



DO MATERNAL NUTRITIONAL RESERVES LIMIT
FETAL GROWTH IN UNDERNOURISHED WOMEN ?

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IN UNDERNOURISHED WHOMEN ? André BRIEND, ORSTOM, Nutrition

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Epidemiological evidence shows that in undernourished pregnant women the fetal growth is less affected than the accumulation of maternal nutritional reserves. On the other hand, low maternal nutritional reserves are said to be a major limiting factor of fetal growth in the developing world. If these two propositions were true, one would expect the birth weight to be roughly proportional to maternal weight in thin undernourished women. This assertion was tested in 136 Senegalese women selected in a post natal check-up for their poor nutritional status. A log-log regression showed that :

$$\log (\text{birth weight}) = - 0.084 \pm 0.322 \pm 0.240 * \log (\text{maternal weight})$$

The slope of this regression is significantly lower than 1 (p less than 0.001). In other words, the mothers that weighed less had noticeably bigger newborns when compared to maternal weight. This rejects at least one of the tested propositions. In this part of Africa, most mothers successfully breast-feed their babies after delivery we suggest that the limiting effect of maternal nutritional reserves on fetal growth should be reconsidered in the first place.

Birth weight is a major determinant of survival during the first months of life. In the developing countries, mean birth weight of term babies is lower than in the industrialized countries. This results in an excess of neo-natal mortality which could not be totally removed by an improved standard of pediatric care. Better standards of care is the priority to decrease neo-natal mortality in the tropics, but a better knowledge about the factors depressing birth weights is desirable.

Small for data newborns have anatomic characteristics reminiscent of those of older children suffering from malnutrition. Since on the other hand, women in the poor countries have food intakes often well below the recommended allowances; it is often taken for granted that maternal malnutrition is the major cause of fetal growth retardation. It is often stated that mothers have not enough of nutrients to support fetal growth up to the end of pregnancy or that fetal growth is regulated by maternal nutritional reserves: it has even been suggested, from a teleological point of view that if a moderately malnourished mother must care for a runt, chances are that the mother will recover when food becomes available and that low birth weight should be considered as an adaptation to low food intakes.

These hypotheses assuming a limitation or rather a regulation of birth weight by maternal nutritional reserves imply that when the mothers are seriously malnourished, one should have a constant ratio between maternal and neo-natal weight. This should be the case in population where birth weight is definitely below the optimal birth weight, associated with the lowest neo-natal mortality. Moving from the most underweight women toward those with an acceptable body weight, one should observe a progressive increase of birth weight, proportional to birth weight, if one admits that the fetus has some priority over the build-up of maternal nutritional reserves. A birth weight increasing more slowly than the maternal weight is conceivable only when the birth weight is approaching its optimal value.

To test the hypothesis of a birth weight regulation by maternal weight, we examined the relation between these two variables in a sample of Senegalese women selected for their poor nutritional status and whose newborns had a birth weight well below the optimal birth weight. We determined whether in this sample there was a constant ratio between maternal and neo-natal weight.

Subjects and methods :

This study was done in a maternity hospital in the periphery of Dakar attended by the most underprivileged women. Most of them, before going back home have a short clinical examination with a control of blood pressure and research of severe anemias. During this check-up, we take anthropometric data of these women in order to make a long term survey on birth weight regulation. For this preliminary work, we selected, among the 450 records of two months of the survey, 136 women who had a mid upper arm circumference below 80 % of the international standards, i.e. below 228 mm. We chose this criteria because, contrarily to nutritional indicators based on body weight, it is not influenced by the size of the uterus or by the water retention which vary a lot between different women and are not really related to maternal nutritional status. These women had a mean weight of 48.9 kg (range : 37.5 - 63). Their mean height was 1.63 m - (range : 147 - 179 cm). Mean birth weight in this sample was 2.890kg. This is well below the optimal birth weight associated with the lowest perinatal mortality which in West Africa, as in Europe or in North America is between 3.5 and 4.0 kg.

Birth weight and maternal weight were transformed into logarithms before the statistical analysis. If birth weight were a constant fraction of maternal weight, one should observe a significant correlation between these two variables with the slope of the regression line, or the allometric coefficient close to 1.

Results :

The logarithms of birth weight and of maternal weight are significantly correlated ($r = 0.226$, p less than 0.05).

The slope of the regression line is 0.322 , s. d. 0.120 . This is highly significantly less than 1 (p less than 0.01).

In other words, there is no constant ratio between maternal and neo-natal weights and birth weight, related to maternal weight is significantly higher in women with a small body size.

Discussion :

Although the correlation coefficient between the logarithms of maternal and neo-natal weights is significant (p less than 0.05), variations of maternal weight explain 5.1 % only of the variance of birth weight. This fits poorly in this population of poorly nourished women with the concept of maternal reserves being a major limiting or regulating factor of fetal growth.

That maternal and neo-natal weight are not related by a constant ratio is also difficult to explain assuming that birth weight is regulated by maternal weight. The hypothesis of low birth weights being an adaptation to low maternal reserves does not seem likely : the observed reduction of birth weight in underweight women is less than expected if this reduction were to adjust neo-natal size to maternal nutritional reserves.

Energy needs of breast fed infants are roughly proportional to their body weight. Maternal energy reserves are also directly related to their weight. One should observe a constant ratio between these two variables.

We suggest that maternal nutritional reserves do not regulate nor limit fetal growth. This is supported by the very satisfactory growth of breast fed infants in Sénégal.

Low birth weight newborns often catch-up international standards while they are breast - fed only although their nutritional needs are more demanding for the mother than they were in utero.

An alternative interpretation could be that the effect of maternal weight on birth weight might be mediated by a vascular mechanism. An interspecies regulation of birth weight by maternal cardiac output recently been suggested by Battaglia et al. considering the allometric relation between maternal and neo-natal weight. The observed allometric exponent in our sample, which is markedly less than one suggests that a similar regulation could exist in human reproduction.

It seems very likely that underweight women have a reduced cardiac output compared to heavier women. The relation between body weight and cardiac output however is unlikely to be linear. Cardiac output is more likely to be related to the power $2/3$ of maternal weight.

If fetal growth is limited when fetal oxygen uptake requires a given proportion of maternal cardiac output, one would expect an allometric exponent close to 0.66 between maternal and neo-natal weight or even a lower one if fetal oxygen uptake increase more rapidly than fetal weight as suggested by M. Hollyday. This last possibility is compatible with our data.

Maternal-neo-natal relation received little attention in the study of human birth weight. This approach however, may give some clues on birth weight regulation. It suggests that maternal nutritional reserves are unlikely to directly regulate birth weight and that a vascular mechanism could be involved.