ENVIRONMENTAL FACTORS AFFECTING FETAL AND CHILD GROWTH 1/

FACTORES AMBIENTALES QUE AFECTAN EL CRECIMIENTO DEL FETO Y DEL NIÑO

FACTEURS DU MILIEU AFFECTANT LA CROISSANCE DU FOETUS ET DE L'ENFANT

Guillermo Guzmán, M.D., Jean-Pierre Habicht, M.D., Aaron Lechtig, M.D., Reynaldo Martorell, Ph.D., Charles Yarbrough, Ph.D., Hernán Delgado, M.D., and Robert E. Klein, Ph.D.

Division of Human Development
Institute of Nutrition of Central America and Panama (INCAP)
Guatemala City, Guatemala, Central America

The objective of this paper is to discuss the results of an ongoing experiment concerning the effects of nutrition and other environmental factors on the child's physical growth and mental development in four rural villages of Guatemala[1]. The population is characterized by mild to moderate protein-calorie malnutrition. Two villages receive a protein-calorie supplement (atole) while two paired controls receive a supplement containing only calories (fresco). The total amount of supplement ingested by the pregnant and lactating women as well as by the children is recorded daily. In addition,

---

1/ This research was supported by Contract No. PH43-65-640 from the National Institute of Child Health and Human Development (NICHD), National Institutes of Health, Bethesda, Maryland.

the home diet, health status, anthropometry and socioeconomic status of mother and child are assessed.

I. PRENATAL GROWTH

We have presented evidence elsewhere that caloric supplementation during pregnancy produces a significant decrease in the rate of low birthweight (LBW $\leq$ 2.5 kg) babies[2].

Here we will present the most important maternal characteristics that, in addition to caloric supplementation during pregnancy, correlate with birthweight. Also, we will describe our preliminary results regarding the effect of nutrition on postnatal growth.

Maternal Anthropometry and Birthweight. Table 1 shows that the head circumference and height of the mother are associated with birthweight. This relationship might reflect the long term effect of the mother's nutritional condition during her early life since the bulk of the retardation in head circumference and height in the adult is a consequence of events occurring during the first two and seven years of age respectively.

In addition, mother's weight and arm circumference at 36 weeks of pregnancy were significantly associated with birthweight, reflecting perhaps the influence of the maternal nutritional status during pregnancy. We believe that these findings would reflect the effect of the maternal nutritional status -before and during pregnancy- on birthweight.

Obstetric Characteristics and Birthweight. All the obstetric characteristics studied (age of the mother, gestity, parity and gestational age) were positively associated with birthweight (Table 1). The associations of maternal age and gestity with birthweight were mostly explained by the effect of parity.

In addition, studying differences between siblings, birth interval showed a positive correlation with birthweight. Of the two components of the birth interval, the periods of lactation and non-lactation, the latter was the primary determinant of the association between birth interval and birthweight[3]. Therefore, the main obstetric variables correlated with birthweight in this population were parity, gestational age and duration of the previous non-lactation period.

Maternal Morbidity during Pregnancy and Birthweight. Maternal morbidity data was gathered through fortnightly recall surveys. Duration of diarrhea and of anorexia showed a significant negative association with birthweight. Days in bed due to illness also approached significant r values. Table 1 shows that a pooled indicator of morbidity during pregnancy, composed of diarrhea, anorexia and days in bed, was significantly associated with birthweight. The mothers in the low morbidity group showed a proportion of LBW babies of 10.5% compared with 33.3% among the mothers with high morbidity. Because of the trend to lower caloric intake in the group

TABLE 1

RELATIONSHIP BETWEEN MATERNAL CHARACTERISTICS AND BIRTHWEIGHT

	correlation value	number of cases	probability value ≤
I. ANTHROPOMETRY			
Height	.13	400	.01
Head circumference	.20	391	.01
Arm circumference (36th week)	.19	234	.05
Weight (36th week)	.24	234	.01
II. OBSTETRIC			
Age	.11	405	.01
Gestity	.15	405	.01
Parity	.15	405	.01
Gestational age	.22	396	.01
III. MORBIDITY DURING PREGNANCY			
Composite scale (diarrhea, anorexia and bed)	-.15	249	.05
Cord IgM levels	-.10	170	.10
IV. SOCIOECONOMIC STATUS			
Composite scale	.22	364	.05

of mothers with high morbidity, our interpretation of these results is that disease during pregnancy leads to low dietary intake which in turn results in fetal growth retardation[4].

Cord Level of IgM and Birthweight. There is evidence that high cord IgM levels reflect intrauterine infection and several intrauterine infections are associated with greater prevalence of LBW babies. There was a negative although non-significant correlation between IgM levels and birthweight (Table 1). Furthermore, within the group with low IgM values (<20 mg%) this correlation was positive while in the high IgM values (≥ 20 mg%) group the r value was significantly negative. These results suggest that there are at least two factors regulating the relationship between cord IgM levels and birthweight. The first is the fact that heavier babies produce greater quantities of antibodies. The second is intrauterine infection which would produce both: increased levels of IgM and fetal growth retardation[5].

Socioeconomic Factors and Birthweight. The published literature indicates that pregnant women from developed countries are taller, have greater weight gain during pregnancy and higher caloric intake than women in developing countries. Also, within developing countries, pregnant women from high socioeconomic strata are better nourished than those from low socioeconomic strata. A cross sectional study in an urban population of

Guatemala City showed that low socioeconomic status mothers had higher non-essential/essential aminoacid ratio and lower creatinine excretion than mothers from high socioeconomic class. In these comparisons, birthweight was higher in the high socioeconomic strata than in the low ones[6]. These facts indicate that there is a causal link between socioeconomic conditions, nutrition of the mother and birthweight. Table 1 shows that in our study population, a socioeconomic score (SES) was significantly associated with birthweight. The association between the SES and birthweight was reduced to a half, but remained significant, after controlling for the maternal anthropometric characteristics. The remaining association disappeared when the interaction between maternal characteristics and SES was controlled for. Our interpretation of these results is that the SES indicates environmental conditions resulting in malnutrition and disease during pregnancy (reflected in the mother's anthropometry) which in turn will lead to a lower birthweight. This hypothesis is supported by the fact that food supplementation produced the greatest effects in the low SES groups[7].

II. POSTNATAL GROWTH We have examined some of the factors affecting prenatal growth. Now we will discuss some determinants of postnatal growth studied in a semilongitudinal sample of preschool children from birth to seven years of age. The results presented in Table 2 indicate that there is a positive association between both atole and fresco intake and growth

TABLE 2

CORRELATION VALUES[1] BETWEEN FOOD SUPPLEMENTATION AND YEARLY GROWTH RATES IN HEIGHT AND WEIGHT FROM BIRTH TO SEVEN YEARS OF AGE

	ATOLE (N = 1450)[2]	FRESCO (N = 1346)	TOTAL (N = 2796)
HEIGHT	.16**	.13**	.15**
WEIGHT	.13**	.08**	.11**

** $p < .01$

[1] Average of correlations between yearly growth rates and intake during the year for the following periods: 3-15, 6-18, 9-21, 12-24, 18-30, 24-36, 30-42, 36-48, 48-60, 60-72, and 72-84 months.

[2] Number of total yearly increments studied. The number of yearly increments studied per child vary between 1 and 4.

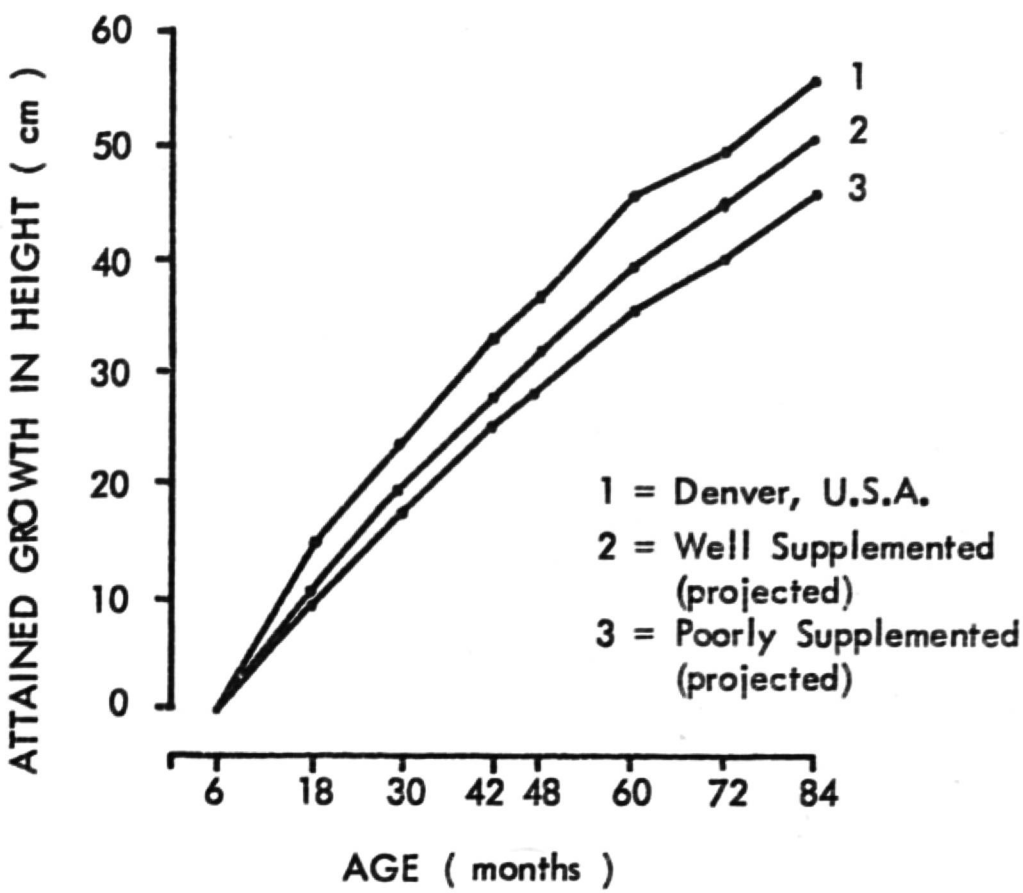
rates in height and weight. We are at present studying the possibilities that other factors are responsible for the association between food supplementation and better growth. This requires a demonstration that this association is not due to bias produced by factors such as home diet, illness, medical care, socioeconomic status or sex. Preliminary analyses indicate that the relationship between food supplementation and growth is causal. In order to estimate the public health implications of this finding we present in Figure 1 the growth projections for children from conception to 7 years old. It is clear that the projections for high supplemented children are substantially better than are those for the poorly supplemented children. We estimate that the final result of food supplementation up to seven years of age will be a reduction of about 50% of the deficit in height between the low supplemented children and the U.S.A. standards[8].

We are also exploring why the projections for the well supplemented children do not attain completely the U.S.A. standards. The first analysis revealed that diarrhea reduces growth about as much as supplementation increases growth. This effect of diarrhea is independent of whether the child is supplemented or not and it probably is the factor limiting the growth rates in the well supplemented children[9].

In conclusion, from these results, we postulate that malnutrition and infection are the most important causes of the retardation in physical growth

FIGURE 1

PROJECTED ATTAINED GROWTH IN HEIGHT OF WELL AND POORLY SUPPLEMENTED CHILDREN COMPARED TO U. S. A. STANDARD



observed in this population during pre and postnatal life.

REFERENCES

1. Klein, R.E., Habicht, J-P., & Yarbrough, C.: Some methodological problems in field studies of nutrition and intelligence. In: D. J. Kallen (Ed.): Nutrition, Development and Social Behavior, Proceedings of the Conference on the Assessment of Tests of Behavior from Studies of Nutrition in the Western Hemisphere. Washington, D.C.: U.S. Government Printing Office, 1973, p. 61-75, DHEW Publication No. (NIH) 73-242.

2. Lechtig, A., Habicht, J-P., Yarbrough,C., Delgado,H., Lasky,R.E., Martorell,R., & Klein,R.E.: Maternal nutrition and birthweight. Paper presented at the XIV Congreso Internacional de Pediatría, Buenos Aires, Argentina, October, 3-9, 1974.

3. Delgado,H., Habicht,J-P., Lechtig,A., Klein,R.E., Yarbrough,C., & Martorell,R.: Prenatal nutrition. Paper presented at the Symposium on "Current Concepts in Nutrition: Nutrition in the Life Cycle", University of Southern California, Los Angeles, September 29,1973.

4. Lechtig,A., Habicht,J-P., Guzmán,G., & de León,E.: Morbilidad materna y crecimiento fetal en poblaciones rurales de Guatemala. Archivos Latinoamericanos de Nutrición, 1972,22: (2), 243-253.

5. Lechtig,A., Mata,L.J., Habicht,J-P., Urrutia,J.J., Klein,R.E., Guzmán, G., Cáceres,A., & Alford,C.: Levels of immunoglobulin M (IgM) in cord blood of Latin American newborns of low socioeconomic status. Ecology of Food and Nutrition, 1974, in press.

6. Lechtig,A., Béhar,M., Arroyave,G., Habicht, J-P., Yarbrough,C., Viteri,F., Mata,L.J., Delgado,H., Filer, J., & Klein,R.E.: Influence of maternal nutrition on the characteristics of the placenta and fetal growth. Paper presented at the Symposium "Effects of Inadequate Nutrition on Human Development" from the Continental Meeting on Science and Man, Mexico,D.F., July, 1973. Sponsored by the American Association for the Advancement of Science, Washington University, St. Louis, Mo. and "Consejo Nacional de

Ciencia y Tecnología de México, Instituto Nacional de la Nutrición Tlalpan, México".

7. Lechtig,A., Delgado,H., Lasky,R.E., Klein,R.E., Engle,P.L., Yabrough,C., & Habicht, J-P.: Socioeconomic factors related to maternal nutrition and fetal growth in preindustrialized societies. Paper presented in the Workshop on Latent Effects of Malnutrition and Infection During Pregnancy as Determinants of Growth and Development of the Child., Guatemala, January, 10-12, 1973. American Journal of Clinical Nutrition. In press.

8. Hansman,C.: Anthropometry and related data. In: McCammon, R.W., Human Growth and Development, Springfield, Ill.: C.C. Thomas, 1970, pp. 101-154.

9. Martorell, R., Habicht,J-P., Yarbrough,C., Lechtig,A., & Klein,R.E.: Morbidity and physical growth in children from rural Guatemala. Paper presented at the XIV Congreso Internacional de Pediatría, Buenos Aires, Argentina, October 3-9, 1974.