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FACTORS INFLUENCING HUMAN BIRTH WEIGHT IN NORMAL PREGNANCY: A PROSPECTIVE STUDY IN A BRAZILIAN UNIVERSITY HOSPITAL

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ABSTRACT

The effects of 17 variables on birth weight have been assessed in a prospective study of 1,045 singletons without major malformations, born at a Brazilian teaching hospital to mothers with neither diabetes mellitus nor chronic hypertension. These variables were as follows: sex of the newborn, gestational age at delivery, type of delivery, birth order of the newborn, placental shape, placental weight, umbilical cord length, point of insertion of the umbilical cord in the placenta, consanguinity between the parents of the newborn, maternal skin color, height and age, paternal age, trimesters of antenatal care, average number of cigarettes smoked daily during pregnancy, maternal schooling, and economic status of the newborn's family. The interrelations between these variables were analysed in order to investigate their relative importance as determinants of birth weight variations. Only gestational age, placental weight, smoking during pregnancy, maternal height, sex of the newborn and birth order were retained as significant factors, influencing and explaining 60% of the total variance of birth weight. Among these factors, gestational age and placental weight were the most important since they explained 40% and 16%, respectively of the total variance of birth weight.

INTRODUCTION

Knowledge of factors influencing the weight of newborns is extremely valuable, since it has been demonstrated that a low birth weight (less than 2,500 g) is associated with respiratory, metabolic, immunologic and neurologic disorders, and also has a strong

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influence on neonatal and perinatal mortality (Erhardt *et al.*, 1964; Harper and Wiener, 1965; Fitzharding and Steven, 1972; Chandra, 1975; Laski *et al.*, 1975).

Since the fifties it has been accepted that the genotype of the fetus is less important than some characteristics of the maternal constitution or maternal environment in determining human birth weight (Karn *et al.*, 1951; Karn, 1952; Robson, 1955; Morton, 1955; Fraccaro, 1957; Nance *et al.*, 1983; Carr-Hill *et al.*, 1987). As a consequence, extensive literature on the effect of maternal constitution and environment on the weight of newborns has been accumulated. These papers include some written by Brazilian authors who have added a great deal to the understanding of the causes of variation in human birth weight (Ciari Jr. *et al.*, 1975; Araújo and Salzano, 1975; Siqueira *et al.*, 1975, 1985; Tanaka *et al.*, 1977; Matheus and Sala, 1977; Yunes *et al.*, 1978; Trindade *et al.*, 1979-1981; Souza and Azevedo, 1984; Nóbrega, 1985; Benício *et al.*, 1985; Zisman, 1987; Pinheiro, 1989; among others).

Much work is still necessary for further documentation of birth weight variations under different conditions, particularly in the Third World (Bantje, 1986). This need is enhanced by the fact that investigation on the effect of intercorrelated variables on birth weight, by means of multiple regression analysis, has only been conducted by a small number of researchers. Moreover, few reports based on prospective clinical studies have been available.

SUBJECTS AND METHODS

From November 1984 to December 1985 all 1,119 children born at the maternity hospital of the Federal University of Paraná (UFPR), in Curitiba, State of Paraná, Brazil, were examined by one of us (R.F.P.). Of these, only 1,045 surviving singletons without major malformations, born to mothers with neither diabetes mellitus nor chronic hypertension were selected for the present study (536 males and 509 females), since it is known that infants born to diabetic mothers are larger and heavier than those of the same gestational age born to normal mothers, while the opposite occurs for infants exhibiting major malformations or born to mothers with chronic hypertension.

The UFPR mainly attends patients who live in the suburbs or in the neighbourhood of Curitiba. This population differs socially, culturally and racially from that of the urban area of this capital city (Marçallo *et al.*, 1964), which is composed predominantly of Caucasoids with a high standard of living. In contrast, the population who seeks this hospital includes a high proportion of Negroids, has a low income, and a low cultural level.

In the present study the following variables were considered for analysis, but could not always be assigned to all individuals:

1. Sex of the newborn.

2. Birth weight.

3. Gestational age at delivery, which was estimated from the first day of the last menstrual period and expressed in complete weeks. When a mother was unable to provide this date, the gestational age at delivery was estimated according to the method of Parkin *et al.* (1976).

4. Type of delivery.

5. Birth order of the newborn.

6. Placental shape.

7. Placental weight, which was determined as soon as the placentas were obtained after delivery. The adhering membranes at the cords were cut off, the blood clots removed, and gentle pressure during about five minutes was applied to empty the placentas of blood before their weight was recorded in grams.

8. Umbilical cord length, obtained after cutting off the cords close to the placentas.

9. Point of insertion of the umbilical cord in the placenta.

10. Consanguinity between the parents of the newborn.

11. Skin color of the mother. The Negroids were classified as Negroes and Mulattoes (light, medium and dark).

12. Maternal height.

13. Maternal age.

14. Paternal age.

15. Trimesters of antenatal care.

16. Average number of cigarettes smoked daily by the mother during pregnancy.

17. Maternal schooling.

18. Economic status of the newborn's family.

The statistical treatment of the data included analysis of variance, Student's *t* test for differences between means, chi-square, simple regression and correlation analyses, and stepwise regression analysis in which the dependent variable was the birth weight.

RESULTS

As expected, the mean birth weight calculated from the raw data for 536 males ($\bar{x}$ = 3,106 g; s = 561 g) and 509 females ($\bar{x}$ = 3,020 g; s = 467 g) showed a significant sex difference (t = 2.696; P < 0.01). When these newborns were distributed according to their weight it was seen that 12.1% of the males and 12.2% of the females weighed 2,500 g or less. It was also seen that this distribution departed slightly, but significantly from normality (χ^2 = 12.567; 5 d.f.; P < 0.05 for males and χ^2 = 11.157; 5 d.f.; P < 0.05 for females) as a consequence of asymmetry and kurtosis. The coefficient of asymmetry was

-0.6585 for males and -0.6822 for females, while the coefficient of kurtosis was 4.5292 for males and 4.1005 for females.

This distribution was brought to normality (χ^2 = 4.436; 5 d.f.; P = 0.49 for males and χ^2 = 3.465; 5 d.f.; P = 0.63 for females), by adjusting the birth weight of 486 males and 473 females to 40 weeks of gestational age, according to the equation $y_a = y + b(40-x)$, where y_a is the adjusted birth weight, y is the raw birth weight, b is the regression coefficient of the birth weight on gestational age (89.2664 ± 9.0781 for males and 91.6996 ± 8.8577 for females) and x is the observed gestational age. The sex difference for birth weight observed in the crude data was maintained in the adjusted birth weight ($\bar{x}$ = 3,200 g; s = 469 g for males and $\bar{x}$ = 3,060 g; s = 420 g for females; t = 4.365; P < 0.001). Moreover, the proportion of children with birth weight under 2,500 g remained high both among females (10.3%) and males (7.4%), in spite of the adjustment of birth weight for gestational age.

The mean gestational age at delivery for 959 babies was 39.3 weeks (s = 1.86 weeks) the procedure of delivery being normal for 71.4% of them (65.1% without and 6.3% with forceps). The parturition of the remainder was through cesarean section (27.6% without and 1.0% with forceps).

When the newborns were grouped according to their birth order the following percentages distribution were found among 961 children: 1st = 36.2; 2nd = 20.6; 3rd = 13.2; 4th = 9.3; 5 th = 6.9; 6th = 4.7; 7th = 3.3; 8th = 1.9; 9th = 1.1; 10th = 1.1; 11th or more = 1.7. Children born to multiparous mothers were significantly heavier than those born to primiparous women. For instance, the mean birth weight of the babies whose mothers had at least seven children was 3,400 g (s = 387 g) for 45 males, and 3,139 g (s = 343 g) for 41 females, while the mean birth weight of infants born to primiparous women was 3,097 g (s = 436 g) for 190 males, and 3,020 g (s = 384 g) for 158 females.

Among 945 placentas classified according to their shape 52.7% were circular, 21.6% were oval and 25.7% were atypical, their mean weight being 575.8 g (s = 114.6 g). The umbilical cords were on average 49.8 cm (s = 13.23 cm) long, 1045 of them being classified as central (31.9%), eccentric (43.2%) or marginal (24.9%), according to their point of attachment in the placenta.

Consanguinity between parents of the newborn infants was not found among 96.9% out of 1034 couples. The remaining 3.1% were composed of first cousins (9), first cousins once removed (10), second cousins (9), second cousins once removed (1), and third cousins (3). So, the mean inbreeding coefficient of the population represented by the examined infants was estimated as F = 0.0010. This estimate is greater than that found by Bassi and Freire-Maia (1985) in the records of four parishes from Curitiba of about 629 couples who married in 1980 (F = 0.00005). The striking difference between these two estimates may be due to the fact that most couples (80%) investigated by Bassi and Freire-Maia (1985) had a high or medium social level, while those studied by us had a

low income and a low cultural level. Moreover, Bassi and Freire-Maia (1985) analysed couples from the urban area of Curitiba, while our sample included people who live in the suburbs or in the neighbourhood of Curitiba.

According to skin color, 560 mothers (53.6%) were classified as Caucasoids and 485 (46.4%) as Negroids (8.4% Negroes, 20.4% light Mulattoes, 10.8% medium Mulattoes and 6.8% dark Mulattoes). The mean height of these 1,045 women was 154.5 cm (s = 5.94 cm) and their mean age estimated from 1,036 of them was 25.49 years (s = 6.43 years). Among them 27.3% were less than 21 years, 50.1% had between 21 and 30, 14.7% were between 30 and 36, and 7.9% were 36 or more years old. In this distribution 83.9% of the mothers were between 18 and 35 years, a period which most authors consider as ideal for reproduction.

The mean age of fathers of 1,011 newborn was 30.20 years (s = 8.76 years). Among them 9.1% were less than 21 years, 49.4% had between 21 and 30, 19.9% between 30 to 36, 11.8% between 36 and 42 and 9.8% were 42 or more years old.

Most of the 1045 mothers received antenatal care during all trimesters of pregnancy (76.5%), while 1.9% received this attention during two trimesters, 1.8% during one trimester, and 19.8% had no antenatal care at all.

The investigation of maternal smoking during pregnancy revealed that among 959 mothers 65.8% were nonsmokers 11.5% consumed less than five cigarettes per day, 8.4% smoked five to nine, 7.2% smoked 10 to 15 and 7.1% consumed more than 15 cigarettes daily. The babies born to non-smokers were significantly heavier ($\bar{x}$ = 3,258 g; s = 470 g for 314 males, $\bar{x}$ = 3,102 g; s = 408 g for 317 females) than those born to smokers ($\bar{x}$ = 3,093 g; s = 450 for 172 males; $\bar{x}$ = 2,975 g; s = 432 g for 156 females).

Concerning maternal schooling 947 mothers were distributed among the following classes: illiterate (16.1%), no schooling but able to read (8.7%), incomplete elementary school (46.3%), elementary school (15.6%), incomplete high school (8.4%), high school (4.2%), college (0.7%).

The monthly earning of the newborns' families was very low, since among 989 informative families it was less than one minimum wage (about US$ 70) for 76%, between one and two for 19%, and greater than two minimum wages for only 5%.

Type of delivery, placental shape, point of insertion of the umbilical cord in the placenta, consanguinity between the parents of the newborn, skin color of the mother, trimesters of antenatal care, maternal schooling as well as economic status of the newborn's family did not influence the birth weight. The analyses of variance of the weight of the newborn children in the different classes of each of these variables showed that the birth weight means did not differ significantly. Neither maternal nor paternal age were significantly correlated with birth weight.

In contrast, a simple correlation matrix has shown that birth weight was significantly correlated with gestational age at delivery (r = 0.544; $P < 0.001$), umbilical

cord length (r = 0.259; P < 0.001), maternal height (r = 0.196; P < 0.001), average number of cigarettes smoked daily by the mother during pregnancy (r = -0.173; P < 0.001), birth order (r = 0.106; P < 0.01), and sex (r = 0.078; P < 0.05). The correlation between birth weight and the last six variables remained significant even after correction of birth weight for length of gestation. As a consequence, only these variables were taken into account in a stepwise regression analysis in which the birth weight was considered as the dependent variable (Table I).

Table I - Stepwise regression analysis of birth weight on several concomitant variables.

Independent variable	Regression coefficient	Standard error	t	Determination coefficient	Increase
Gestational age at delivery	152.645	6.886	22.167***	0.4011	-
Placental weight	1.675	0.104	16.106***	0.5607	0.1596
Average number of cigarettes smoked daily during pregnancy	-43.157	7.836	5.508***	0.5773	0.0166
Maternal height	10.618	1.893	5.609***	0.5929	0.0156
Sex of the newborn	86.801	22.684	3.826**	0.6004	0.0075
Birth order	9.941	4.652	2.137*	0.6028	0.0024

***P < 0.001; **P < 0.01; *P < 0.05.

Table I shows that the most important and significant factors influencing birth weight are, in decreasing order of importance, the length of gestation, placental weight, smoking during pregnancy, maternal height, sex of the newborn, and birth order.

DISCUSSION

In spite of the small variability of gestational age, this factor accounted for about 40% of the variation of birth weight (Table I). Our results are, therefore, in agreement with those of several authors who observed that the length of gestation is the most important variable influencing birth weight (Love and Kinch, 1965; Dougherty and Jones, 1982; Cnattingius *et al.*, 1984; Jimenez *et al.*, 1984; Bantje, 1986; Pinheiro, 1989, among others).

Correlation between weight of the placenta and birth weight published in pertinent literature vary considerably, depending upon the methods used in handling the

placentas (Younoszai and Haworth, 1969). In spite of this, most authors agree that placental weight is more correlated with birth weight than with gestational age (Armitage *et al.*, 1967; Younoszai and Haworth, 1969; Trindade *et al.*, 1979; Bonds *et al.*, 1984). We were able to corroborate this, since by simple correlation analysis placental weight gave $r = 0.544$ with birth weight, and $r = 0.248$ with gestational age. Placental weight was the second most significant factor influencing birth weight. Unfortunately we could not find comparable results in the literature since only Kuizon *et al.* (1985) included placental weight in multiple regression analysis, with birth weight as the dependent variable, and found that placental weight was more important than gestational age in determining birth weight.

Since Simpson (1957) first observed that maternal smoking during pregnancy is associated with reduced birth weight, a large number of studies have confirmed this association. While it is known that several variables which have an effect on birth weight are correlated with maternal smoking, presently there are no doubts that smoking itself plays a causal role in reducing birth weight. This relation between maternal smoking and fetal development may arise from an indirect effect mediated by a reduction in maternal weight gain (Davies *et al.*, 1976) or from a direct toxic effect of nicotine and other substances, like cadmium, that provoke the decrease of blood supply to the fetus (Mochizuki *et al.*, 1985; Roelfzema *et al.*, 1985). Fortunately, the birth weight of children born of women who were formerly smokers increases after cessation of smoking (Wainright, 1983).

The birth weight of the children born at the UFPR hospital was negatively correlated with maternal smoking (Table I), this factor being the third most important influence on birth weight. We also observed that even light smoking (less than 10 cigarettes per day) provokes a significant loss of birth weight (132 g in male babies, and 103 g in female babies). Thus, while the male children born to 314 non-smoking mothers had a mean weight of 3,258 g ($s = 470$ g), those born to 100 mothers who smoked less than 10 cigarettes per day weighed 3,126 g ($s = 479$ g) ($t = 2.411$; $P < 0.02$). Concerning the mean birth weight of the female babies, those born to 317 non-smoker mothers had 3,102 g ($s = 408$ g), while those born to 91 light smokers had 2,999 g ($s = 347$ g) ($t = 2.396$; $P < 0.02$). Taking into account these data and the knowledge that even exposure to smoke during pregnancy reduces birth weight (Rubin *et al.*, 1986) it is regrettable to find that a large proportion (34.2%) of parturients seeking care at the UFPR hospital did not stop smoking during pregnancy.

It has been known for a long time that the taller the woman, the heavier her infant (Love and Kinch, 1965) and that children with low birth weight prevail among those born to Brazilian mothers with less than 149 cm height (Ciari Jr. *et al.*, 1975; Siqueira *et al.*, 1975). Therefore, it was not surprising to find in our data that maternal height was significantly correlated with birth weight (Table I). This correlation would

probably be higher if maternal height in our sample had a greater coefficient of variation than that observed (3.8%).

Correction of mother's height for her weight at the time of conception reduces the correlation between maternal height and birth weight (Nóbrega, 1985), suggesting that smaller women deliver lighter children because of their reduced weight. Unfortunately, the information we had on mothers' weight at the time of conception was unreliable.

In the stepwise regression analysis, sex was the fifth variable significantly influencing birth weight (Table I). This result obviously reflects the significant difference between the mean birth weights of males and females both in the raw data and after adjustment for gestational age. Even the adjusted birth weight means ($\bar{x}$ = 3,200 g; s = 469 g for males, and $\bar{x}$ = 3,060 g; s = 420 g for females) are far below the mean weight of normal Brazilian newborns, that is to say, 3,350 g for males and 3,280 for females (Orlandi, 1987). More troublesome was the observation that the proportion of children weight under 2,500 remained high even after the adjustment of weight at birth for gestational age (10.3% of the females and 7.4% of the males).

Our data agree with those of other authors in showing that birth order influences birth weight significantly (Karn and Penrose, 1951; Fraccaro, 1957; Jayant, 1964; Doubherty and Jones, 1982, among others). Nevertheless, in spite of the dramatic difference in birth weight of children born to multiparous women as compared to those born to primiparous mothers, parity was the least important factor significantly influencing birth weight (Table I). On the other hand, since parity is correlated with maternal age one would expect to find a significant correlation between birth weight and maternal age at least by simple correlation analysis. A similar result was expected for birth weight and paternal age, since the ages of fathers and mothers are highly correlated. Thus, we could not find a good explanation for the absence of a significant simple correlation coefficient for birth weight and maternal age.

The significant correlation between birth weight and umbilical cord length vanished in the stepwise regression analysis, probably because umbilical cord length is correlated with both placental weight (r = 0.287; $P < 0.001$) and length of gestation (r = 0.204; $P < 0.001$) which, as we have seen, are the variables most correlated with birth weight. The mean length of the umbilical cord we observed ($\bar{x}$ = 49.8 cm; s = 13.23 cm) is shorter than the 59 cm reported in pertinent Brazilian literature (Barcellos and Nahoum, 1987). Moreover, we observed that 67% of the umbilical cords were included in the 41 to 70 cm length group, instead of the expected 80%, as mentioned by Barcellos and Nahoum (1987).

We could not confirm Yunes *et al.* (1978) observation that children with a low birth weight are more frequent among those born through a cesarean delivery. Such discordance is probably due to the fact that in the UFPR maternity hospital cesarean

sections were indicated predominantly for fetal suffering, pregnancy toxemia, as well as for pelvic or transverse fetal presentation. On the other hand, the use of prophylactic forceps predominanted in forceps handling.

Shanklin (1970) claimed that newborns weighing less than 2,000 g are more frequently found among those with the umbilical cord attached marginally in the placenta. Like Woods and Malan (1978) we could not confirm this finding, since according to our data neither the point of insertion of the umbilical cord in the placenta nor the placental shape influenced birth weight.

Morton (1958) observed that inbreeding has a slight but significant decreasing effect on the mean birth weight, but does not influence its variance. Slatis and Hoene (1961) could not find a significant difference between the mean birth weight of children born to first cousins and that of newborns of non-consanguineous couples, in spite of observing that the former weighed less. Our data could not support Morton's (1958) or Slatis and Hoene's (1961) findings, since the children born to consanguineous parents had a slightly higher mean birth weight than those born to non-consanguineous couples (though this difference was not significant).

Niswander and Gordon (1972) claimed that among newborns with a gestational age of 40 weeks or more, Caucasoids are, on the average, 200 g heavier than Negroids. We could not confirm their finding, neither when the Negroid sample was divided according to the intensity of the mothers' skin color, nor when all Negroids were pooled together. We agree, therefore, with Araújo and Salzano (1975), who did not observe significant racial differences in birth weight among children born to mothers with the same economic level.

Absence of antenatal care, particularly for mothers of a low socioeconomic level, is known to be an important factor for decreasing birth weight (Benício *et al.*, 1985). It was, therefore, surprising to find that the mean birth weight of children born to mothers getting antenatal care during all trimesters did not differ from that of babies born to mothers getting this care during two trimesters or getting no antenatal care at all. The most plausible explanation for such a result is that most of the women belonging to the group with no antenatal care might have concealed that they in fact did receive antenatal care in other medical institutions in order to enjoy free hospital care at the university hospital.

Low maternal schooling is associated with low socioeconomic status which, in turn, is associated with factors that decrease birth weight, such as malnutrition, high morbidity and deficient antenatal care (Comstock *et al.*, 1971; Lechtig *et al.*, 1972; Miller *et al.*, 1976; Nóbrega, 1985; Benício *et al.*, 1985). As a consequence, we expected to find at least a "naïve correlation", as it was called by Dougherty and Jones (1982), between birth weight and maternal schooling or socioeconomic level. Nevertheless, in our data both these variables did not show the expected association with birth weight. This was

most probably due to the homogeinity in terms of schooling and socioeconomic status, of the women who seek care at the UFPR hospital concerning.

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RESUMO

Os efeitos de 17 variáveis sobre o peso do recém-nascido foram analisados em um estudo prospectivo de 1.045 crianças sem malformações graves, nascidas de parto único em um hospital-escola brasileiro de mães sem diabetes mellitus e sem hipertensão crônica. Essas variáveis foram as seguintes: sexo do recém-nascido, idade gestacional por ocasião do parto, tipo do parto, ordem de nascimento, forma da placenta, peso da placenta, comprimento do cordão umbilical, ponto de inserção do cordão umbilical na placenta, grau de consangüinidade entre os genitores do recém-nascido, cor da pele da mãe, estatura materna, idade materna, idade paterna, trimestres de acompanhamento pré-natal, número médio de cigarros fumados por dia durante a gravidez, escolaridade materna e nível sócio-econômico da família do recém-nascido. As inter-relações dessas variáveis foram analisadas para investigar sua importância relativa na determinação da variabilidade do peso ao nascer. Somente a idade gestacional, o peso da placenta, o tabagismo durante a gravidez, a estatura materna, o sexo do recém-nascido e a ordem de nascimento foram retidos como fatores com influência significativa sobre o peso do recém-nascido e capazes de explicar 60% de sua variância total. Desses fatores, a idade gestacional e o peso da placenta são os mais importantes porque explicaram, respectivamente, 40% e 16% da variância total do peso ao nascer.

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