson E6 (USA) ultrasonography device with a transabdominal approach. Biometric evaluation of fetus was determined with measurements taken for BPD, Head circumference (HC), Abdominal Circumference (AC), FL and HL. The fetal gender was assessed, and fetal anomaly screening was performed. HL was properly measured in the horizontal plane between the two ends of the diaphyseal portion of the bone in close proximity to the probe as recommended by ISUOG.[5] The percentile values of Göynümer et. Al. and Yorgunlar et. Al studies [6,7] and the WHO fetal growth chart study according to fetal HL are shown side by side with our study results

The statical analyses were performed using SPSS (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL) 22. Descriptive data were presented as n, % values for categorical data, and mean±standard deviation (mean±SD) and percentile values for continuous data and the percentile values of Göynümer et. Al. and Yorgunlar et. Al studies and the WHO fetal growth chart study according to fetal HL are shown side by side with our study results. The suitability of continuous variables for normal distribution was assessed by the Kolmogorov-Smirnov test. The Mann-Whitney U test was used to compare paired groups

The level of statistical significance in the analyses was accepted as $p<0.05$.

Results

The study included 660 pregnant women with a mean age of 27.5±3 (min=18 - max=45) years. Overall, 305 (46.2%) fetuses were female and 355 fetuses were (53.8%) male. The mean height of the pregnant women was 164.9±5.4 cm, the mean weight was 70.8±12.5 kg and the mean BMI was 26.1±4.3 kg/m2. The mean gravida was 2.2±1.3 and the mean parity was 1,2±1.0 (Table 1). When the gestational weeks of the pregnant women were analyzed, 75 (11.4%) were in the 19th week, 207 (31.4%) in the 20th week, 199 (30.2%) in the 21st week, 106 (16.1%) in the 22nd week, 55 (8.3%) in the 23rd week and 18 (2.7%) in the 24th week.

Table 1. Main demographic features of study group

	n % Mean±SS
Maternal Age	27,5±5,3
Height (cm)	164,9±5,4
Weight (kilograms)	70,8±12,5
BMI (kg/m2)	26,1±4,3
Gravida	2,2±1,3
Parity	1,2±1,0

BMI:Body Mass Index

Comparision of all biometric measurements in terms of fetal gender is summarized by Table 2. The BPD measurements of female fetuses were found to be significantly lower than that of male fetuses (p=0.041). No significant difference was observed between the genders for remaining features (p>0.05 for all).

Table 2. Comparison of biometric measurements according to gender

	Female				Male				p*
	mean±SS	5p	50p	95p	mean±SS	5p	50p	95p	
BPD (mm)	50,8±4,5	44	50	58	51,6±4,9	45	51	60	**0,041**
HC (mm)	189,5±14,3	169	188	216	191,4±15,7	170	190	221	0,164
AC (mm)	165,6±16,8	144	163	191	166,8±16,6	144	165	198	0,245
FL (mm)	36,3±4,0	30	36	43	36,3±4,2	30	36	43	0,841
HL (mm)	34,9±3,5	30	34	41	34,8±3,8	30	35	41	0,626
EFW (grams)	446,5±102,8	312	427	636	453,8±109,5	319	434	677	0,461

* Mann Whitney U test was performed.

A second analysis was performed for each gestational week as shown in Table 3. BPD (p=0.018), HC (p=0.003) and EFW (p=0.023) of female fetuses at 21 weeks gestational age were significantly lower than those of male fetuses. At 22 weeks gestational age, BPD measurements of female fetuses were significantly lower than those of male fetuses (p=0.01). The BPD measurement of female fetuses at 23 weeks of gestation was significantly lower than that of male fetuses (p=0.005). The HC (p=0.006) and AC (p=0.035) measurements of female fetuses at 24 weeks' gestation were significantly lower than those of male fetuses (Table 3).

Table 3. Comparison of measurements by gender according to gestational weeks

		Female		Male		p*
		mean±SS	**5p-50p-95p**	**mean±SS**	**5p-50p-95p**	
19. w	BPD	46,5±2,8	42-47-52	46,7±2,5	42-47-50	0,793
	HC	173,0±8,6	158-172-188	172,9±7,0	160-174-182	0,856
	AC	151,0±7,6	136-150-166	149,1±9,4	134-150-162	0,602
	FL	32,0±2,1	28-32-36	31,7±2,0	29-32-34	0,784
	HL	30,7±2,1	27-31-34	30,9±2,2	27-31-35	0,884
	EFW	342,7±37,0	274-340-404	335,0±37,6	266-333-388	0,392
20. w	BPD	48,2±2,7	44-49-52	49,6±4,6	45-50-54	**0,004**
	HC	179,9±7,5	167-180-190	183,2±9,0	169-184-197	**0,005**
	AC	156,0±10,6	142-155-173	159,1±12,2	145-160-173	**0,001**
	FL	33,5±2,4	29-33-37	34,6±3,7	30-34-38	**0,032**
	HL	32,7±2,1	29-33-36	33,1±2,3	30-33-37	0,108
	EFW	374,6±49,0	299-373,5-452	397,9±48,4	320-399-480	**0,001**
21. w	BPD	50,6±2,6	46-50-55	51,5±2,7	48-52-56	**0,018**
	HC	188,5±8,1	175-189-203	192,1±7,7	180-192-206	**0,003**
	AC	165,2±8,9	154-163-183	167,3±10,7	151-168-182	0,145
	FL	36,1±2,2	32-36-40	36,5±2,5	32-37-40	0,131
	HL	34,9±2,3	32-35-39	35,1±3,6	31-35-39	0,865
	EFW	433,7±53,0	355-438-522	450,0±58,8	349-456-548	**0,023**
22. w	BPD	53,5±2,9	49-53,5-58	55,1±2,8	50-55-60	**0,010**
	HC	201,8±8,8	185-201,5-216	204,7±7,7	194-205-218	0,090
	AC	174,2±15,8	161-175,5-194	178,5±9,6	165-177-198	0,117
	FL	39,9±2,2	36-40-45	39,2±2,3	35-39-42	0,172
	HL	37,8±2,2	34-38-41	37,5±2,3	34-37-41	0,357
	EFW	531,1±64,3	422-533,5-639	540,3±61,7	452-534-651	0,530
23. w	BPD	56,9±6,3	52-56-59	58,2±3,9	50-59-63	**0,005**
	HC	210,7±7,6	203-209-223	213,8±12,2	187-214,5-232	0,172
	AC	190,4±20,0	173-187-208	189,1±9,9	167-190-202	0,284
	FL	41,9±2,3	39-42-46	41,8±3,1	37-41-47	0,819
	HL	39,4±2,7	36-39-45	39,4±2,6	35-39-43	0,852
	EFW	607,6±61,9	517-600-702	617,6±91,0	437-614-754	0,414
24. w	BPD	58,7±4,5	50-60-63	61,2±2,8	55-61-66	0,285
	HC	214,9±6,1	202-216-221	228,7±14,4	216-227-265	**0,006**
	AC	193,4±9,3	183-191-211	204,5±10,2	184-203-224	**0,035**
	FL	43,3±2,4	40-44-46	44,3±2,8	40-45-48	0,425
	HL	40,0±2,3	37-40-43	41,5±2,5	36-41-45	0,246
	EFW	680,3±86,6	569-657-803	755,2±86,1	594-797-862	0,085

* Mann Whitney U test was performed.

The main findings of the HL percentiles for each Gestational week are shown in Table 4, regardless of gender.

Table 4. HL percentiles acording gestational weeks, regardless of gender

	Percentiles								
Gestational week	2,5	5	10	25	50	75	95	97,5	99
19.w	25,9	27,0	28,0	30,0	31,0	32,0	34,0	35,0	35,0
20.w	28,2	30,0	30,0	31,0	33,0	34,0	36,0	37,0	37,0
21.w	31,0	31,0	32,0	33,0	35,0	36,0	39,0	39,0	43,0
22.w	32,7	34,0	35,0	36,0	38,0	39,0	41,0	42,0	42,0
23.w	34,4	36,0	36,0	37,0	39,0	41,0	44,0	45,0	45,0
24.w	35,9	36,0	36,9	40,0	41,0	43,0	45,0	45,0	45,0

A significant positive correlation was observed between HL and BPD, HC, AC, FL and gestational week (Table 5, Figure 1-4)

Table 5. Correlation of Humerus Lenght with other parameters

	HL (mm)	
	r	p
BPD (mm)	0,741	<0,001
HC (mm)	0,813	<0,001
AC (mm)	0,748	<0,001
FL (mm)	0,834	<0,001
Gestational week	0,753	<0,001

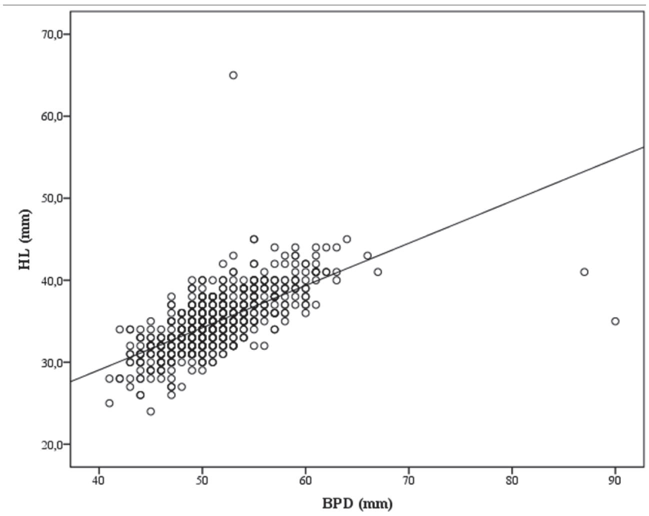

Figure 1. Correlation between HL and BPD measurments

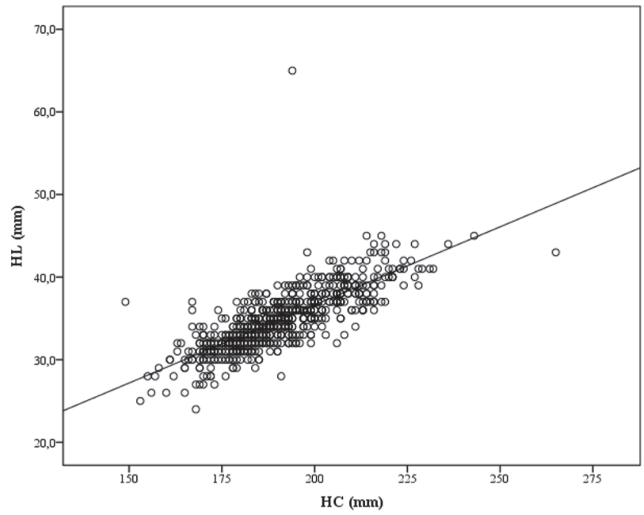

Figure 2. Correlation between HL and HC measurments

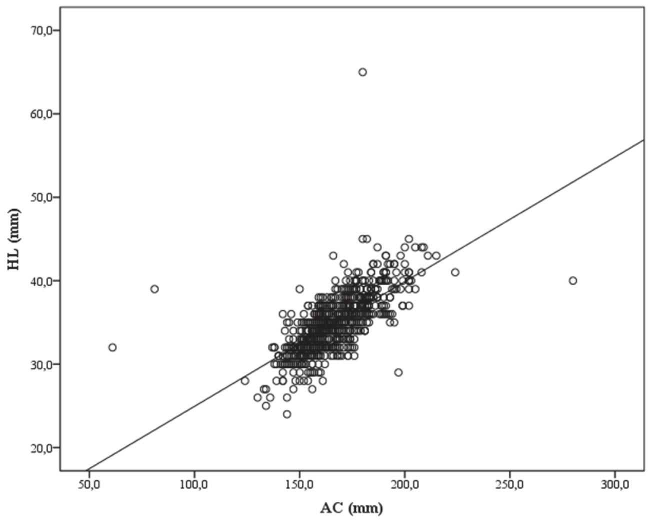

Figure 3. Correlation between HL and AC measurments

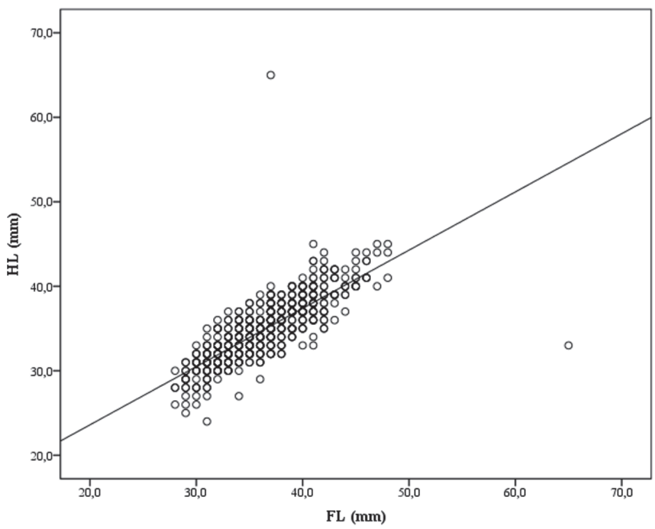

Figure 4. Correlation between HL and FL measurments

Comparision of our findings with previous Turkish studies and WHO fetal growth charts are summarized in Table 6

Table 6: Table showing HL percentiles by Gestational week (GW) in studies conducted in different Turkish populations and WHO Fetal Growth Charts.

GW	Our study				WHO Fetal Growth Charts			Göynümer et. Al.			Yorgunlar et. Al.		
	2,5p	5p	50p	95p	5p	50p	95p	5p	50p	95p	5p	50p	95p
19.w	25,9	27	31	34	25	28	31	25	29	32	22	29	33
20.w	28,2	30	33	36	28	31	33	29	32	35	26	31	35
21.w	31	31	35	39	31	34	36	30	33	37	30	32	37
22.w	32,7	34	38	41	33	36	39	33	36	39	32	35	38
23.w	34,4	36	39	44	35	38	41	34	38	41	34	37	41
24.w	35,9	36	41	45	37	41	43	35	39	45	36	39	42

Discussion

Fetal HL at 19-24 weeks of gestation is a critical parameter in prenatal assessments, serving as a reliable indicator of fetal growth and development. Furthermore, it is used to predict aneuploidy and FGR. Therefore, it is essential to investigate whether HL nomograms differ regionally, racially and between fetal genders. Integrating these demographic factors into clinical practice not only supports individualized patient care, but also contributes to better prenatal monitoring, diagnosis and fetal health outcomes.[4]

The findings presented by Kasraeian et al., in their study on fetal long-bone length provide crucial insights into the development of a nomogram for fetal HL. Their research highlights that variations in long-bone measurements among different populations can significantly influence the accuracy of gestational age assessment and the identification of potential congenital anomalies, thereby underscoring the necessity of spesific reference standards in obstetric practice.[8] Similarly; another study established nomograms for all the fetal limb bones in the Chinese ethnic population, which showed lengths comparatively shorter than Caucasian and Afro-Caribbean nomograms. They antipiciated that this would reduce the false alarm of short fetal limb bone lengths and the consequent anxiety and intervention.[9]

Our study revealed that the length of the humerus is greater than that observed in other populations, as documented in the WHO fetal growth charts. Additionally, it was noticed that there can be regional variations in this phenomenon. When the literature was reviewed, only 2 studies in terms of HL measurement from Turkey was found.[6,7] Both previous studies provided a comprehensive analysis of fetal HL during gestational weeks 18-24 in the İstanbul region and their HL nomograms are different from ours but very similar to the WHO growth charts.[10] The percentile values of these two studies and the WHO fetal growth chart study according to fetal HL are shown in Table 6 side by side with our study results. In particular, when the 2.5 percentile values of all gestational weeks in our nomogram were considered, these values were found to be consistent with the 5 percentile values in other studies, and when the 5 percentile values were considered, these HL values were found to be 1.2 mm longer on average across all gestational weeks compared with other studies. This result may be based on the fact that the population of Istanbul is diverse and consists of many different ethnic groups. While the greater HL measurements in our study may be attributed to the participation of a perinatologist, the utilisation of advanced ultrasound equipment, or advancements in prenatal care and nutrition, it remains possible that ethnic and geographic differences still exist and emphasises the need for the development of customised nomograms as literature indicates.

Fetal gender differences in fetal measurements have also been studied previously. Literature indicates that while there may be variations in fetal growth patterns between male and female fetuses, the differences in HL specifically may not be as pronounced as in other measurements. Hassan's study highlighted that fetal HL and femur length were comparable in estimating fetal age among Saudi fetuses, suggesting that while gender may play a role in overall fetal growth, it may not significantly impact HL length.[11] Similar to the literature, we found no statistically significant difference between HL measurements in terms of fetal gender.

The clinical utility of a fetal HL nomogram extends beyond mere measurement; it can also facilitate early detection of FGR and aneuploidies. The findings presented by Carvalho et al. highlighted the importance of utilizing spesific fetal HL nomograms, particularly in the context of identifying growth restrictions. The research findings indicated that fetuses with shortened HL may require closer monitoring especialy for FGR;[2] also the association between fetal bone lengths and chromosomal abnormalities, such as

Down syndrome, has also been well-documented.[12] Y. Tannirandorn et al. confirm that HL is significantly shorter in Down syndrome fetuses than in normal fetuses also support the previous literature about Asian population ,that second trimester fetuses in Asian population have shorter HL compared with caucasian and Afro-American fetuses.[13,14] Additionally, these studies suggest that gender and ethnic differences may impact the accuracy of FGR and congenital genetic anomalies and accordingly fetal outcomes.

The limitations of our study are that it was performed in a single center, the number of patients was small and it was retrospective.

Our study provides a comprehensive analysis of fetal humeral length between 19 and 24 weeks of gestation, with particular consideration of the ethnic and gender characteristics of the fetuses. The findings of our study demonstrate the necessity of ethnic-specific fetal HL nomograms. Furthermore, we anticipate that our results will contribute to the development of customised fetal nomograms for the Turkish population, in the future. In conclusion, by using a nomogram that accounts for ethnic differences, clinicians can better identify at-risk populations and provide targeted interventions, ultimately improving fetal outcomes.

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