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AN EQUATION FOR COMPUTING EXPECTED BIRTH MEASUREMENTS (INCLUDING BIRTHWEIGHT) FOR THE TURKISH POPULATION (BASED ON PREGNANCY CHARACTERISTICS)*

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The extent of intrauterine development depends upon transplacental support and the inherent growth potential of the fetus. However, it has been shown that maternal age, height, pre-pregnancy weight, the number of pregnancies and the sex of the baby also influence fetal growth. It is reported that the influence of these factors on growth may differ according to various populations[1-3], and the computed deviations from expected baby size can be taken as a more objective way to identify babies who are either small or large for their gestational age[4].

This study was undertaken to assess the contributions of the duration of gestation, sex of the baby and maternal characteristics which affect birthweight, and to derive an equation for computing expected birthweight in Turkish newborns so as to identify altered fetal growth.

Material and Methods

One thousand consecutive pregnancies were studied, and complete data were compiled for 525 mothers and their liveborn infants delivered in the general mater-

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nity hospital of Ankara, Turkey, in July and August 1978. The babies were weighed immediately after birth. Since many mothers did not know the date of their last menstrual period, the gestational age was determined by Dubowitz scoring[5] performed between 24 and 48 hours after delivery. At the same time the babies underwent physical examination, and anthropometric measurements including skinfold thickness were obtained. Babies born to diabetic or eclamptic mothers, those with congenital malformations, and those born earlier than 35 weeks of gestation were not included in the study.

A questionnaire was given to mothers to determine certain socio-cultural factors liable to influence intrauterine development. Anthropometric measurements of the mothers were also obtained.

Simple product: moment correlations and multiple regression analyses of the babies' anthropometric measurements with maternal age, height and pre-pregnancy weight, number of pregnancies and baby's sex and gestational age were computed, and regression coefficients for predicting the size of the baby were developed.

Results

The mean range of the anthropometric measurements of 525 newborns is shown in Table I.

TABLE I

NEWBORN ANTHROPOMETRIC DATA

n = 525

Variable	Range	Mean ± SD
Birthweight (gm)	1850.00 - 4800.00	3262.25 ± 454.99
Crown-heel length (mm)	440.00 - 570.00	499.41 ± 20.26
Fronto-occipital circumference (mm)	300.00 - 400.00	349.86 ± 14.34
Chest circumference (mm)	250.00 - 380.00	327.74 ± 19.19
Right thigh circumference (mm)	105.00 - 200.00	149.26 ± 14.09
Right arm circumference (mm)	70.00 - 135.00	99.45 ± 10.28
Skinfold measurements (mm)		
Right thigh	2.00 - 12.00	4.49 ± 1.48
Right arm	1.00 - 8.00	3.02 ± 1.21
Interscapular	1.00 - 8.00	2.65 ± 1.00

Table II shows the mean of maternal factors (age, height, pre-pregnancy weight, gestational age, number of pregnancies) affecting birthweight, while Table III correlates these factors with the newborns' anthropometric measurements.

TABLE II

MATERNAL FACTORS USED FOR THE ADJUSTMENT OF BABY SIZE

n = 525

Variable	Range	Mean ± SD
Maternal age (yr)	15 - 30	22.76 ± 3.97
Gestational age (wk)	35 - 42	39.84 ± 1.93
Pre-pregnancy weight (kg)	34 - 100	56.49 ± 8.76
Maternal height (cm)	135 - 175	155.82 ± 5.88
Pregnancy number	1 - 4	1.78 ± 1.07

Multiple regression analyses showed that maternal factors, gestational age and sex of the baby accounted for 23% of the variance in birthweight and 20% of that of length ($p < 0.0001$, Table IV). The partial regression coefficients by which the mother's age, height, pre-pregnancy weight and number of pregnancies and the baby's sex and gestational age modify birthweight are computed to be 13.16, 11.31, 5.65, 73.81, 69.45 and −124.04, respectively (Table V). Using these coefficients, the expected birthweight was calculated by the following equation:

$$y = 13.16\,(X_1) + 73.81\,(X_2) + 5.65\,(X_3) + 11.31\,(X_4) + 69.45\,(X_5) - 124.04\,(X_6) - 1999.45\,(X_7)$$

where y = expected birthweight; X_1 = mother's age; X_2 = gestational age; X_3 = mother's pre-pregnancy weight; X_4 = mother's height; X_5 = number of pregnancies; X_6 = baby's sex (♂ = 1, ♀ = 2) and X_7 = intercept.

Table VI shows the contribution of maternal factors and baby sex to birthweight, length and head circumference.

Discussion

There has been growing recognition of and increasing concern for altered fetal growth in recent years. The studies center mostly on factors which control and affect intrauterine development.

It is known that ethnic and genetic characteristics, age, height and pre-pregnancy weight of the mother as well as gestational age and the number of pregnancies are associated with growth of the fetus[3,6-8].

Ounsted and Ounsted and Tanner and Thomson emphasized that tall, adequately nourished mothers have larger babies than mothers who are on the shorter side of the spectrum[2,6]. Fetal sex is associated with significant differences in median fetal weights in the latter part of pregnancy[3]. Males weigh approximately 200 gm more than females at term[2]. Generally, the mother's first baby is smaller than the next one[3]. The influence of these factors may cause significant differences in the standards of birthweight in different populations. For example, a 3700 gm mean birthweight for American Indians of the Cheyenne Tribe is in contrast to the 2400 gm mean birthweight in the Lumi Tribe of New Guinea[1]. The mean birthweight in North Carolina reported by Brenner et al is higher than that in India and Singapore but lower than those in Sweden and Holland[3,9-12].

In our study group the mean birthweight was determined to be 3265 gm and the height 49.9 cm. These are lower than the U.S.A. standards while the fronto-occipital circumference (34.9 cm) is comparable[3,13]. These examples indicate the necessity of adjusting baby size for the above mentioned factors and possibly others in order to identify more correctly fetally malnourished or excessively large babies. To this end, the present study was undertaken to investigate the degree of influence of the above-mentioned factors on the birthweight and other measures of size of Turkish newborns.

Most simple correlations of each maternal factor and the baby's sex with the baby's anthropometric measurements were statistically significant (Table III), although the correlations were not very strong. On the other hand, multiple correlations (R^2)* indicate that the maternal factors evaluated can explain 23%, 20% and 23% of the variance in the adjusted birthweight, length and fronto-occipital circumference, respectively (Table IV). The contribution of gestational age is the most important (Tables V and VI).

In a similar study from Oklahoma, maternal factors including nutrition can explain 65% of the variance in adjusted birthweight ($R^2 = 0.65$), and the contributions of gestational age, sex of the baby, maternal height and pre-pregnancy weight to adjusted birthweight were 20%, 4.4%, 1.1% and 1.5%, respectively[14]. The difference of the effects of maternal factors on adjusted birthweight ($R^2 = 0.23$ and $R^2 = 0.65$) derives from the inclusion of plasma nutrient and maternal leucocyte bioactivity variables in the Oklahoma study, which combined with maternal measures could account for a larger proportion of the variance in that study. The differences in the partial regression coefficients in the two study groups indicate the necessity for the adjustment of birthweight, and other measures of the baby as well, for each population.

* R^2 = coefficient of multiple correlation.

TABLE III

SIMPLE CORRELATIONS OF NEWBORN ANTHROPOMETRIC DATA WITH CERTAIN MATERNAL FACTORS AND BABY'S SEX

n = 525

Newborn anthropometric data (dependent)	Age	Maternal factors (independent) Gestational age	Pre-pregnancy weight	Height	Pregnancy number	Baby's sex
Birthweight	0.233	0.317	0.199	0.219	0.217	−0.123
Length (crown-heel)	0.191	0.292	0.105	0.211	0.146	−0.189
Fronto-occipital circum.	0.242	0.327	0.135	0.185	0.146	−0.187
Chest circum.	0.249	0.318	0.101	0.178	0.221	−0.151
Right thigh circum.	0.235	0.233	0.185	0.157	0.232	0.137
Right arm circum.	0.311	0.197	0.088	0.177	0.231	0.038 *
Skinfold measurements:						
Right thigh	0.071 *	0.143	0.084 *	0.052 *	0.084 *	0.100
Right arm	−0.011 *	0.221	0.070 *	0.026 *	0.030 *	0.125
Interscapular	0.095	0.123	0.096	−0.002 *	0.140	0.127

Note: If n = 525 and degree of freedom = n - 2, all r's except those with an asterisk are statistically significant and
$p < 0.01$ where $r > 0.115$
$p < 0.05$ where $r \geqslant 0.088$

TABLE IV

MULTIPLE CORRELATIONS OF DEPENDENT WITH INDEPENDENT* VARIABLES AND TEST OF SIGNIFICANCE

Dependent variable	Multiple correlation coefficient	F. Statistics	p values
Birthweight	0.23	26.04	<0.00000
Length (crown-heel)	0.20	26.99	<0.0000
Fronto-occipital circum.	0.23	26.08	<0.0000
Chest circum.	0.20	21.84	<0.0000
Right thigh circum.	0.17	17.24	<0.0000
Right arm circum.	0.16	16.74	<0.0000
Skinfold measurements:			
Right thigh	0.04	4.05	<0.00056
Right arm	0.08	7.09	<0.00000
Interscapular	0.06	5.52	<0.00001

* Independent variables: maternal age and height, gestational age, pre-pregnancy weight, baby's sex.

TABLE V

PARTIAL REGRESSION COEFFICIENTS FOR ADJUSTING INDEPENDENT VARIABLES FOR DEPENDENT VARIABLES

n = 525

Independent variables	Dependent variables: Birth-weight	Crown-heel length	Fronto-occipital circumference
Maternal age	13.16	0.65	0.74
Maternal height	11.31	0.58	0.27
Pre-pregnancy weight	5.65	4.78	0.10
Gestational age	73.81	2.91	2.36
Pregnancy number	69.45	1.93	0.71
Baby's sex	− 124.04	−8.82	−6.08
Intercept	−1999.45	0.283	198.50

TABLE VI

THE CONTRIBUTION OF INDEPENDENT FACTORS TO R^2 FOR BIRTHWEIGHT, LENGTH AND HEAD CIRCUMFERENCE

n = 525

	R^2	Maternal age	Pre-pregnancy weight	Maternal height	Gestational age	Pregnancy number	Baby's sex
Birthweight	0.23	1.31	1.18	2.14	9.75	2.65	1.85
Length	0.20	1.61	0.05	2.83	7.68	1.04	3.98
Head circumference	0.23	4.17	0.37	1.22	10.08	0.28	4.49

The terminology and criteria for retarded intrauterine development are still controversial. Lubchenco et al have grouped the babies whose birthweights are below the 10th percentile for gestational age in the Denver growth curves as intrauterine growth retarded[13,15]. Gruenwald, meanwhile, has included in this group those babies whose birthweights are more than 2 SD below the mean birthweight[16].

Neither of these classifications takes into account the expected birthweight of a particular newborn, and it is this missing factor which is provided by our equation; in which maternal factors and baby sex are weighted to find the birthweight which an individual baby, properly nourished, should attain. That a baby weighs less than expected on the basis of this equation may be the best indication of retarded intrauterine growth, and the statistically significant correlation ($r = 0.86^*$, $p < 0.001$) of observed birthweight with predicted birthweight in our 525 cases supports this. This view is also supported by significant differences in other newborn measures, including skinfolds and maternal size, diet, etc. in babies who are > 1 SD below their expected size and are considered to have fetal malnutrition[17]. Partial regression coefficients of anthropometric measurements other than birthweight can also be used for the adjustment of these parameters for newborns (Table V).

We believe that the results of this paper may be considered to apply to Turkey in general, since mothers from different regions of the country and different socio-economic backgrounds were included in the study[18].

* r = coefficient of partial correlation.

Summary

Five-hundred twenty-five mothers and their liveborn infants were studied to assess the effects of certain maternal factors and the baby's sex on birth measurements in the Turkish population.

Multiple regression analyses relating the babies' anthropometric measurements with maternal age, height, pre-pregnancy weight, number of pregnancies and the baby's sex and gestational age were computed, and the following equation for expected birthweight of an individual baby was obtained: y (expected birthweight) = 13.16 (mother's age) + 73.81 (gestational age) + 5.65 (pre-pregnancy weight) + 11.31 (mother's height) + 69.45 (number of pregnancies) — 124.04 (baby's sex) — 1999.45.

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