On a Fetal Growth Study Using Ultrasound Measurements

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1. Growth Models for Ultrasound Data

The Rossavik model has been popular for modelling fetal growth in the clinical ultrasound literature. We examine this model and compare with some other simple growth models in this note. Specific models under consideration are:

(1) Rossavik model: $f(t) = ct^{b+at}$

(2) Logistic model: $f(t) = \dfrac{ac\exp(at)}{a + bc(\exp(at) - 1)}$

(3) Linear model: $f(t) = a + bt$

(4) Exponential model: $f(t) = a\exp(bt)$

(5) Completely nonparametric model: $f(t) =$ arbitrary.

Ultrasound measurements on biparietal diameter, femur length and abdominal circumference from a fetal growth study are examined via the above models. Comparisons of the models are given in the next section.

2. Data from the Alabama Small-for-Gestational Age Study

A prospective study of risk factors for intrauterine growth retardation includes 1518 women who delivered at the University of Alabama at Birmingham from December 1985 to October 1988. Fetal anthropometry was scheduled at 17, 25, 31 and 36 weeks of gestation. Final ultrasound measurements on biparietal diameter, femur length and abdominal circumferences totalled more than five thousand over various gestational ages. In this note we fit the various fetal growth models listed in the previous section to the three different ultrasound measurements. For the Rossavik, linear and exponential models, we assume spatial covaraiance structure within the same fetus. The findings are: all the models fit reasonably well . If the sum of the squared residuals is a measure of goodness of fit for comparison. For **abdominal circumference**, they are 11242, 11465, 11876 and 32305 for the **logistic**, the linear, the Rossavik and the exponential models respectively. For **femur length**, they are 413, 468, 615 and 2898 for the **Rossavik,** the logistic, the linear and the exponential models respectively. For **biparietal diameter**,

they are 473, 543, 839 and 2290 for the **logistic**, the Rossavik, the linear and the exponential models respectively. The model parameter estimates are given in ***Table 1***. Notice that both Rossavik and logistic models have 3 parameters while both linear and exponential models have only 2. If the sum of squared residuals is the measure of goodness of fit, the Rossavik and logistic models appear to be the best for these three ultrasound measurements. However when the fitted models are plotted, they are remarkably similar. We present the fitted values of abdominal circumference at gestational ages 15, 20, 25, 30, and 35 weeks in ***Table 2***. Patterns for biparietal circumference and femur length are the same and will not be presented here. Not only the fitted values under different models are very close to each other, but the estimated growth rates are also close. We have performed a routine two-way analysis of variance for the five different fitted values over the five time points for the abdominal circumference, the biparietal diameter and the femur length. Of course there is a time (growth) effect, but there is no significant model effects. When we perform a routine analysis of variance for the growth rates, there are no significant time and model effects. From these preliminary findings, it appears that the Rossavik model is a good fit for the three ultrasound measurements. However, since a linear model is much simpler and more well understood, it can be an excellent candidate for modelling fetal growth using ultrasound measurements.

Table 1. Model Parameter Estimates.

	Rossavik			***Logistic***			***Linear***		***Exponential***	
	a	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***a***	***b***
Abdominal Circum.	0.003	0.612	3.426	0.112	0.003	6.124	4.207	1.060	8.180	0.054
Biparietal Diameter	0.000	0.655	1.078	0.132	0.013	1.904	2.186	0.258	2.947	0.044
Femur Length	-0.002	0.942	0.397	0.145	0.018	1.062	0.833	0.242	1.642	0.059

Table 2. Abdominal Circumference (AC) and Growth Rate (Rate).

	Rossavik		***Logistic***		***Linear***		***Exponential***		***Empirical***	
Weeks	***AC***	***Rate***	***AC***	***Rate***	***AC***	***Rate***	***AC***	***Rate***	***AC***	***Rate***
15	9.37	1.21	9.67	0.83	9.51	1.06	10.72	0.58	9.45	1.21
20	14.93	1.05	14.43	1.06	14.81	1.06	14.05	0.76	14.80	1.03
25	20.08	1.03	20.07	1.17	20.10	1.06	18.41	1.00	20.09	1.05
30	25.26	1.05	25.81	1.05	25.41	1.06	24.12	1.30	25.59	0.99
35	30.65	1.11	30.84	0.90	30.71	1.06	31.61	1.71	31.04	1.04

REFERENCE

Deter, R.L., Rossavik, I.K., Harrist, R.B. and Hadlock, F.P. (1986). Mathematical moeling of fetal growth: Development of individual growth curve standards. Obstetrics and Gynecology, 68, 156-161.

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RESUME

On a d erminé que le mod e Rossavik s뭈dapte bien aux mesures hographiques de la circonf ence abdominale, longueur du f ur et diam re bipari al. Le mod e lin ire peut re un bon mod e, particuli ement cause de sa simplicit