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Feature Article

Low Birth Weight of Contemporary African Americans: An Intergenerational Effect of Slavery?

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ABSTRACT The average birth weight in the contemporary African-American population is about 250 g lower than the average birth weight of European Americans. Differences in genetic and socioeconomic factors present between these two groups can explain only part of birth weight variation. I propose a hypothesis that the low birth weight of contemporary African Americans not only results from the difference in present exposure to lifestyle factors known to affect fetal development but also from conditions experienced during the period of slavery. Slaves had poor nutritional status during all stages of life because of the inadequate dietary intake accompanied by high energetic costs of physical work and infectious diseases. The concept of "fetal programming" suggests that physiology and metabolism including growth and fat accumulation of the developing fetus, and, thus its birth weight, depend on intergenerational signal of environmental quality passed through generations of matrilinear ancestors. I suggest that several generations that have passed since the abolition of slavery in the United States (1865) has not been enough to obliterate the impact of slavery on the current biological and health condition of the African-American population. Am. J. Hum. Biol. 21:16–24, 2009. © 2008 Wiley-Liss, Inc.

The birth weight of contemporary African Americans is significantly lower than birth weight of European Americans. Low birth weight leads to higher morbidity and mortality, especially during the first year of life and it is also associated with the long-term negative health consequences, such as increased risk of hypertension, cardiovascular diseases, insulin resistance and adult onset diabetes (Barker, 1994, 1997, 2002; Gluckman et al., 2005), and changes in reproductive physiology (Jasienska et al., 2006a,b).

About 65% of the total variance in birth weight is due to nongenetic causes (Bogin, 1999). It is well established that maternal conditions during pregnancy, especially smoking, alcohol consumption, or disease may influence duration of pregnancy, leading to prematurity and low birth weight (Bogin, 2001). These factors may also be associated with reduced birth weight in full-term pregnancies. However, when variation in socioeconomic factors and differences in exposure to risk factors of low birth weight have been accounted for, significant "racial" [Following Bogin (1999; p 71), I use quote marks around "race" to point that "for human beings 'racial' categories denote socially defined groups and not biologically or genetically justifiable classifications."] differences in birth weight still remain. Since neither genetic factors nor current socioeconomic determinants can adequately explain the existence of birth weight variation between "races," other environmental, social, and historical reasons must be considered. The following observation points to slavery as the factor of potentially profound importance: contemporary black women who were born in African countries ancestral to slave populations, but who live in the United States, give birth to children with significantly higher weight than black women in the United States who have slave ancestry (Cabral et al., 1990; David and Collins, 1997).

This article suggests that the low birth weight of contemporary African Americans results, to a large extent, from conditions experienced during the period of slavery. I review the evidence that slavery was associated with poor nutritional status in utero, childhood, and adulthood. Poor nutritional status resulted from inadequate dietary intake and excessive workload, an imbalance between energy intake and energy expenditure, and the energetic costs of fighting infectious diseases. Poor nutritional status of the slave mother led to low birth weight of her children. Importantly, birth weight in contemporary populations is not only determined just by the current maternal condition but also by the influence of intergenerational life conditions, i.e., influences integrated across several generations (Emanuel et al., 1992; Kuzawa, 2005). Theoretical framework, supported by empirical results, of "developmental origins of health and disease" or "fetal programming" suggests that physiology and metabolism, including growth and fat accumulation of developing fetus, depends on intergenerational signal of environmental quality passed through several generations of matrilinear ancestors (Kuzawa, 2005).

The physiological and metabolic mechanisms responsible for intergenerational effects on fetal weight are not well understood, but the rapidly developing area of studies on epigenetic inheritance suggests that intergenerational information about environmental quality can be passed to next generations by changing gene expression, i.e., via methylation of the DNA or changes in the confor-

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mation of chromatine (Jablonka and Lamb, 2005). Therefore, information about environmental quality such as nutrition, workload, and diseases can be passed across generations (Kuzawa, 2008).

The birth weight of the mother herself shows a positive correlation with that of her baby (Bakketeig et al., 1979; Magnus et al., 1993; Selling et al., 2006). A review of 14 studies shows that per every 100 g of maternal birth weight, birth weight of children was, on the average, 10–20 g higher (Ramakrishnan et al., 1999). In part, this relationship can be explained by the presence of common genes shared by the mother and her offspring, and paternal birth weight also positively correlates with the birth weight of the child (Ramakrishnan et al., 1999). However, the magnitude of the relationship is greater for maternal birth weight than paternal birth weight, suggesting that effects of the maternal environment are important as well. Recent studies originating from egg donations show that the child's birth size is more strongly correlated with the stature of the egg recipient than with the stature of the egg donor (Brooks et al., 1995), again emphasizing the importance of the maternal environment during the preconception period.

Intergenerational effects on size at birth are not limited to a correlation between birth weight of the mother and her offspring. Birth weight of the child also depends on its mother's growth during her childhood. Mothers who are taller as children subsequently give birth to heavier babies and this relationship does not change after controlling for mother's own birth weight and her adult height (Martin et al., 2004). In fact, birth weight is well predicted by maternal leg length, which is a sensitive indicator of nutrition during childhood (Gunnell, 2002). Intergenerational effects seem to be stronger for female lines than for male lines (Emanuel et al., 2004; Ounsted, 1986; Ounsted et al., 1986) and can span across several generations. A mother's birth weight is determined by her mother's birth weight and also her mother's childhood growth and adult statute (Emanuel et al., 2004). Therefore, baby's birth weight is in part determined by its grandmother's birth weight, but also very likely by its great-grandmother's birth weight and her childhood nutritional status.

BIRTH WEIGHT OF CONTEMPORARY AMERICANS: "RACIAL" DIFFERENCES

American mothers of African descent face a higher risk of having children with low birth weight and higher degree of prematurity than do American mothers of European decent. The National Vital Statistics Reports (National Vital Statistics Reports, 2007) show that in 1995 African-American infants had the average birth weight of 284 g lower, and in 2005, 259 g lower than an average white infant (Table 1). Among African-American infants clinically low (less than 2,500 g) birth weight occurred about twice as frequently as in white infants. In the same years, US Hispanic population had average birth weights only 73 and 55 g, respectively, lower than European Americans.

The observed "racial" differences in birth characteristics result, to some extent, from the differences in the present socioeconomic status. It is important to note, however, that even after taking into account the socioeconomic inequalities, significant differences in birth characteristics remain. Among women with low incomes, black women have babies weighting 200 g less, on the average, than babies of white women (Goldenberg et al., 1996). Black mothers also had significantly younger gestational ages of newborns (38.1 weeks vs. 38.7 weeks for white mothers), higher percentage of preterm deliveries (16.7 vs. 11.3), and higher percentage of low birth infants (14.8 vs. 8.7). "Racial" groups compared in this study differed in factors increasing likelihood of poor birth outcomes, but in fact black women were better educated, smoked less, scored better on psychological tests reported having better housing and had higher body weight than white women. Only maternal height, weight, blood pressure, diabetes, and smoking had any impact on birth outcomes, but none of these factors explained the entire difference among "racial" groups. After adjusting for all the potential risk factors, the black babies still weighted 139 g less than white babies, and only about 30% of the variation in birth weight was explained by the examined maternal characteristics, with hypertension being the most important risk factor among black women (Goldenberg et al., 1996).

TABLE 1. Mean birth weight and rate of low birth weight (below 2,500 g) among singletons in "racial" groups in the United States in 1995 and 2005 (National Vital Statistics Reports, 2007)

	African Americans		European Americans		Hispanic Americans	
Year	1995	2005	1995	2005	1995	2005
Mean birth weight (g)	3,132	3,105	3,416	3,364	3,343	3,309
Rate of low birth weight (%)	11.66	11.90	4.87	5.32	5.36	5.69

African-American women are twice as likely as European American women to deliver children with weight below 2.5 kg (Farley, 1989) (Table 1). A study in South Carolina found that, even after controlling for education level, the use of prenatal care and the interval since the previous birth, black women still had higher proportion of low birth weight infants (Carlson, 1984). Further, "interracial" couples have lower percentage of low-birth-weight children than black couples, but higher than white couples (Bogin, 2001). Notably, among mixed marriages those with black mothers more often have children with low birth weight than those where the father is black.

Differences in birth weight between African Americans and European Americans in relation to socioeconomic and health variables were examined based on data from the Johns Hopkins Hospital from the years 1897 to 1935 and the data from the 1988 National Maternal and Infant Health Survey (NMIHS) (Costa, 2004). In the period from 1897 to 1935, based on live birth statistics only, European American babies had mean birth weight of 3,422 g while in African Americans it was 3,183 g, or 239 g (7%) lower. In 1988 birth weight of European Americans was 3,426 g and of African Americans 3,132 g (294 g or 8.6% lower). In the 1897–1935 data, the only characteristics that explained significant fraction of variation in birth weight between European Americans and African Americans was prematurity or gestational age. "Racial" differences in prematurity were, in turn, in 30% explained by maternal infection with syphilis. However, after controlling for prematurity, 91% in the racial variation in full-term birth weights remained unexplained and none of the socioeconomic variables analyzed by the study explained these differences.

Differences in prematurity explained the highest fraction of "racial" variation in birth weights also in the 1988 NMIHS study. Differences in prematurity (fraction of premature babies was 0.066 for European Americans and 0.172 for African Americans) were, in turn, in 16% attributable to differences in marital status, with more African-American women being unmarried. Maternal birth weight was tested by this study as the variable having a potential effect on child's birth weight. Irrespective of "race", maternal birth weight had a statistically significant impact on birth weight of the child. An extra 100 g in maternal birth weight increased child's birth weight by 16 g, or by 14 g when only full-term births were analyzed. However, maternal birth weight explained only a small fraction (6–7%) of "racial" differences in children's birth weights. In summary, in the NMIHS study, thanks to additional information about maternal birth weights and weigh gain during pregnancy, 70% in the "racial" weight variation was left unexplained in comparison to with 91% that was unexplained in the Johns Hopkins study.

NUTRITIONAL STATUS OF CHILDREN DURING SLAVERY

African Americans have a long, multigenerational history of nutritional deprivation, excessive workloads, and poor health due to years of slavery and the postslavery period of economic hardship. Although there is an ongoing debate about the nutritional status of adult slaves, there is a general agreement about poor nutritional status of slave children (Kiple and Kiple, 1977). Fertility of slave women in the United States was relatively high, with estimated 7 (Farley, 1965) or even 8.2 (Zelnik, 1966) children born, on the average, during the reproductive span. Most likely, short duration of breastfeeding and high infant mortality contributed to such high fertility rates. Breastfeeding in slave women lasted probably for less than a year and supplementation with poor quality, low in protein, pap and gruel, began as early as second or third month of the infant's life (Steckel, 1986a).

Although there were no actual measurements of birth weight of slave children, such weight was estimated to be 2,330 g, on average, based on measurements of children's height at young ages (Steckel, 1986b). Assuming normal distribution and the coefficient of variation of birth weights on the order of 20% [conservatively using modern values for African Americans (National Vital Statistics Reports, 2007)], we would conclude that approximately two-thirds of all slave children born would be considered as being below clinically low birth weight. This estimation would be over five times higher than the current rates for low birth weight (~12% among African Americans).

Slave children grew more slowly and were shorter than white children. Although babies were breast-fed and, therefore, probably received relatively good nutrition during this early stage of life, the quality of their diet dramatically decreased after weaning (Kiple and Kiple, 1977). Plantation owners believed that child's diet should consist of fat, cornbread, and hominy (Kiple and King, 1981), and slave children grew up having diet high in fat and carbohydrates but deficient in protein, calcium, magnesium, and iron (Kiple and Kiple, 1977).

Slave children began working at very young ages, although considerable variation existed among plantations and among individual slave owners (King, 1995). Forty-eight percent of children began working before the age of 7, and 84% before they reached 11 years. Girls began working at younger ages than boys and were usually more productive at the same tasks, as, for example, when picking cotton (Steckel, 1996).

Data on heights of individual slaves are available thanks to the 1807 Congress bill for the abolition of the slave trade (Steckel, 1986a). The law did not permit the African slave trade but allowed the coastwise trade of American slaves. Captains of ships transporting slaves were required to keep records of their ages and heights, which were used as proof that the slaves arriving in American ports were not illegally transported from Africa (Steckel, 1986a). Slave heights recorded at that time suggest that they were growing in poor nutritional and health conditions. For example, at the age of 3, slave children were at 0.2 centile of modern height standards. According to Steckel (1986a,b), this statistic suggests that standards of living were lower than those for children from the contemporary slums of the poorest African countries. An important issue to address here is whether the measurements of the traded slaves are representative of the general slave population. Some historians suggested that slaves shipped in the coastwise trade were selected to be sold because of their poor health, and other historians suggested that traders selected taller slaves to increase their profits (Pritchett and Freudenberger, 1992). Others, however, argued that the traded slaves were a representative sample of the general slave population (Komlos and Alecke, 1996; Steckel, 1995): children selected for coastwise trade did not differ in height from other slave children, and a comparison of heights of traded slaves and men from the US Colored Troops shows that they did not differ in average stature.

Mortality of black children aged 0–9 was twice as high as mortality of white children (26.3 vs. 12.9 per 1,000, respectively) (Kiple and Kiple, 1977). During the first year of life, the mortality rate for slave children was 350 per 1,000 births, whereas the overall infant mortality for the United States population was 179 per 1,000 (Steckel, 1986a). Slave children also had twice as high mortality rates as the average for the US population in early childhood (for ages 1–4, 201 vs. 93 per 1,000, respectively), and between ages 5 and 9 (54 vs. 28 per 1,000, respectively) (Steckel, 1986a). Slave children more often than white children suffered high rates of diarrhea, neonatal tetanus, convulsions, diphtheria, respiratory diseases, and whooping cough (Savitt, 1978).

Poor nutritional status of adolescent girls can further deteriorate once they become pregnant. An adolescent mother has to allocate energy to three major categories (child's growth and development, her own metabolism, and her own growth), whereas an adult woman supports only two of these needs. The mean age of first birth was estimated at 22.5 years and the median age at 20.8 years, with 40% of women giving birth before they were 20 years old (Fogel and Engerman, 1974), but another study examining the actual data on age at first birth at several plantations showed that the mean value varied from 17.7 years of age to 19.6 years (Gutman, 1976; Gutman and Sutch, 1976). The Ball family plantation records suggested that the mean age at first birth for five time periods from years 1750 to 1839 ranged from 19.1 to 20.0, with no significant trend in time (Cody, 1977). Although these data suggest that some of the slave women did not face competing energy demands from their own growth while pregnant, more interesting are the data showing the distribution of maternal age at first birth. More than 50% of all women gave birth to their first child between 17 and 21 year of age and between 10 and 20% of all women had their first child between the ages of 12 and 16. This suggests that many women were still growing themselves while pregnant or lactating their first, and possibly also the second child. Young mothers faced trade-offs in energy and nutrients allocation between maternal growth and fetal growth and that resulted in reduced birth weight of their children.

NUTRITION AND WORKLOAD OF ADULT SLAVES

The average nutritional status of the African-American population during the years of slavery is difficult to be assessed because of substantial variation in lifestyle imposed by different types of plantations. For example, rice culture of South Carolina and Georgia was demanding more physical labor than the tobacco culture of Virginia and Maryland, and, therefore, slaves from the Lower South were shorter than those from the Upper South (Komlos, 1994). Historians presented conflicting views on slave nutrition. Some estimates suggested that slave diets were energetically and nutritionally adequate (Fogel and Engerman, 1974). Based on the analysis of census documents of cotton plantations, these authors estimated that an adult male slave diet provided 4,185 calories a day, whereas diets of slaves on rice plantations were estimated to yield between 3,150 and 4,200 calories for an adult male (Swan, 1972). Such high estimates may be resulted from calculations of caloric and nutritional content of raw, instead of processed foods (Blonigen, 2004). In fact, processing causes food to lose volume, energy content, and nutrients. Typical diet of adult male slaves on rice plantations in Georgia and South Carolina in 1860s was estimated to have 3,162 calories when analyzed in its raw state, but after adjustment for loss during processing its caloric intake was reduced to 2,856 calories (Blonigen, 2004). Nutritional status of women was additionally compromised by the custom of males consuming most meat given to slave families (Morgan, 2008).

Daily energy expenditure of most slaves varied seasonally. Estimates of daily energy expenditure of male slaves from Louisiana sugar plantations during the cane-planting season show that mean energy expenditure was over 5,100 kcal/day, whereas energy intake at 20–40% less than the expenditure (Follett, 2003). During the harvest season, with workday lasting between 12 and 16 h, the daily energy expenditure reached 6,500 kcal/day (Follett, 2003).

Extremely high levels of energy expenditure cannot be easily compensated by intake, even when additional food is freely accessible. There are physiological limits to the rate of food conversion into usable energy (Peterson et al., 1990). When an individual is experiencing high energetic demands, increases in food intake, at some point, cease to generate additional energy. Metabolism completely fueled by energy intake, without relying on energy reserves, is called the sustained metabolism (Peterson et al., 1990). Sustainable energy budgets appear to be limited by the maximum rate of energy assimilation which, in turn, is constrained by either the physiological capacity to digest food or by the capacity to absorb nutrients and energy (Weiner, 1992). In hardworking slaves, therefore, high levels of energy expenditure had to be compensated by energy generated by metabolizing body fat reserves.

WORK AND CONCEPTIONS

Plantation manuals and daily work records show that women worked very hard and were not allowed to reduce their workload before the fifth month of pregnancy (Campbell, 1984). In more advanced pregnancy, women were usually allowed to work less intensely. Records from cotton plantations show that while nonpregnant women collected 87.8 pounds of cotton per day, 1–4 weeks before giving birth their work output decreased to 67.0 pounds, and decreased further during the week of giving birth and the week immediately following the birth, when women collected just 31.3 pounds (Steckel, 1986b). High energetic demands placed on slave women are suggested by a documented significant seasonality of births. Such seasonality implies seasonality of conceptions, and the conception itself, while clearly affected by many factors, depends on ovarian function. Ovarian function is very sensitive to the increases in physical activity and reacts with suppression (Jasienska, 2003; Jasienska and Ellison, 1998, 2004; Panter-Brick and Ellison, 1994).

At the Ball plantation during 1735 and 1865, most births occurred during August, September, and October, which indicated that most conceptions occurred during winter months (Cody, 1977) when the work intensity was reduced. The lowest percentage of conceptions occurred between May and July—a period of high labor demands. A rise in conceptions, which began in August, may suggest an improvement in nutritional status of women, thanks to the postharvest increase in food supply. However, the rates of conception still rose after August, suggesting that a reduction in energy expenditure may have more pronounced and lasting effects on relaxing ovarian suppression than have positive changes in energy intake.

PHYSICAL ACTIVITY DURING PREGNANCY

Intense physical activity during pregnancy may create conflicting physiological demands. Exercise affects redistribution of uterine blood flow, which may result in fetal hypoxia, hyperthermia, and decreased carbohydrate intake by a fetus (Sternfeld, 1997). Consequently, the rate of intrauterine growth is reduced and birth weight of a baby is lower. Increased uterine contractility may also lead to preterm labor. Ethiopian mothers who did intense physical work during pregnancy gave birth to children weighing on average 210 g less than the babies of less physically active mothers (Tafari et al., 1980). Australian women who did more than four 30-min sessions of vigorous exercise per week had babies with mean birth weight 315 g lower in comparison with babies of women who did not exercise (Bell et al., 1995).

In another study, women who were physically active before becoming pregnant were randomly assigned to one of the three following exercise regimes while in pregnancy (Clapp, 2000). Women from the group with most intense exercise had lower placental volume and their babies were 45 g lighter and had body fat reduced by 30% in comparison with women from the group with least intense exercise regime. The type of exercise may also be important and it is likely that weight-bearing exercise is needed to have a pronounced effect on birth weight (Clapp, 2000). In general, while moderate exercise in pregnancy is safe for healthy, well-nourished women, intense exercise, and most likely intense physical work as experienced by slave women, especially during the harvest season, might have led to a substantial reduction in birth weight of their children.

Data from cotton plantations, which document seasonality in workload, show seasonal variation in infant mortality during the first month of life. It is suggested that seasonality of maternal workload may have been responsible for the observed mortality pattern (Steckel, 1996). On the Kollock cotton plantations in Georgia, women whose infants successfully survived their first year of life had received more days off work during their pregnancy than did women whose children did not survive (27.2 vs. 19.2 days, respectively) (Campbell, 1984). In pregnancy, energetic status of the mother during the last trimester of pregnancy has the most pronounced effect on reducing the newborn size during World War II. Dutch women suffering from famine during the last trimester had babies with almost 300 g reduced birth weight in comparison with babies born after the famine (Painter et al., 2005, 2007). Similarly, slave women who experienced increased workload during the last months of pregnancy most likely had babies with reduced birth weight. Therefore, while low energetic status resulting from inadequate nutrition and intense work contributed to the generally low average birth weight in the slave population, seasonal increases in workload were most likely responsible for seasonal variation in birth weight and related variation in infant mortality.

FURTHER EVIDENCE ON SLAVERY AND BIRTH WEIGHT: CARIBBEAN SLAVERY

The United States was not the only country using slave labor in the 18th and 19th centuries. Although approximately 0.4–0.5 million of African slaves were shipped to the United States, 4–5 millions were imported into the Caribbean. I discuss the relationship between living conditions and biological conditions of slaves in Caribbean and implications for birth weight of contemporary populations elsewhere (Jasienska in prep.), but briefly. Living conditions of slaves from Caribbean were as harsh, and in some aspects even more difficult than conditions for slaves in the United States (Higman, 1984). Caribbean slavery differed in many aspects from the slavery in the United States. Demographic data suggest that the Caribbean slaves suffered very high mortality rates and relatively low fertility, with a resulting negative rate of natural increase. Birth rates for Caribbean slaves were lower than for most slaves in the United States. In Jamaica, the crude birth rate for Creole-born slaves was estimated at about 25–27 per 1,000 individuals, whereas for the US slaves at about 50–55 per 1,000 people (Kiple, 1984).

Caribbean slave mothers breastfeed their children for a longer period than slave mothers in the United States (at least 2 (Handler and Corruccini, 1986) or even 3 years after birth (Kiple, 1984) in Caribbean and about 1 year in the United States). Supplementary foods were not introduced before the child was 1 year old (Kiple, 1984). In later childhood and adolescence, however, the Caribbean slave children had much less rapid catch-up growth than the US slave children (Steckel, 1994), suggesting an even more dramatic decline in nutrition after weaning.

As adults, the Caribbean slaves were shorter than the US slaves. During the period from 1826 to 1860, the average height of US male slaves aged 25–40 was 171.2 cm, while in Trinidad in 1813, averaged for both African-born and Caribbean-born slaves, was only 164.5 cm. Comparable figures for females are 159 cm and 154.4 cm, respectively (Higman, 1979, 1984). Higman (1979) argues that differences in height observed between the United States and Caribbean slaves resulted from differences in caloric intake.

In addition, workload of Caribbean slaves was more intense than in the case of the slaves in the United States. It is generally agreed that slaves working on sugar plantations had much more demanding work regime than slaves working in any other type of agriculture or those working in towns (Follett, 2003; Higman, 1984). Although some sugar plantations operated in the United States, mostly in the 19th century Louisiana, they were much more common in the Caribbean. In women, a combination of poor nutrition and exhaustive work often led to amenorrhea, and physicians and planters frequently observed "obstructions of the menstrua" in the slave Caribbean women (Kiple, 1984; p 110). Poor diet-related diseases, such as scurvy, resulting from vitamin C deficiency, anemia from the lack of iron, pellagra from the lack of niacin and riboflavin, and beriberi from thiamine deficiency, frequently occurred among slaves (Kiple, 1984). Infectious diseases, especially internal parasites and malaria, were also very common in the Caribbean, especially in Guyana, Trinidad, and Jamaica (Higman, 1979). Infectious diseases are also capable of reducing birth weight. Mothers with malaria are known to have smaller babies than healthy, noninfected mothers (Akum et al., 2005).

The observed birth weights in the contemporary Caribbean countries seem to support the hypothesis that long-term, multigenerational exposure to harsh nutritional conditions, as experienced during slavery, is related to reduced birth weight. In Barbados, during the late 1950s and 1960s, average birth weight was almost 200 g lower than the average birth weight of African-American infants (Wells, 1963). More recent data from Jamaica show that the mean birth weight between 1985 and 1989 was 3,232 g. During the same years, birth weight for European Americans was 3,500 g (Peabody et al., 1998). Another study reported mean birth weight for Jamaican newborns in 1990 being 3,191 g on the average (Thame et al., 1997). In that study, maternal stature was shown to be an important predictor of birth weight, birth length, head size, and size of the placenta, suggesting that poor birth outcomes resulted not only from maternal condition during pregnancy but also from a longer, most likely intergenerational, exposure to nutritional deprivation.

BIRTH WEIGHT IN CONTEMPORARY MIGRANT POPULATIONS

Most African Americans have West African ancestry. It is estimated that about 75% of the genetic make-up of African Americans is West African in origin and the remaining is of European origin (Adams and Ward, 1973; David and Collins, 1997; Reed, 1969). It can be assumed that if the "racial" difference in birth weight is genetic, women born in West Africa should have babies with equally low or even lower (due to the presence of "high birth weight" European genes in African American women, which are not present in the West African women) birth weight than African American women. Of course, maternal condition during pregnancy may constitute a confounding factor, and therefore the ideal setting to test this hypothesis would be provided by comparing only women currently living in the United States.

Infants of the US-born white women, Africa-born black women, and the US-born black women were compared (David and Collins, 1997). White women had babies weighing 3,446 g at birth and the US-born black women babies weighting 3,089 g. Africa-born women had much heavier babies than US-born black women with average birth weight of 3,333 g. The overall distributions of birth weights were almost identical for white and Africa-born black women, and they were different from the distributions of birth weight among US-born black women. After statistically controlling for differences between these two groups in age, education, marital status, gravidity, prenatal care, and the history of fetal loss, white women's babies still weighed 98 g more than babies of Africa-born women. A similar analysis, which after controlling for the same major risk factors associated with low birth weight, compared babies of white women with that of the US-born black women showed that there was a remaining 248 g difference in average birth weight.

Data were reanalyzed including only women at the lowest risk for having babies with low birth weight. Women who were included in this analysis were between 20 and 39 years of age, began prenatal care in the first trimester, had at least 12 years of education and were married to partners who also had at least 12 years of education. The differences between infants of white and Africa-born black women in mean birth weight became even less pronounced, whereas the differences between infants of white women and US-born black women did not change. Importantly, the proportion of infants with very low birth weight (less than 1,500 g) was similar in both groups of black women, suggesting that mean birth weight was not affected by the fact that one group was more likely to give birth to small and premature babies. This study clearly suggests that genetic factors have little impact on differences in birth weight between white and black women in the United States.

A comparison of the US-born black women and foreign-born black women from Africa, Cape Verde, the Caribbean, and England who gave birth in the Boston City Hospital show higher birth weight for foreign-born black women (Cabral et al., 1990). After adjusting for risk factors, including the use of cigarettes, alcohol, marijuana, and cocaine in pregnancy (which in this study were more common among the US-born women), the foreign-born black women still had babies weighing 135 g more.

THE RECALCITRANT BIRTH WEIGHT

It is hard to predict how many generations with improved nutrition and health condition are needed for a significant increase in birth weight. In the last half-century, the mean birth weight of white population in the US has increased. Birth weight of female infants of the US-born white women increased from 3,309 g for cohorts born between 1956 and 1975, to 3,374 g for cohorts born between 1989 and 1991, which is 65 g in 25 years or 26 g per decade. During the same period, birth weights of female infants born to the US-born African-American women was not only lower, but it increased only by 17 g (from 3,060 to 3,077) or less than 7 g per decade. Moreover, the average birth weight did not change for African Americans for many years: in the 1990 it was 3,128 g and a century before it was 3,183 g (Costa, 2004).

Studies of migrant populations from countries with poor economic status to countries where people do not experience nutritional shortages show that birth weight cannot be easily improved. In England, during the last 40 years, there has been no secular trend in birth weight for infants born to mothers from the Indian subcontinent. No difference in mean birth weight was observed between mothers who were themselves born on the Indian subcontinent, but gave birth to children after having immigrated to England and mothers of the same ethnic group who were born in England (3,120 and 3,119 g, respectively; only singleton births delivered at term were analyzed in this study) (Margetts et al., 2002). Another study from England comparing first and second generations of Asian women showed a similar lack of differences in birth weight (3,044 and 3,022 g, respectively) (Draper et al., 1995). Other ethnic groups also did not show changes in birth weight after immigrating to the United Kingdom. Black Caribbean mothers born in the Caribbean had female infants weighing 3,129 g and male infants 3,320 g, whereas children of black Caribbean mothers born in the United Kingdom had corresponding birth weights of 3,223 g and 3,275 g. Differences between birth weights of the UK-born and Caribbean-born mothers were not statistically significant. A similar lack of improvement in birth weights was noted for black African mothers.

Within the United States, a study based on data from the National Longitudinal Survey of Youth 1979 and the 1970 US Census showed that upward socioeconomic mobility contributed to improved birth outcomes in European American women who were poor as children. Equally positive changes in socioeconomic status did not influence the proportion of infants born with low birth weight among African-American women (Colen et al., 2006).

Although living for a few generations in improved conditions seems to have no effect on birth weight, there are, of course, differences in mean birth weight between infants born in countries differing in the overall level of economic development. South Asian babies born in the United Kingdom are significantly heavier, by about 300 g, than South Asian babies born on the Indian subcontinent (Rao et al., 2001). It is suggested that a lower load of infectious diseases and improved maternal nutrition may explain this difference (Margetts et al., 2002). However, what is interesting, and as discussed earlier, that after this initial improvement in birth weight there are no further increases, and babies of migrant women remain significantly lighter than babies of the UK white women. This suggest than the intergenerational component of birth weight is very resistant to nutritional improvement.

ARE LOW BIRTH WEIGHTS OF AFRICAN AMERICANS DUE TO SLAVERY?

In summary, currently the mean birth weight of African Americans is lower than birth weight of European Americans. Although variation in socioeconomic factors and differences in exposure to risk factors are able to explain a part of this variation, significant "racial" difference in birth weight still remains. This difference is also unlikely to be genetic in origin since contemporary African-born black women who live in the United States give birth to children with much higher weight than black women in the United Status who have slave ancestry (Cabral et al., 1990; David and Collins, 1997).

Birth weight, among many other factors, is determined by the influence of the intergenerational life conditions, especially for the female line. Low birth weight of contemporary African Americans may result from conditions experienced during the period of slavery and especially poor nutritional status in utero, childhood, and adulthood. It is well documented that slave populations had inadequate diet and strenuous workload, experienced an imbalance between energy intake and energy expenditure, and had high energetic costs of fighting infectious diseases.

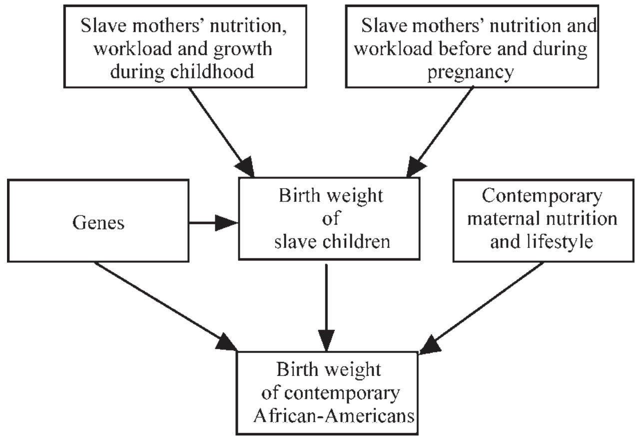

Fig. 1. A schematic model suggesting determinants of birth weight in the contemporary African-American population. Poor maternal nutritional status and poor children's nutritional status during years of slavery are important intergenerational factors responsible for low birth of African Americans today.

In the United States the condition of many slaves did not improve after the abolition of slavery and freed slaves were treated as second-class citizens. Ex-slaves were not employed in skilled jobs and many lived in sharecropped system (Robertson, 1996). The 1900 census data showed that African Americans suffered higher mortality than Euro-Americans from all major diseases except cancer (Rose, 1989). Skeletal analysis from the postslavery populations from Southwest Arkansas suggested that nutritional deprivation still occurred both during childhood and adult life (Rose, 1989).

I suggest that the low birth weight of contemporary African-American children has at least three major causes, all related to the years of slavery from the past (see Fig. 1). First of all, slave children had low birth weight as a direct consequence of maternal undernutrition and intense physical labor experienced both during pre-pregnancy and during gestation. Second, low birth weight is determined by the rate of childhood growth of the mother, which was greatly reduced in slave girls by poor nutrition and intense labor experienced from the young age. Third, birth weight is influenced by maternal (and grand-and great-maternal) birth weights, therefore slave mothers had low-birth-weight children as a result of their slave mothers and grandmothers having poor nutritional status during development and adult life, including pregnancy. These factors may also have a joint effect on birth weight. For example, a girl born with low weight may grow slower in childhood. Birth weight is a predictor of disease status early in life, and a sick child often receives poor nutrition because of the lack of appetite or an inability to seek additional food. Therefore, her own child will have a low birth weight as a result of both her low birth weight and her poor growth during childhood.

Even a short-term nutritional deprivation of pregnant women, when very severe, seems to have some intergenerational effect. Dutch women exposed to famine as fetuses in mid- and late-gestation had reduced birth weights themselves, but the effect was also detectable years later, since the birth weight of their children was also reduced. First-born children of the second generation whose mothers were undernourished as fetuses in the last trimester of pregnancy (i.e., the grandchildren of women who suffered through famine) still had slightly lower birth weights (by 43 g in comparison with offspring of unexposed women) (Stein and Lumey, 2000), despite the fact that their mothers had good nutritional status while living in modern Netherlands. The association between famine and birth weight of second generation was less consistent for later-born offspring.

African Americans suffered much longer-lasting nutritional deprivation. Although their caloric intake was higher than during the Dutch famine, their levels of energy expenditure were extreme. In addition, hard work during pregnancy reduces birth weight, regardless of maternal caloric intake. Multigenerational exposure to harsh energetic conditions may change the maternal assessment of the quality of environmental conditions. Even when the mother is well nourished herself, an intergenerational experience, which may be integrated in her own maternal physiology and anatomy, may cause her organism to follow the physiological strategy, which results in a reduced birth weight of her children. The specific physiological mechanisms are unknown at present, but there are two possible, mutually not exclusive, evolutionary reasons for a multigenerationally, nutritionally deprived mother to follow the strategy of reduced allocation of nutrients and energy to fetus. First reason is to have a child, and consequently an adult, with a reduced body size. Small body size is energetically less expensive to maintain, and thus more likely to survive in the conditions of low energy availability. Second reason, is to invest less in a given offspring, in expectation of declining energetic conditions in the future. Based on a multigenerational signal a woman's body expects that, in general, nutritional conditions are poor, therefore by investing less in a given offspring, the mother may save energy for future reproduction. Small infant is also less energetically costly for the mother during breastfeeding and early childhood (Wells, 2003).

It is difficult to determine if producing a child with small size at birth represents an adaptive strategy or is just the best outcome possible in a given situation. There are trade-offs associated with having a small size at birth. Although smaller body size may allow an individual to survive on limited resources, mortality of children with small size at birth is very high, especially during the first year of life. Such infants are more susceptible to infections and may have health problems, which negatively affects their future development. Even in the contemporary US, small size at birth is still associated with higher mortality. In conditions in which slaves were forced to live, having a child with small size at birth, was an extremely risky maternal strategy.

The main hypothesis presented in this article states that in African Americans too few generations have elapsed with improved energetic status to counteract the tragic multigenerational effects of nutritional deprivation on birth weight of children. An alternative, would be the view which postulates the direct, psychological effects of discrimination still reported by many African-American women in the contemporary US, causing the low birth weight of African-American children (Collins et al., 2004; Mustillo et al., 2004; Rich-Edwards et al., 2001). Although socioeconomic and lifestyle differences are often carefully controlled, some other differences are more difficult to quantitatively assess but potentially very relevant.

Self-reported racism has recently achieved attention as the factor with impact on health, with most evidence suggesting its negative relationship to mental health and health-related behaviors (Paradies, 2006). The potential relationship between self-reported racial discrimination and negative pregnancy outcomes (i.e., preterm delivery, low birth weight) was also addressed. A small study of poor African-American women with no health insurance showed that self-reported racial discrimination was associated with giving birth to extremely low-birth-weight infants, i.e., weighing below 1,500 g (Collins et al., 2004). Higher risk of preterm delivery in women who reported racial discrimination was also reported in some (Dole et al., 2004; Mustillo et al., 2004) but not all (Rosenberg et al., 2002) studies.

It is suggested that racial discrimination may cause high levels of chronic psychological stress (Mustillo et al., 2004). Such stress has been linked in human and animal studies to immunosuppression, susceptibility to infections, and preterm birth (Desouza, 1993; Goepfert and Goldenberg, 1996). However, studies controlling other determinants of psychological stress are needed (Hogue et al., 2001). For example, racial discrimination seemed to be related to depressive symptoms in mid-pregnancy among over 2,700 African American and European American women, but this relationship was no longer significant after controlling for self-reported discrimination due to gender and socioeconomic status (either of which showed statistically significant relationship with the depression score, Canady et al., 2008). It should be noted that studies on self-reported racial discrimination have often been criticized for serious methodological limitations, e.g., the absence of cohort studies, validated questionnaires, and clear definitions of racism, and for confounding racism with psychological stress (Paradies, 2006).

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