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Ultrasound evaluation of the sex of the fetus after the 7th week of pregnancy

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ABSTRACT

The authors attempted the ultrasound determination of fetal sex in the first trimester of pregnancy. The study included 240 pregnant women between 5-13 weeks of pregnancy. The crown-rump length (CRL) of male and female fetuses was compared. Statistical analysis of the results showed a significantly faster increase in CRL in male fetuses starting from the 7th week of pregnancy. This effect can be linked to the effects of fetal testosterone. The obtained results indicate the possibility of the forecast, with high probability, the sex of the fetus from the 7th week of pregnancy.

Keywords: *Fetal gender, fetal sex, first trimester*

The Aim

This study aims to try to determine the sex of the fetus in the first trimester of pregnancy based on measuring its crown-rump length (CRL) in an ultrasound examination.

Methods

The study included 240 pregnant women between the 5th and 13th week of pregnancy. Ultrasound examinations were carried out by an ultrasound specialist certified by FMF using the GE Voluson 730-Pro. Until the 11th week of pregnancy, the tests were carried out with the vaginal transducer and from the 11th week of pregnancy with the abdominal convex transducer. Fetal length/CRL/ was assessed concerning gestational age in weeks/HBD/ calculated based on the date of the last menstrual bleeding /LMP/ and the sex of the child after birth. The women included in the study gave birth to 134 boys and 106 girls. The relationship between the CRL and the gestational age expressed in weeks since the last menstrual bleeding was assessed using the linear

and exponential regression function (Starzyńska, 2006).

In this way, the absolute and relative increases in CRL depending on the week of pregnancy were examined. Observing the values of the regression coefficients, the significance of differences in CRL increases for both sexes was determined.

Initially, the obtained CRL measurements were divided into pregnancies up to week 7 and after the 7th week. The rationale for this division was the fact that up to 7 weeks in the group of boys, CRL is weakly dependent on the age of the pregnancy.

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A logistic regression model (Stanisz, 2007) was used to assess the probability of fetal sex based on CRL and gestational age. For the studied population, the so-called odds ratio is the product of correctly classified cases to incorrectly classified cases.

Results

The relationship between the fetal parietal length and a gestational week was expressed by linear and exponential regression functions. In this way, the absolute and relative increases in CRL parameters depending on the week of pregnancy were examined. Observing the values of the regression coefficients, the significance of the difference in the increments of the CRL parameter in the groups of boys and girls was determined. The trial was divided into the 7th week and the 7th week. The justification for this division is the situation in the group of boys, where development is weakly dependent on the week of pregnancy until 7 weeks. It is visible in the regression coefficients of the linear (0.0533) and exponential (13.24%) model, which are positive, but statistically insignificant. On the other hand, for girls, the regression coefficients are positive and statistically significant (linear model - 0.5431; exponential model - 88.19%). In Figure 1, the regression lines for boys are more horizontal than for girls. When looking at development in the early stages of pregnancy, there is little time dependence and a wide dispersion of results. The models reflect this by the low coefficients of determination.

The gains in length in boys after 7 weeks are statistically significantly greater than in girls ($p = 0.0003$) and amount to 0.9569 and 0.7378, respectively. These values are greater than in the model for the entire observed range.

Also, the growth rate of boys after 7 weeks is faster than girls' length and amounts to 36.04% and 32.78%, respectively. however, it is not statistically significant ($p = 0.3459$).

The situation in Figure 2 is visible as diverging functions in the linear model and more parallel functions in the exponential model. No statistically significant difference in the exponential model is due to the development difference before the 7th week.

The presented models are characterized by good statistical properties, i.e. high determination coefficients, slightly higher in the linear model (approx. 0.8) than in the exponential models (approx. 0.7)), and statistically significant regression coefficients (for all $p < 0, 00005$).

The estimated error of the CRL parameter in the linear model at the level of about 0.65-0.66 is not small, but it is also difficult to require that living organisms, each of which has some individual characteristics, develop the same.

The study of the relationship between the CRL parameter by gender and gestation week can also be presented at mean levels. Figure 3 and Table 3 show a progressive difference in the CRL between boys and girls from the 10th week of pregnancy, but the average length of CRL for boys is higher already in the 8th week of pregnancy.

A logistic regression model was used to estimate the probability of a child's sex based on the parameters of the gestation week and the crown-rump length. Table 4 presents the parameters of this model in the son's probability version. The model has good properties with the significance of the chi-square statistic at the level of $p = 0.0077$. Also, the individual parameters of the model are either statistically significant, for the CRL variable the obtained $p = 0.0073$ or close to statistical significance, for the HBD variable the obtained $p = 0.0595$.

The logistic model takes the form here: Figure 4 shows a logistic regression model of son probability estimation depending on the level of HBD and CRL variables. It shows that the higher the CRL value with a lower HBD value, the greater the probability that the child will be male and the less likely that the child will be female.

Conversely, the lower the CRL value with the higher HBD value, the less likely the child is to be male, and the greater the likelihood that the child will be female.

The values of this function are also presented in tabular form (Table 5). For a given HBD and CRL values from the analyzed range, the probability of giving birth to a son was given.

Conversely, the lower the CRL value with the higher HBD value, the less likely the child is to be male, and the greater the likelihood that the child will be female.
The values of this function are also presented in tabular form (Table 5). For a given HBD and CRL values from the analyzed range, the probability of giving birth to a son was given.

Figure 4 shows a logistic regression model of son probability estimation depending on the level of HBD and CRL variables. It shows that the higher the CRL value with a lower HBD value, the greater the probability that the child will be male and the less likely that the child will be female. Conversely, the lower the CRL value with the higher HBD value, the less likely the child is to be male, and the greater the likelihood that the child will be female.

The values of this function are also presented in tabular form (Table 5). For a given HBD and CRL values from the analyzed range, the probability of giving birth to a son was given.

Based on the observation of the studied population, the so-called odds ratio, i.e. the ratio of the product of correctly classified cases to the product of incorrectly classified cases (Tab. 6)

In the study population, the odds ratio is 1.79. This value is higher than the value 1, which is a random classification. Thus, using the relationship between HBD and CRL parameters, the prediction of a child's gender can be improved.
The poor result in predicting the sex of daughters (31.13% correct) was because by the 7th week there was no significant difference in the length of children.
As results from previous analyses, a clear difference between the length of boys and girls occurs after 7 weeks.

In the case of a child with an above-average CRL, the model classifies it as a boy, hence the results. However, despite the inconvenience achieved in estimating the probabilities of girls, the overall score is better than the random prediction.
By limiting the model to the data from 8 weeks on, we obtain a higher value of the odds ratio, as it is 2.57, and the improvement in predictions to the level of 35.42% for daughters and 82.43% for sons (Tab. 7).
Unlike in female fetuses, the differentiation of male sexual organs is preceded by the maturation of the gonads. The male phenotype depends on the presence of testosterone and Anti-Müllerian hormone secreted in the testes of the fetus, while the female phenotype depends on their absence. The onset of testicular differentiation falls on the 6-7th week of pregnancy when the sex cords formed by Sertoli cells are formed. In the 8th week of pregnancy, the testicle shows Leydig cells differentiated from the mesenchyme, producing testosterone. Testosterone production is stimulated by high levels of HCG. Lack of testicular development in 6-8 weeks of pregnancy is evidence of a primary, temporarily inactive ovary. / 9- L. Speroff /.
Early diagnosis of the sex of the fetus is important especially in the context of genetic diseases related to the X chromosome.
In the world literature of the last 15 years, several attempts to assess the sex of the fetus based on ultrasound examination performed in the first trimester of pregnancy have been presented. (1,2,3,4,5,6). All these studies focused on the final weeks of the first trimester and covered the range of 11-13.6 weeks of gestation. The authors assessed the distance between the caudal end of the fetus and the base of the sexual nodule / 1 /, the angle of the genital nodule measured in the sagittal plane / 2,4,5,6 /, or the total CRL and the genital area of the fetus / 3 /.

The authors of the presented studies agree that the accuracy of fetal sex assessment increases significantly with the age of the pregnancy. They set the cut-off point for reliable results at 11 weeks of pregnancy / 1 /,

12.2 weeks of pregnancy and CRL 56.7 mm / 2 / and 11.4-12 weeks of pregnancy and CRL 50 - 54.9 mm / 3.4, 5.6 /.

Our study indicates the possibility of earlier than previously thought, with a high probability of prediction of the sex of the fetus based on ultrasound examination.

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weeks of pregnancy and CRL 56.7 mm / 2 / and 11.4-12 weeks of pregnancy and CRL 50 - 54.9 mm / 3.4, 5.6 /. Our study indicates the possibility of earlier than previously thought, with a high probability of prediction of the sex of the fetus based on ultrasound examination.

Conclusion

In the presented work, the research problem was the relationship between gestational age, fetal length, and sex. The obtained results, analyzed statistically, show that:

- Until the 7th week of pregnancy, the increase in CRL was faster in girls
- After 7 weeks of pregnancy, there is a statistically significant faster growth of male fetuses. Male fetuses increased an average of 0.9569 cm per week, while female fetuses increased by an average of 0.7378 cm per week. As a result, at 11 weeks of gestation, male fetuses are on average 1 centimeter longer than female ones.
- Despite a significantly higher increase in CRL of male fetuses, sex assessment is difficult due to the large dispersion of these parameter values in the subsequent weeks of pregnancy. However, compared to the random assignment of sex, the designated logistic model allows for the prediction of the male gender with high probability.
- The worse results obtained in identifying female fetuses should be associated with the fact that fetuses with high CRL parameters are classified as male, while among them, although much less frequently, are female ones.

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Figure 1. Relationship of CRL and HBD, up to 7th week (linear and exponential model)

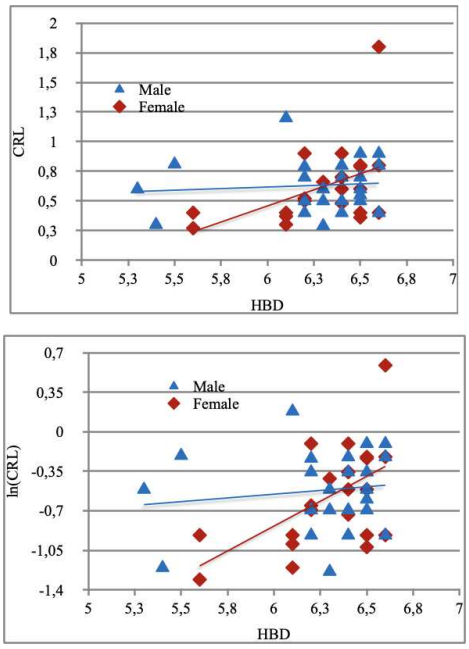

Table 1. Statistics of the linear and exponential regression model of HBD effect on CRL up to 7th week.

Model parameters	Linear model		Exponential model	
	Male	Female	Male	Female
a	0,2971 (0,7111)	-2,8010 (0,0561)	-1,3475 (0,3090)	-6,1270 (0,0023)
b	0,0533 (0,6770)	0,5431 (0,0217)	0,1324 (0,5277)	0,8819 (0,0048)
R square	0,0080	0,2172	0,0184	0,3088
Estimated error	0,2192	0,2837	0,3583	0,3631
t (regression difference)	1,9323		2,1485	
p (regression difference)	(0,0598)		(0,0372)	

Explanations

a - free model expression, b – regression model coefficient in the brackets levels of the relevant levels of *p* parameters.

Figure 2. Effect of HBD on CRL, from 7th week (linear and exponential model)

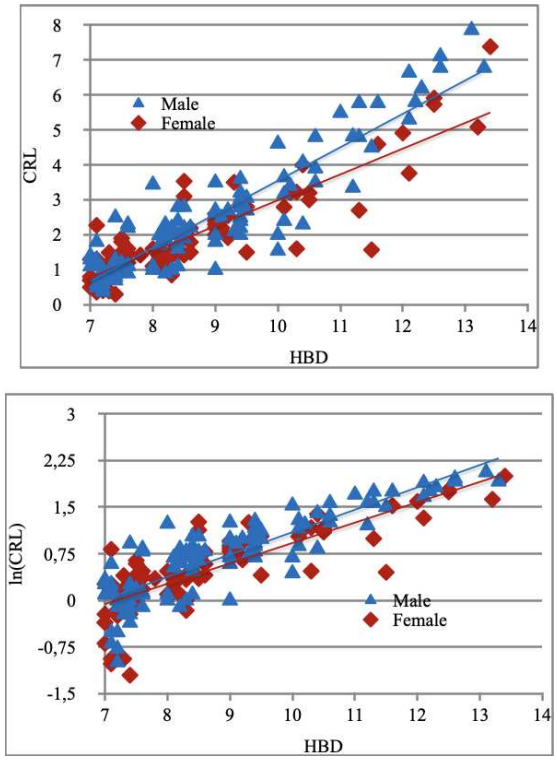

Table 2. Statistics of the linear and exponential regression model of HBD effect on CRL at the 7th week

Model parameters	Linear model		Exponential model	
	Male	Female	Male	Female
a	-6,0227 (0,0000)	-4,3895 (0,0000)	-2,5061 (0,00000	-2,3554 (0,0000)
b	0,9569 (0,0000)	0,7378 (0,0000)	0,3604 (0,00000	0,3278 (0,0000)
R square	0,8446	0,7686	0,7508	0,6306
Estimated error	0,6608	0,6545	0,3342	0,4057
t (regression difference	3,6474		0,9450	
p (regression difference)	(0,0003)		(0,3459)	

Explanations:
a - free model expression, b – regression model coefficient in the brackets levels of the relevant levels of *p* parameters.

Figure 3. Average CRL level in the following weeks of pregnancy

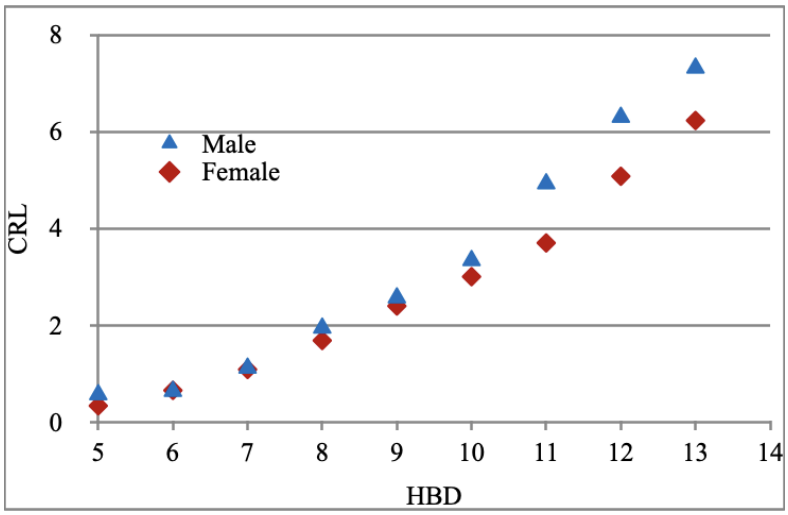

Table 3. Mean CRL levels in the following weeks of pregnancy

Sex	Gestational week								
	5	6	7	8	9	10	11	12	13
Male	0,57	0,64	1,12	1,95	2,57	3,34	4,93	6,30	7,32
Female	0,34	0,65	1,09	1,68	2,40	3,00	3,70	5,08	6,23

Figure 4. Logistic regression model for son probability estimation

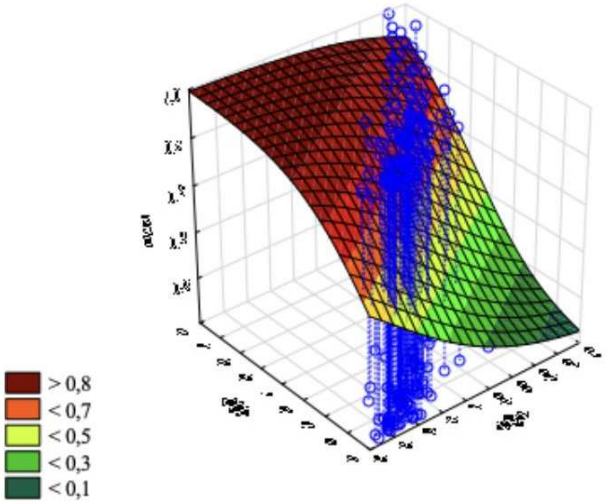

Table 5. Probability of having a son depending on the combination of HBD and CRL parameters

CRL (In cm)	HBD Gestational week								
	5	6	7	8	9	10	11	12	13
0	0,5629	0,4763	0,3911	0,3120	0,2426	0,1845	0,1377	0,1014	0,0738
1	0,6985	0,6207	0,5361	0,4493	0,3656	0,2892	0,2232	0,1687	0,1253
2	0,8065	0,7465	0,6752	0,5948	0,5090	0,4227	0,3408	0,2674	0,2050
3	0,8824	0,8412	0,7890	0,7254	0,6510	0,5684	0,4819	0,3964	0,3169
4	0,9310	0,9050	0,8706	0,8262	0,7704	0,7032	0,6260	0,5417	0,4549
5	0,9604	0,9449	0,9237	0,8953	0,8579	0,8100	0,7507	0,6801	0,6002
6	0,9776	0,9686	0,9561	0,9390	0,9157	0,8847	0,8442	0,7928	0,7298
7	0,9874	0,9823	0,9751	0,9651	0,9513	0,9324	0,9069	0,8731	0,8293
8	0,9930	0,9901	0,9860	0,9803	0,9723	0,9613	0,9460	0,9253	0,8974

Table 6. Case classification of the studied sample population

Observed	Estimated		Correct forecast
	Daughter	Son	
Daughter	33	73	31,13
Son	27	107	79,85

Table 7. Case classification of the studied sample population (age from 8 weeks)

Obserwowany	Estimated		Correct forecast percentage
	Daughter	Son	
Daughter	17	31	35,42
Son	13	61	82,43