The Epidemiology of White Full-Term Infants with Short Crown-Heel Lengths for Gestational Ages at Birth

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Received November 21, 1988

Fetal growth retardation was diagnosed in 137 (7.8 percent) of 1,757 white full-term infants who had crown-heel lengths below the fifth percentiles for their gestational ages. The incidence of short infants was 121 (11.1 percent) among 1,093 mothers with high-risk pregnancies compared to 16 (2.4 percent) in 664 low-risk mothers (p < 0.0001). There were four high-risk categories: spontaneous premature rupture of membranes (PROM), fetal conditions, complications of pregnancy, and adverse maternal practices. The incidence of short infants was significantly higher in each of the four high-risk categories than in the low-risk group.

There were three other conditions that were present in all pregnancies that were associated with the frequency of short infants: maternal height, socioeconomic status of head of household, and sex of infant. A short maternal height (under 157.7 cm — 62 inches) was significantly associated with an increase in short infants among mothers who smoked cigarettes at any level during pregnancy and among mothers with PROM in combination with other risks, but not in the group of 664 low-risk mothers.

Significantly more short girls than short boys were born to mothers who smoked ten or more cigarettes a day throughout pregnancy or who had multiple adverse maternal practices, but no statistically significant differences were noted among mothers who smoked fewer than ten cigarettes per day, among those with PROM as the only risk factor, or among those with medical or obstetrical complications. Moreover, those mothers who were in socioeconomic groups III and IV and had other risk factors had a significantly higher incidence of short infants than did similar mothers in socioeconomic groups I and II.

INTRODUCTION

There are two types of growth retardation in newborn infants: fetal malnutrition (reduction of soft tissues) and fetal growth retardation (reduction in crown-heel length for gestational age). These two types were described more than 25 years ago [1], but the distinction has often been neglected since by neonatologists, who favored a single entity—intrauterine growth retardation (IUGR)—diagnosed by a low birth weight for gestational age. IUGR was favored because it was easier to obtain reliable birth weights than reliable measurements of crown-heel length [2]. A reliable method of measuring crown-heel length at birth is available, however, and fetal malnutrition diagnosed by a low ponderal index can be distinguished from growth retardation diagnosed by a short crown-heel length for gestational age [2].

Abbreviations: CI: 95 percent confidence intervals on the relative risk (after Miettinen) d.f.: degrees of freedom FGR: fetal growth retardation IUGR: Intrauterine growth retardation LBW: low birth weight (less than 2,501 g) N.S.: not statistically significant at alpha = 0.05 PROM: premature rupture of membranes RR: risk ratio; relative risk SES: socioeconomic status

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It is important to make the distinction, because their pathogeneses, clinical courses, and prognoses differ [3,4]. The ready availability of growth hormone for treating growth failure has increased the need for obtaining reliable measurements of crown-heel length at birth [5,6,7]. In this paper we use the term “fetal growth retardation” (FGR) to mean short crown-heel length, and “fetal malnutrition” to mean reduced soft-tissue mass. We prefer these terms to the terms “symmetric” and “asymmetric” IUGR, as used by some, or “proportionate” and “disproportionate” IUGR, as used by others, because the latter terms are neither descriptive of the process nor do they parallel the terminology used in pediatrics, where short stature (length) is called “growth retardation,” and inadequate soft-tissue mass is called “malnutrition.” We see no reason to change these terms for the fetus, and several reasons to keep them the same as in general pediatric use.

The objective of the present study was to determine the epidemiology and frequencies of short crown-heel length in newborn full-term white infants. The epidemiology of fetal malnutrition is the subject of a separate study. Only white infants were used in this report because the number of black infants was considerably smaller, producing less stable estimates, and this approach eliminates the potentially confounding effect of race. Only full-term (37+ weeks’ gestation) deliveries were used, so that the factors causing short crown-heel lengths could be studied independently of factors causing short gestations. Any conclusions from this study should, therefore, not be applied to pregnancies in black women or to premature deliveries without confirmatory evidence.

The general format of the present study was the same as in our previous epidemiologic studies of low birth weight (LBW) infants [8–10]. Briefly, the outcomes of pregnancies were determined in low-risk pregnancies and in pregnancies complicated by the risks listed in Table 1, while controlling for socioeconomic and biologic conditions present in all pregnancies. It has been established that birth weight can be significantly affected, either upward or downward, by such biologic conditions as maternal height, weight-height ratio at conception, age parity, race, and the gestational age and sex of the infant [11,12]. It is essential to take these biologic conditions into account in epidemiologic studies that involve prenatal growth. The arrangement of risk factors shown in Table 1 was first developed by the pediatric investigator (HCM) in 1983, based on the generally accepted information available at that time, although it has been somewhat modified since then [13]. Most of these risk factors were discussed in the Institute of Medicine’s report Preventing Low Birthweight, although the arrangement of the factors was considerably different [14].

METHODS

The 1,757 white mothers and their singleton full-term infants were the same as in our previous studies [8–10]. The infants were born between April 1975 and April 1979 at the University of Kansas Medical Center. The pediatric investigator (HCM) interviewed each mother between her delivery and discharge from the hospital to clear up any uncertainties in her medical and obstetric record and to obtain data on cigarette smoking. Infants were usually measured before interviews, because seeing the mothers often had to be postponed, as they frequently were receiving post-delivery nursing or medical care, but the mothers were occasionally interviewed first. It is unlikely that this method produced interviewing bias, because at the time there were no studies in the U.S. indicating the importance of crown-heel measurements.
TABLE 1
Risk Conditions

1. Environmental Factors
   - High altitude
   - Exposure to specific toxic agents
2. Spontaneous Premature Rupture of Membranes (PROM)
3. Fetal Factors
   - Multiple birth
   - Congenital malformations
   - Fetal infections
   - Inborn errors of metabolism
   - Maternal-fetal blood incompatibility, producing disease in the fetus
4. Medical Complications of Pregnancy
   - Toxemia of pregnancy
   - Chronic hypertension
   - Severe vaginal bleeding in third trimester
   - Abnormally high glucose tolerance curves
   - Malformations of placenta, cord, or uterus
   - Anemia: hemoglobin level <10 g/dL
   - Severe chronic maternal disease
   - Leukemia
   - Malignant solid tumors
   - Large ovarian cysts or uterine fibroids
   - Continuous maternal medication with corticosteroids or immunosuppressive, teratogenic, or fetal-growth-retarding drugs
   - Polyhydramnios or oligohydramnios
5. Adverse Maternal Practices
   - Cigarette smoking during any part of pregnancy
   - Low weight gain in trimesters 2 and 3
   - Low weight for height at conception
   - Delivery <17 years of age
   - Delivery >34 years of age
   - No professional prenatal care
   - Use of addicting drugs or consumption of large amounts of alcohol during pregnancy

*Low weight gain, <228 g per week in trimesters 2 and 3
*Low weight, < 15 percent below normal on Sargent's table for young women (J Nutr 13:318, 1963)

Mothers were assigned to the five high-risk categories in Table 1 according to a specific protocol. Mothers were placed in category 1 (environmental factors) regardless of what other risks in Table 1 were present. (There were no mothers in category 1 in this study.) Mothers were placed in category 2 (spontaneous premature rupture of membranes, or PROM) even if risks in categories 3, 4, and 5 were present. Mothers were assigned to category 3 (fetal factors) even if risks in categories 4 and 5 were present. Mothers were assigned to category 4 (medical or obstetric complications of pregnancy) even if risks in category 5 were present. Mothers were assigned to category 5 (adverse maternal practices) provided none of the risks in categories 1 through 4 were present. Mothers who had none of the risks in Table 1 were assigned to the low-risk group.

There were four socioeconomic groups, as follows: mothers in groups I and II paid full hospital costs and physicians' fees; mothers in group I had completed at least 13 years of school, and mothers in group II had completed less than 13 years of school. Mothers in group III either had their hospital costs and physicians' fees discounted or
had them limited to third-party payments. Mothers in group IV either were on welfare or came from homes in which heads of household were unemployed.

All infants were examined and measured by the pediatric investigator (HCM). Gestational ages of full-term infants were determined, whenever possible, from the first day of the mother's last menstrual period. Infants were assigned a definite age in completed weeks if calculated gestational ages were the same as gestational ages estimated by the obstetricians and pediatric investigator. If gestational age could not be calculated, or was in doubt (19.5 percent), the infant was declared a full-term infant on the basis of the obstetrician's estimates and estimates made by the pediatric investigator, using birth measurements and Dubowitz scores [15], with the final decision resting with the pediatric investigator.

The Kansas City fetal growth tables for crown-heel length, head circumference, birth weight, and ponderal index for white babies were used; separate tables were available for boys and girls [12]. These tables were developed on babies resulting from normal pregnancies; that is, infants were excluded from being in the standards group if the pregnancy had any of the risk factors indicated in Table 1. In addition, there were also separate tables for white females, white males, black females, and black males. Beyond this subdivision, however, they were not adjusted for social or biological variables.

There are many difficulties in measuring crown-heel length, including how to extend the infant to full length without artificial stretching, how to hold the infant still, and how to measure accurately. For this study, the method developed by Miller and Hassanein was used [2]. Briefly, this method involved using a specially constructed box with a movable footboard and built-in tape measure; the infant's head rested exactly against the end of the box, and then the tonic neck reflex was used to relax flexion at the hip and knee on the side the infant was facing in order to obtain full extension without stressing the infant. The movable footboard was then brought up to the infant's foot and the reading was measured where the footboard touched the tape. Intra-rater reliability (ten measurements on each infant) produced standard deviations which averaged less than .25 cm. Inter-rater reliability on 25 consecutively born infants between the pediatric investigator (HCM) and the senior resident found identical readings on 13 infants, differences of 0.5 cm on ten infants, and a difference of 1 cm on two infants [2].

Outcomes of pregnancies were determined in the high-risk categories and in the low-risk group, while controlling for biologic and socioeconomic conditions present in all pregnancies. The biologic conditions were maternal height, weight-height ratio at conception, age, and race, and the sex and birth order of infants; the socioeconomic conditions were socioeconomic level of head of household, years of school completed by the mother, and her marital status.

Chi-square, risk ratio, and confidence interval calculations were done on the Statcalc program that is part of the EPIINFO program produced by the Centers for Disease Control (Version 2, February 1987). The loglinear model was calculated using the CATMOD (Categorical Models) procedure in the Statistical Analysis System (SAS), version 6.02, for microcomputers.

RESULTS

There were two broad groups of conditions in pregnancies that were significantly associated with births of short full-term infants: risk conditions in the four high-risk
TABLE 2
Incidence of Short Crown-Heel Length of White Full-Term Infants, by Birth Weights Below and Above 2,500 g by Categories of Risk in Their Mothers' Pregnancies

| Categories of Risk       | Total No. of Infants | Birth Weights |                | Total No. | %     |
|-------------------------|----------------------|---------------|---------------|-----------|-------|
|                         |                      | <2,501 g No. | >2,501 g No. |           |       |
| PROM                    | 110                  | 4             | 12            | 16        | 14.5  |
| Fetal conditions<sup>f</sup> | 19              | 2             | 2             | 4         | 21.1  |
| Complications<sup>d</sup> | 220             | 11            | 21            | 32        | 14.5  |
| Adverse practices<sup>f</sup> | 744             | 12            | 57            | 69        | 9.3   |
| Total high-risk        | 1,093                | 29            | 92            | 121       | 11.1  |
| Low-risk                | 664                  | 0             | 16            | 16        | 2.4   |
| Total                   | 1,757                | 29            | 108           | 137       | 7.8   |

<sup>*</sup>Short infants: crown-heel lengths below fifth percentiles for gestational age
<sup>b</sup>PROM: spontaneous premature rupture of membranes
<sup>c</sup>Fetal conditions: category 3 in Table 1
<sup>d</sup>Complications: Medical or obstetrical complications (category 4, Table 1)
<sup>f</sup>Adverse maternal practices: category 5, Table 1
<sup>l</sup>Low-risk: absence of all risks in Table 1

Chi-square (total high-risk vs. total low-risk): 43.1;  d.f. = 1;  \( p < 0.0001 \)  RR = 4.59  (CI 2.91, 7.24)

categories as shown in Table 1, and conditions present in all pregnancies, including maternal height, socioeconomic status of head of household, and sex of infant. The effects of the four risk factors are shown in Tables 2 through 5, and the effects of conditions present in all pregnancies, controlled for risk group, are shown in Tables 6 through 8.

In Table 2 the incidence of short infants in the four high-risk categories is compared to the incidence of 16 (2.4 percent) short infants born to 664 low-risk mothers. The incidence in the four high-risk categories were as follows: PROM, 16/110 (14.5 percent); fetal conditions, 4/19 (21.1 percent); complications of pregnancy, 32/220 (14.5 percent); and adverse maternal practices, 69/744 (9.3 percent). The numbers of infants equal to or above 2,501 grams and below 2,501 grams are shown separately, to demonstrate that the incidence of full-term, adequate-weight babies that are nevertheless short is not inconsequential, although this group is seldom considered in the literature or in clinical practice.

Comparison of the proportions of short infants between the total high-risk and the low-risk categories (Table 2) was highly significant statistically, with the risk ratio for short crown-heel length equaling 4.59 (the 95 percent confidence limits were 2.91 and 7.24 [method of Miettinen]). Significantly, no short full-term infant had a birth weight under 2,001 grams.

Comparisons are made in Table 3 between mothers who had multiple and single risks in their pregnancies. In most cases, the multiple-risk factors included smoking plus one (or occasionally two) other risk factors, such as a medical/obstetrical factor or another adverse maternal practice. The sample sizes of the various combinations became too small for more detailed analyses by risk combinations.

The incidence of 64 (16.2 percent) short infants born in the group of 394 mothers with multiple risk factors was significantly higher than the incidence of 57 (8.2
Effects of Single and Multiple Risks per Pregnancy on Incidence of Growth-Retarded White Full-Term Newborn Infants by Category of Risk

| Category of Risk         | No. of Risks per Pregnancy | Total No. | Short Stature No. | %  |
|--------------------------|----------------------------|-----------|-------------------|----|
| PROM                     | Single                     | 32        | 0                 | —  |
|                          | Multiple                   | 78        | 16                | 20.5 |
| Fetal conditions         | Single                     | 5         | 0                 | —  |
|                          | Multiple                   | 14        | 4                 | 28.6 |
| Complications            | Single                     | 95        | 11                | 11.6 |
|                          | Multiple                   | 125       | 21                | 16.8 |
| Adverse practices        | Single                     | 567       | 46                | 8.1 |
|                          | Multiple                   | 177       | 23                | 13.0 |
| Total high-risk          | Single                     | 699       | 57                | 8.2 |
|                          | Multiple                   | 394       | 64                | 16.2 |
| Total low-risk           |                            | 664       | 16                | 2.4 |

Chi-square = 66.03; d.f. = 2; p < 0.0001

percent) short infants born in the group of 699 mothers with single risk factors, and higher than the 16 short infants (2.4 percent) among the low-risk pregnancies. In each of the high-risk categories in Table 3, the incidence of short infants was consistently higher among mothers with multiple than with single risk factors.

Adverse Maternal Practices

Mothers who had only adverse maternal practices in their pregnancies were the largest high-risk group (n = 744) and are studied in Table 4. The incidence of short infants born in the group of 177 mothers with multiple adverse practices was 23 (13.0 percent), which is considerably and significantly higher than the incidence of 16 (2.4 percent) short infants born to the group of 644 mothers with no risk factors (p < 0.0001). One hundred and sixty-nine of the 177 mothers with multiple adverse practices (95 percent) smoked cigarettes during pregnancy, and 135 of these 177 mothers smoked ten or more cigarettes a day throughout pregnancy.

The incidence of short infants among 209 mothers whose only known risk was that they smoked twenty or more cigarettes a day throughout pregnancy was 19 (9.1 percent), an incidence that also is much higher than the incidence of 2.4 percent among low-risk mothers, although less than for mothers with multiple risk factors. The incidence of short infants born in the group of 250 mothers who smoked less than twenty cigarettes a day was 21 (8.4 percent), an incidence that is still considerably higher than the incidence of 2.4 percent among low-risk mothers, but similar to the incidence to mothers who smoked 20 or more cigarettes per day. An overall chi-square was done for Table 4, comparing the proportion of infants with short stature in the multiple risk factor group, the single risk factor group, and the low-risk group (p < 0.0001). As a group, the mothers with only single adverse practices had much higher rates of infants with FGR than the low-risk group (p < 0.0001).

An apparent synergistic effect on the incidence of short infants is demonstrated in Table 5 among the 78 mothers who had PROM in combination with other risks in
TABLE 4
Incidence of Short Full-Term Infants Born to Mothers with Adverse Maternal Practices

| Adverse Practices          | Total No. of Infants | <2,501 g No. | ≥2,501 g No. | Total No. | %  |
|----------------------------|----------------------|--------------|--------------|-----------|----|
| Multiple practices         | 177                  | 7            | 16           | 23        | 13.0|
| Single practices           | 567                  | 5            | 41           | 46        | 8.1 |
| Cigarette smoking          |                      |              |              |           |     |
| ≥20 cigarettes/day*a       | 209                  | 3            | 16           | 19        | 9.1 |
| <20 cigarettes/day*a       | 250                  | 1            | 20           | 21        | 8.4 |
| Non-smokersc               | 108                  | 1            | 5            | 6         | 5.6 |
| Low-riskd                  | 664                  | 0            | 16           | 16        | 2.4 |
| Total                      | 1,408                | 12           | 73           | 85        | 6.0 |

*a20 or more cigarettes per day throughout pregnancy
*b70 of these mothers smoked only part of their pregnancies, and five (7.1 percent) had short infants.
*cNon-smokers: 51 had low weight gain; 23 were underweight; 11 were <17 years; 22 were >34 years; one had no prenatal care.
*dLow-risk: absence of all factors in Table 1

Chi-square (multiple practices vs. single practices vs. low-risk): 34.8; d.f. = 2; p < 0.0001 (Note: Multiple practices vs. low-risk, chi-square = 33.1 on 1 d.f., and single practices vs. low-risk gave a chi-square of 21.7 on one d.f.; both were highly significant.)

Table 1: 16 (20.5 percent) of these 78 infants were short. This incidence is almost twice the 10.7 percent of short infants born to mothers with other risk factors, but not PROM. Under an additive model, these two risks are summed to give an expected value in the combined group of 10.7 percent, instead of the 20.5 percent observed. We applied the expected 10.7 percent to the 78 with combined risks, and performed a chi-square on one degree of freedom to compare the observed and expected numbers. The chi-square was 7.99, which is highly significant statistically. Therefore, the risk for the combined groups is significantly more than would have been expected under the additive model.

TABLE 5
Effect of PROM Combined with Other High Risks on Incidence of White Full-Term Infants with Short Stature

| Risk Conditions            | Total No. | Short Stature* No. | %  |
|----------------------------|-----------|--------------------|----|
| PROM onlyd                 | 32        | 0                  | 0.0|
| Other risks with no PROMe  | 983       | 105                | 10.7|
| PROM combined with other risks | 78      | 16                 | 20.5|
| Low-risk                   | 664       | 16                 | 2.4|

*dCrown-heel lengths below fifth percentiles for gestational ages
*ePROM: spontaneous premature rupture of membranes
fOther risks: 19 fetal conditions, 220 complications of pregnancy, and 744 adverse maternal practices

Comparing the observed distribution in “PROM combined with other risks” with what would be expected using the model of 10.7 percent expected gives a chi-square of 7.99 on 1 d.f., p < 0.005.


Accordingly, taller mothers with smoking interaction produced short infants with other risk factors, which had an incidence of short infants in the group of mothers with low-risk pregnancies; however, maternal height was associated with higher risk of short infants among short mothers who also smoked cigarettes at any level during pregnancy, and among short mothers who had PROM in connection with other risk factors in Table 1. In the cigarette-smoking group of mothers under 62 inches, 13/49 (27 percent) of the infants born were short at birth compared to 27/408 (6.6 percent) short infants born to taller smoking mothers; the difference between the two shortest groups of mothers, on the one hand, and the two taller groups, on the other, is statistically significant. In Table 6, by chi-square there was no statistically significant difference in the distribution of maternal heights between either the smoking group or the PROM group when compared to the low-risk group, so no test for interaction was required.

In the group of 77 mothers with PROM plus other risks, the 12 short mothers produced six short babies (50 percent), compared to ten (15 percent) born to the 65 taller mothers with this combination of risks; the difference is statistically significant. Therefore, although low maternal height alone did not produce an increased incidence of FGR, low maternal height did so in combination with either smoking or PROM.
TABLE 7  
Association of Socioeconomic Status on Incidence of Short Infants by Risk Conditions

| Socioeconomic Group Conception | Low-Risk* Total | Short No. | % | Smoke Total | Short No. | % | Complications Total | Short No. | % |
|--------------------------------|-----------------|----------|---|--------------|----------|---|---------------------|----------|---|
| Group I                        | 257             | 4        | 1.6 | 61           | 4        | 6.6 | 41                  | 4        | 9.8 |
| Group II                       | 196             | 8        | 4.1 | 156          | 8        | 5.1 | 28                  | 1        | 3.6 |
| Group III                      | 87              | 1        | 1.1 | 81           | 10       | 12.3 | 6                   | 2        | 33.3 |
| Group IV                       | 116             | 3        | 2.6 | 156          | 18       | 11.5 | 19                  | 4        | 21.1 |
| Total                          | 656             | 16       | 2.4 | 454          | 40       | 8.8  | 94                  | 11       | 11.7 |

Chi-square \( d^d \) 
- \( X^2_{1} = 0.27, \) d.f. = 1

Probability by chance alone 
- 0.602 (N.S.)

Relative Risk (CI) 
- Low SES/High SES
  - 0.74 (0.24, 2.27)

- 2.14 (1.14, 4.02)

- 3.31 (1.15, 9.53)

* Had none of the risk factors in Table 1

* All smokers (full- or part-time)

* Complications: single medical or obstetric complications of pregnancy (Table 1)

* Each chi-square on 1 d.f. compares the higher two SES groups combined with the lower two SES groups combined.

The analysis of three-way table: SES \( \times (\text{Smoke/not smoke}) \times (\text{short/normal}) \):

First analysis: interaction of SES and smoking group on outcome was not statistically significant \( (p = 0.142 \) on 3 d.f.). Therefore, for the second analysis, the interaction term was dropped, and the independent effects of SES and the smoking group on outcome were studied. The SES was not statistically significant (chi-square \( = 3.41 \) on 3 d.f., \( p = 0.333 \)), but the smoking group was highly significant (chi-square \( = 10.82 \) on 1 d.f., \( p = 0.001 \)).

Socioeconomic Status (SES)

In Table 7 a low socioeconomic status (groups III and IV) alone did not significantly alter the incidence of short infants born to low-risk mothers \( (p = 0.602) \). Low socioeconomic status, however, did predict a higher rate of short babies among mothers who smoked and among mothers who had medical or obstetric complications of pregnancy.

Among mothers with medical or obstetrical complications, there were six short infants (24 percent) born to 25 mothers in SES groups III and IV, which is higher than the five short infants (7.2 percent) born to 69 similar mothers in SES groups I and II \( (p = 0.036) \). There was no statistically significant difference in the distribution of mothers by SES between the low-risk group and the mothers with complications, so the effect of SES would appear to be direct in this group.

Among smoking mothers, however, there were 28 short infants (11.8 percent) born to 237 mothers in socioeconomic groups III and IV, which is higher than the incidence of 12 (5.5 percent) short infants born to 217 smoking mothers in SES groups I and II. There was a statistically significant association between SES and smoking status, so that the adverse effect of low SES on crown-heel length might have been mediated through smoking. A log-linear model on a three-way table studying the relationship of SES, risk group (smoke/low-risk), and outcome (short/not short), did not, however, show the interaction to be statistically significant after the other effects were controlled. Therefore, we conclude that smoking had a clear adverse effect, and the
TABLE 8
Incidence of Short Girls and Boys Born to Mothers According to Their Risk Conditions

| Risk Conditions                  | Total | Short | %  | Total | Short | %  |
|---------------------------------|-------|-------|----|-------|-------|----|
|                                 | No.   | No.   | %  | No.   | No.   | %  |
| Low-risk                        | 351   | 6     | 1.7| 313   | 10    | 3.2|
| High-risk                       | 554   | 38    | 6.9| 536   | 82    | 15.3|
| Multiple adverse practices      | 87    | 4     | 4.6| 90    | 19    | 21.1|
| Cigarette smoking only          |       |       |    |       |       |    |
| ≥20 cigarettes/day              | 110   | 3     | 2.7| 99    | 16    | 16.2|
| 10–19 cigarettes/day            | 61    | 4     | 6.6| 59    | 9     | 15.3|
| <10 cigarettes/day              | 66    | 3     | 4.5| 61    | 5     | 8.2 |
| Fetal conditions                | 13    | 0     | —  | 6     | 4     | 66.7|
| PROM only                       | 16    | 0     | —  | 16    | 0     | —  |
| PROM plus other risks           | 40    | 7     | 17.5| 38    | 9     | 23.7|
| Complications                   | 106   | 16    | 15.1| 114   | 15    | 13.2|
| Other single (non-smoking) risks| 55    | 1     | 1.8| 53    | 5     | 9.4 |

*aCrown-heel lengths below fifth percentile for gestational age
*bAbsence of all risks in Table 1
*cCategory 5, Table 1
*dCategory 3, Table 1
*eCategory 4, Table 1
*fCategory 5, Table 1

Chi-square (low-risk boys vs. low-risk girls): 0.99, d.f. = 1, Not significant
Chi-square (multiple adverse practices + PROM with other risks, boys vs. girls): 8.59, d.f. = 1, p < 0.003; RR = 2.53 (1.36, 4.7)
Chi-square (single risk, boys vs. girls): 11.38; d.f. = 1; p = 0.0007; RR = 2.09 (1.36, 3.22)

apparent adverse effect of SES does not go beyond the fact that lower SES women were more likely to smoke.

Sex of the Infant

Data in Table 8 demonstrate that girls were more likely to be born short than were boys. There was no significant difference in the proportion of short girls and boys born to low-risk mothers. There was a greater proportion of short girls than short boys born to mothers who smoked and mothers with multiple adverse maternal practices (which usually included smoking 20+ cigarettes per day throughout pregnancy). In the group of 209 mothers who smoked 20 or more cigarettes a day, three short boys were born to 110 mothers (2.7 percent) and 16 short girls were born to 99 mothers (16.2 percent). The difference is statistically significant.

In the group of mothers with multiple adverse practices, four short boys were born to 87 mothers (4.6 percent), and 19 short girls were born to 90 mothers (21.1 percent); the difference is statistically significant.

No significant associations were observed between: (1) the number of years of school completed by mothers (over 12 years, 12 years, under 12 years); (2) their marital status (married and not married); (3) their age (over 34 years, 17–34 years, under 17 years); or (4) the birth order (first born and later born) and the incidence of short babies.
DISCUSSION

The present study is one of a series of investigations to determine if there are significant differences in the epidemiology of full-term infants with short crown-heel lengths at birth, full-term infants with fetal malnutrition [16], and low birth weight pre-term infants among whites and blacks [8-10]. Even among full-term babies, the epidemiology of FGR was more complicated than expected.

If the only independent variables used had been the risks listed in Table 1, there would have been considerable similarity in the risk factors for FGR in full-term infants and those for LBW as reported in our previous studies [8-10]; that is, PROM, fetal factors, medical/obstetric complications, and adverse maternal practices all increased the risk for short crown-heel length, as they did LBW. Moreover, multiple risk factors produced much higher rates of abnormality than did single risk factors, as was shown for LBW [9]. Also in agreement with prior studies on the risks for LBW, cigarette smoking was an important risk factor.

When, however, the risk factors in Table 1 were controlled by analyzing the biologic and socioeconomic variables within the different risk groups, some new patterns emerged. In general, the biologic and socioeconomic factors did not produce short babies if no other risks were present, but in combination with smoking or medical/obstetrical complications, biologic and socioeconomic factors appeared to increase the risk for short crown-heel length. This finding echoes a consistent pattern in our studies: mothers often appear to be able to tolerate one risk factor without a major increase in adverse infant outcomes, whereas two or more risk factors in combination are poorly tolerated.

It is doubtful the results of this study could have been obtained without using an appropriate method for measuring crown-heel length, and unless appropriately constructed fetal growth tables were available. In constructing fetal growth tables, it is essential that all possible high-risk conditions, such as those listed in Table 1, be considered in order to avoid, insofar as possible, the inclusion in the tables of infants at high risk for impaired prenatal growth. There have been reports of successful attempts to distinguish the "symmetric" and "asymmetric" forms of growth deficiencies by using ultrasound [17]; however, reliable measurements of fetal crown-heel lengths have not been made [18].

Also, in the epidemiologic studies of fetal growth in newborn infants, seldom has enough emphasis been placed on the formation of a truly low-risk comparison group of mothers to serve as controls for the different groups of high-risk mothers. The risk ratios for risk factors for short infants and for low birth weight infants are strongly influenced by the degree of care with which the group of low-risk mothers is selected. Including high-risk pregnancies in the "low-risk" group markedly reduces the apparent risk ratios and statistical contrasts. In order to obtain a truly low-risk group to study, it is essential to exclude at least those mothers who had any of the risk factors in Table 1, which requires considerably more detailed information than most data sets have, especially those based on birth and death certificates. Moreover, if many of the data are inaccurate or missing, as is true with birth certificates, the result is to decrease the potential to detect real associations. We do not claim that Table 1 includes all of the relevant risk factors; further research undoubtedly will discover additional risk factors not included. A case in point is cocaine abuse in the mothers, which was not seen in this data set [19,20]. Another example now would be maternal AIDS. We do believe that
perinatal epidemiologic studies that do not include careful, systematic measurement of the infant and data collection from each mother will yield progressively diminishing returns. More powerful analysis of large data sets with inadequate and missing data will not answer the current questions. The present situation in perinatal research requires increasingly complete and carefully collected data sets.

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