Gestational Age and its Relationship with Elbow Width, Wrist Width and Forearm Length

Gestasyonel Yaş ile Dirsek Genişliği, Bilek Genişliği ve Önkol Uzunluğu Arasındaki İlişki

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ABSTRACT Objective: Fetal development has been a subject of great interest from earliest times to the present day and can today easily be analyzed using ultrasound (US) and similar devices. The lengths or diameters of various fetal structures are measured, and intrauterine age and development can thus be monitored. Our study investigates the value of a series of lengths measured in the upper extremity in the monitoring of intrauterine age and development. **Material and Methods:** We measured the forearm length, hand length, wrist width and elbow widths of 21 fetuses (seven males, 14 females) estimated at 17.0-35.8 weeks intrauterine age according to foot length and with no visible abnormalities. These were compared to each other and analyzed with respect to gender. Measurements were taken using dividers and a vernier digital caliper. **Results:** No differences were determined between the groups statistically for the parameters measured and when they were compared for gender. Elbow and wrist widths and hand, forearm and foot lengths obtained from fetuses and the ratios of some of these measurements demonstrated considerable correlation (similarity) with measurements and proportions on the opposite side of the body and with intrauterine age. **Conclusion:** Measurable wrist and elbow widths and forearm, hand and foot length in whole or fragmented fetuses were determined to be individually valuable in diagnosing gestational age. It was also concluded that elbow and wrist width to forearm length ratios on the same side were important in monitoring intrauterine extremity development.

Key Words: Gestational age; fetal development; forearm; hand; wrist; elbow

ÖZET Amaç: İlk zamanlardan günümüze merak uyandıran fetal gelişim bugün ultrasonografi (US) ve benzeri cihazların sağlamış olduğu olanaklarla rahatlıkla değerlendirilebilmektedir. Bunun için bir takım fetal yapıların uzunlukları ya da çevreleri ölçülmektedir. Böylece intrauterin yaş ve gelişim takip edilebilmektedir. Çalışmamızda üst extremite de ölçülen bir takım uzunlukların intrauterin yaş ve gelişimin takibindeki değeri sorgulandı. **Gereç ve Yöntemler:** İntrauterin yaşları ayak uzunluklarına göre 17.9-35.8 haftalar ile ilişkilendirilen 21 adet (yedi erkek, 14 kadın) görünür anomalisi olamayan fetusun; önkol uzunluğu, el uzunluğu, el bileği genişliği ve dirsek genişliği ölçüldü. Toplamda ve cinsiyet ayrımı yapılarak birbirleri ile karşılaştırıldılar. Ölçümler açıölçer ve vernier dijital kumpas kullanılarak yapılmıştır. **Bulgular:** Toplamda ve cinsiyet ayrımı yapılarak elde edilen verilerin istatistiksel değerlendirmelerinde grupların birbirlerinden farksız oldukları görüldü. Fetusların ölçümle elde edilen dirsek ve elbilek genişlikleri ile el, önkol ve ayak uzunlukları değerleri ve bunların bazılarının oranları karşı vücut yarısındaki ölçüm ve oranlarla ve intrauterin yaşla büyük benzerlik gösteriyordu. **Sonuç:** Bu çalışmada bütün ya da parçalar halinde abortus edilen fetuslarda ölçülebilecek el bileği ve dirsek genişliği ile önkol, el ve ayak uzunluklarının gestasyonel yaş tayininde ayrı ayrı değerli olduğu görülmüştür. Ayrıca dirsek ve el bileği genişliklerinin aynı taraf önkol uzunluğuna oranlarının ekstremitelerin intrauterin gelişim takibinde anlamlı olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Gestasyonel yaş; fetal gelişim; önkol; el; el bileği; dirsek

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Fetal growth has been the subject of great interest from earliest times to the present day. Fetal structures can now be examined thanks to modern technology, and the pre-birth fetus can be analyzed. The analysis of fetal structures provides information about fetal growth and growth restriction, gestational age and duration, and congenital malformations.[1-5]

Morin et al. report that 40% of pregnant women either do not know their last menstrual period (LMP), or else the date they provide is unreliable.[6] If the pregnancy history provided by the mother lacks definite dating, then gestational age can be estimated using ultrasound (US) and fetal structure analysis. Crown-rump length, foot length (FL), femur length, abdominal circumference (AC), head circumference and biparietal diameter (BPD) measurement and estimated fetal weight calculation are procedures often performed for this purpose using US. In addition, the intrauterine development of the fetus can be monitored with US performed at specific times during pregnancy.[1,6-12] Performed in large numbers, these analyses constitute reference charts for different genetic groups.[13-17]

Some researchers have suggested that in addition to the above analyses, parameters such as transverse cerebellar diameter, nasal bone length, kidney length, sacral length and scapula length also provide useful results.[8,12,18-22] Gottlieb and Galan suggest that in specific clinical situations such as fetal head and abdomen oligohydramnios, the head may be exposed to compression, and BPD and AC measurement may be difficult.[10] Lehtinen states that legal abortions have increased, and because of the techniques employed when the fetus or embryo is aborted physical integrity may be lost. He states that foot length is important in such fetuses and that this is correlated to menstrual age.[23]

In addition to the parameters used in monitoring intrauterine age and fetal development, certain lengths in the upper extremity are also considered to constitute valuable data. We aimed to test whether similar measurements in the upper extremity could meet these needs when the fetus or embryo is not intact, in the same way as Lehtinen's proposed foot length.

MATERIAL AND METHODS

Fetuses, with no visible external abnormalities, at 17.9-35.8 gestational weeks were aged using FL and processed with 10% formaldehyde were used.[2,5,9] Cases with no external pathology or abnormality were obtained from Trabzon Maternity and Children's Hospital between 1992 and 1998. Written consent from the families and the approval of the Ethics Board of the Karadeniz Technical University Faculty of Medicine were obtained prior to the commencement of the study.

The following measurements were taken on the whole body without dissection, and the parameters were obtained using dividers and a vernier digital caliper:

FL (Foot length): measured from the heel to the tip of the longest toe using a divider and a vernier digital caliper.[23]

HL (hand length): The distance between the most distal skin fold in the wrist to the distal edge of the longest finger (using a divider and a vernier digital caliper).

WW (wrist width): Lengths of the transverse line passing from the level of the most distal wrist skin fold (using a divider and a vernier digital caliper).

EW (Elbow width): Length of the transverse line passing over the medial lateral epicendyle and (with the arm in extension) (using a divider and a vernier digital caliper).

FaL (Forearm length): The line joining the two transverse lines measuring wrist and elbow width.

EW/FaL ratio (Elbow width/Forearm length): The value obtained from proportional measurement of the two measurements in the same extremity.

WW/FaL ratio (wrist width/Forearm length): The value obtained from proportional measurement of the two measurements in the same extremity.

Each measurement was repeated five times, and arithmetical means and standard deviations were calculated using SPSS. Normal distribution of data was confirmed using the Kolmogorov-Smirnov test. Similarities between groups were determined using the Mann-Whitney U test and Student's t test. Correlation between parameters was analyzed using Pearson's and Spearman's correlation tests.

RESULTS

Measurements were taken from both upper and lower extremities of 21 fetuses (seven males, 14 females) aged at between 17.9 and 35.8 gestational weeks using FL measurement. No difference was determined in any parameters between the left and right sides. Values measured by gender for right-left extremities were calculated as arithmetic means and standard deviation (Table 1).

FL, HL, FaL, WW and EW measured for right and left extremities were compared and also on the basis of gender (Table 2). There was no difference between these values measured for the different extremities in either case ($p > 0.05$).

A significant correlation was determined between all values obtained from fetus measurement and between gestational ages calculated using these values (Tables 3 a, b).

WW, EW and FaL values obtained from fetal measurement were used to obtain ratios in the form of EW/FaL and WW/FaL, and ratio values were obtained for both upper extremities. There was a high correlation of EW/FaL and WW/FaL ratio values with the ratio values on the opposite side (Table 4).

DISCUSSION

On days 22-26 of embryological development, extremity buds appear as small swellings in the ventrolateral body wall. In this process, the upper extremity develops first, with a 2-day difference.[24] Prenatal US analysis of fetal structures and bone development provides information about fetal development.[25] Studies have recommended the use of tendencies and equations established with US measurements from groups with different genetic origins in order to investigate these groups. Munsick compared the extremity lengths of black and white 9-20 week fetuses and determined no significant difference between the races.[26] In addition, research with male and female fetuses have determined no significant gender-based differences.[27]

Our study determined a significant correlation in the right and left extremities with forearm and hand length and wrist and elbow width, and between foot parameters of the right-left lower extremities of fetuses aged between 17.9 and 35.8 gestational weeks (Table 3a) ($p < 0.001$). The fact and there is a correlation among these structures is in accordance with similar studies in the literature.[23,27]

The groups were similar in terms of lengths measured on the right and left sides (Table 2). They were also similar in terms of lengths divided according to gender on the right and left sides. This finding suggests that any measurement of length from any upper extremity will be adequate for intrauterine investigation; to put it another way, measurements may be made in any of the extremities. Measurements for either side will produce valuab-

TABLE 1: Mean values and standard deviation of lengths measured in the extremities.

SEX	EW		WW		FaL		HL		FL	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Male	18.21 ± 5.69	19.24 ± 5.07	13.94 ± 4.70	14.5 ± 4.62	50.73 ± 15.12	52.40 ± 15.81	41.47 ± 11.36	42.45 ± 11.27	51.81 ± 13.50	52.03 ± 14.20
Female	19.25 ± 6.38	18.67 ± 6.59	16.06 ± 5.28	15.56 ± 5.46	53.80 ± 10.91	52.57 ± 11.25	43.65 ± 11.31	44.33 ± 10.48	54.56 ± 12.82	55.27 ± 13.25
Total	18.87 ± 5.99	18.85 ± 6.02	15.27 ± 5.05	15.25 ± 5.10	52.66 ± 12.30	52.52 ± 12.40	42.92 ± 11.09	43.70 ± 10.50	54.14 ± 13.30	48.42 ± 28.26

Total n= 21 (7 male, 14 female).

EW: Elbow width, WW: Wrist width, FaL: Forearm length, HL: Hand length, FL: Foot length.

TABLE 2: EW, WW, FaL, HL and FL values measured for the right and left extremities compared in all patients and with respect to gender.

Measured length/p value	Male-Female		Total
	Left	Right	Left-Right
EW	0.800	0.661	0.992
WW	0.554	0.930	0.987
FaL	0.499	0.792	0.971
HL	0.709	0.765	0.816
FL	0.552	0.296	0.416

All p values >0.05.

EW: Elbow width, WW: Wrist width, FaL: Forearm length, HL: Hand length, FL: Foot length.

le data for comparing whether or not extremity developments are similar.

In addition, the fetuses used in our study for length measurements and with a calculated gestational age of 17.9-35.8 weeks exhibited a high correlation between the right and left sides. The highest values obtained at correlation analysis were between right and left EW, right and left WW and right and left FaL (Table 3a). It is therefore possible for right or left side measurement to replace one another during intrauterine analysis. Correlation values also showed that these measurements performed on both sides would afford the opportunity to compare whether the extremity development was similar and the early determination of anomalies or similar developmental defects.

Right EW demonstrated the highest correlation with left EW ($r= 0.999$ $p< 0.0005$). The correlation levels then were as followed: right WW, left WW, left HL, right HL, left FL, right FL, right FaL and left FaL. A similar sequence applied to left EW. Following mutual comparison, this exhibited a great similarity to the sequence following right EW. All correlation values determined following pairs analysis were higher in width-width and length-length pairings in the right and left upper extremity, with lower values in width-length matching. There was a high correlation between all the pairings in the analyses in this series (Table 3a).

In addition, a high correlation was determined at analysis of EW and WW to FaL ratios. Analysis of EW and WW to FaL ratios determined a high

TABLE 3a: Correlation between measurements.

Correlation value (r)	Compared measurements	
1	FaL right	FaL left
0.999	EW right	EW left
0.999	WW right	WW left
0.987	FL right	FL left
0.979	HL right	HL left
0.975	HL left	FL right
0.973	HL right	FL right
0.965	FaL right	FL right
0.964	HL left	FL left
0.963	HL right	FL left
0.963	WW left	HL left
0.96	FaL right	FL left
0.958	FaL left	FL right
0.957	WW right	HL left
0.955	FaL left	FL left
0.947	WW left	EW left
0.946	WW left	FL right
0.946	WW left	FL left
0.945	FaL right	HL right
0.945	WW left	HL right
0.943	FaL left	HL right
0.942	EW right	WW right
0.941	WW right	EW left
0.941	WW right	FL left
0.94	WW right	FL right
0.939	HL left	EW right
0.939	HL left	EW left
0.938	FaL right	HL left
0.938	WW right	HL right
0.934	HL right	EW left
0.933	FaL left	HL left
0.931	EW right	HL right
0.928	FL left	EW left
0.924	EW right	FL left
0.911	EW left	FL right
0.911	EW right	FL right
0.903	WW right	FaL right
0.902	WW left	FaL left
0.895	WW right	FaL left
0.895	FaL right	WW left
0.889	FaL right	EW left
0.887	FaL left	EW left
0.883	EW right	FaL right
0.874	EW right	FaL left

$p< 0.0005$ for all values.

EW: Elbow width, FaL: Forearm length, FL: Foot length, HL: Hand length, WW: Wrist width.

TABLE 3b: Correlation between values obtained by measurement and gestational age.

Correlation value (r)	Calculated age and compared measurements
0.977	HL left
0.974	HL right
0.964	FaL right
0.958	FaL left
0.955	WW left
0.951	WW right
0.929	EW left
0.926	EW right

p< 0.0005 for all values.

EW: Elbow width, FaL: Forearm length, FL: Foot length, HL: Hand length, WW: Wrist width.

correlation between right and left EW/FaL-EW/FaL and WW/FaL- WW/FaL ratios. We considered that analysis of the ratio between the two measurements obtained could provide more valuable conclusions than measuring the length or width of an organ or extremity in monitoring intrauterine development (Table 4).

In conclusion, we suppose that:

1. EW and WW values measured in the upper extremity are as valuable as previously known and used fetal parameters,

2. They have a high correlation with known parameters,

3. These measurements performed in the upper extremity can be used for estimating the age of aborted fetuses with impaired physical integrity, and,

4. EW/FaL and WW/FaL ratios can be of value in monitoring intrauterine development.

TABLE 4: Correlation between elbow width and wrist width /forearm length.

	EW Left/FaL Left	WW Left/ FaL Left	EW Right/FaL Right	WW Right/Fal Right
EW Left/FaL Left	-	0.743	0.992	0.679
WW Left/ FaL Left	0.743	-	0.704	0.993
EW Right/FaL Left	0.992	0.774	-	0.693
WW Right/Fal Right	0.679	0.993	0.693	-

For all r values p< 0.0005

EW: Elbow width, FaL: Forearm length, FL: Foot length, HL: Hand length, WW: Wrist width.

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