ARTICULOS GENERALES

PROTEIN-CALORIE SUPPLEMENTATION AND POSTNATAL PHYSICAL GROWTH: A REVIEW OF FINDINGS FROM DEVELOPING COUNTRIES [1]

Reynaldo Martorell [2], *Aaron Lechtig* [2], *Charles Yarbrough* [2], *Hernán Delgado* [2] *and Robert E. Klein* [3]

Institute of Nutrition of Central America and Panama (INCAP), Guatemala, C. A.

SUMMARY

The literature on the effects of protein-calorie supplementation on physical growth rates in height and weight is reviewed. Only studies carried out in moderately malnourished children from developing nations are considered. Two main questions are asked: 1) Do changes in protein-calorie intake cause changes in growth in these children, and 2) How does the impact on growth of supplemental foods vary with changing protein-calorie amounts of the supplement and of the home diet? Although, the experiments reviewed were shown to have a series of limitations, it was concluded that protein-calorie supplementation is causally related to growth. Moreover, the evidence reviewed suggests that the relative contribution of calories and proteins to the association depens upon which nutrient is limiting in the home diet. That is, if proteins are limiting, proteins and not calories are apparently beneficial for growth rates. On the other hand, if calories are limiting, calories alone seem to improve growth rates. This suggests that before expensive supplementation programs are instituted, one should first investigate which nutrients are most limiting in the home diet.

---

1. This research was supported by Contract NO1-HD-5-0640 from the National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland, U.S.A.

2. From the Division of Human Development, Institute of Nutrition of Central America and Panama.

3. Head of the above-mentioned Division.

INCAP Publication I-830.

Recibido: 6-11-1975.

INTRODUCTION

Protein-calorie malnutrition (PCM) is the major nutritional problem in children of developing nations. While severe forms of PCM (kwashiorkor and marasmus) affect less than 3% of all children 1 to 5 years of age, mild and moderate forms affect a larger number, around 75% [1].

Because the most common manifestation of mild-to-moderate PCM is physical growth retardation, most of the indicators proposed to evaluate the impact of public health programs are based upon physical growth [2]. However, while the sensitivity of physical growth to nutritional improvements may be easily demonstrated under rigidly controlled situations as in metabolic wards, it is not clear that such would be the case under field conditions. The problems of measurement as we shall see, vastly complicate any such field study. Consequently, considering the importance of this problem, the present paper reviews the literature on field protein-calorie supplementation experiments and their effects on physical growth in height and weight of mild-to-moderately malnourished children. Two main questions guide the literature review.

A. Do changes in protein-calorie intake cause changes in the growth of mild-to-moderately malnourished children?
B. How does the impact on physical growth of supplemental foods vary with changing protein-calorie amounts of the supplement and of the home diet?

Our focus on only height and weight as physical growth indicators stems from the fact that these are overall indicators of growth widely used in public health to assess nutritional status [2]. In particular, most food supplementation experiments include at least these measurements. They are therefore, a common denominator by which the various experiments can be compared.

METHODS

More emphasis will be devoted to those studies which provide data regarding the protein and the calorie amounts ingested per day from the supplement and the home diet. Our summary will touch on all the following aspects:

1. The study design: number and age of subjects, dietary intake, nature of control groups and duration of the experiment.

2. The food supplement: its characteristics, the degree to which it replaces home dietary intake, its distribution and measurement.
3. The findings: the impact observed on growth and the conclusions reached.

The main characteristics of the studies reviewed are presented in Table 1.

RESULTS

A. *Have Previous Studies Shown that Changes in Protein and Calorie Intake Cause Changes in the Growth of Mild-to-Moderately Malnourished Children?*

By 4 to 5 years of age almost all mild-to-moderately malnourished children are smaller and lighter than almost any child from the developed nations (i.e. the population distribution overlaps less than 3%). These growth differences are usually attributed to environmental factors, principally low dietary intakes and high morbidity rates. In other words, this stunting does not seem to be attributable to genetic factors [3, 4]. It follows, therefore, that bettering the nutrition of these children should result in faster growth.

The literature on this subject is, in general, in agreement with this hypothesis. Except for a minority of studies [5, 6], most previous experiments, according to their respective authors, are suggestive of an effect of proteins, calories or both [7-18]. However, in evaluating each of the studies, a whole series of limitations which potentially may invalidate the conclusions can be identified. The general nature of these is discussed below.

Measurement of the treatment

There are problems related to the reliability with which the independent variable, supplement intake, was measured. In some instances, the supplements were distributed indirectly in weekly supplies to the family [5, 6]. Under these circumstances, one does not easily know how much of the supplement each child really took. In most studies, however, the supplements were given directly to the children in a fixed locale [7-18]. Still, some children may attend more frequently and/or eat more than others. Moreover, if the supplements given to various test

groups differ in terms of factors which may make them less or more attractive such as palatability or prestige, not only individuals but groups as a whole may markedly depart from what one thinks they consumed. Therefore, one needs to measure, for both test and control subjects, not only attendance but intake at the individual level as well.

While this was done by a few studies [8, 13], the information with regard to individual variability was not taken into account in the analyses. Lastly, none of the studies reported on another important aspect: the reliability with which the actual intake of individuals was measured.

Poor reliability takes away power, so that differences between control and test groups may appear to be less certain than they really are in some instances; otherwise true differences may not be statistically significant. In this case, the absence of a finding need not necessarily mean that there was no effect; it simply says that the study lacked the power to establish whether or not an association exists.

It is interesting to note in this regard that the studies here reviewed, where the treatment was given in weekly supplies to the mother, where the poorest reliability would be expected, were the only ones not showing significant differences between test and control subjects [5, 6].

Replacement

Related to the problem of measurement of the independent variable is the whole issue of the supplements replacing dietary intake at the home. Some of the studies reviewed here did not measure replacement rates [5, 6, 9, 10, 16, 17]. Some studies, on the other hand, faced this issue by relying on single dietary surveys in test and control subjects [18] or on single dietary surveys on test groups before and during the experiment [8, 13]. Since the reliability of individual dietary surveys is low [19], either large numbers of subjects or more frequent surveys in a small number of subjects are required to have sufficient power to evaluate the extent of replacement. For example, assuming a standard deviation of 300 calories, it would take a sample of 140 in each of the groups to show at a power of 0.80, that the mean dietary intake of calories of test and control subjects differ significantly ($p < .05$) by 100 calories [20]. It is not surprising therefore, that in all studies where this problem was investigated,

the home dietary intake of test and control groups did not differ significantly [8, 13, 18].

If replacement of the home diet by the supplement does occur, the dose response in terms of growth per calorie or gram of protein given in the supplement will be underestimated. To correct for replacement, one would have to relate the amount of calories actually ingested above the baseline intake with growth.

Replacement may bring about a second kind of problem. In cases where the preparations given to test and control groups differ in terms of their attractiveness or bulk, there may be varying rates of replacement across experimental groups. Such an occurrence may introduce sources of bias which may lead to erroneous conclusions.

Measurement of growth

If the equipment is calibrated and the anthropometrist is adequately trained, measurement of the dependent variable, growth, probably presents no problems given the high reliability of anthropometric measurements, particularly of height and weight [21]. When dealing with incremental, as opposed to attained values, measurement error increases given that error may occur at both end points, beginning and end. How "large" this error is depends upon the ratio of the error variance to the population variance in incremental growth [21]. None of the studies reviewed presented the necessary data to assess these aspects.

Alternative hypothesis

Ideally, a food supplementation experiment should have at least two characteristics. Subjects should be randomly assigned to test and control groups. Secondly, the experimenter should set the amount of treatment to be ingested by each group at a specified frequency. All of this, however, is very difficult to do with human populations because of ethical and operational constraints. Most studies therefore depend upon the willingness of subjects to participate. This of course raises the possibility that the findings observed are due to factors other than the treatment given.

Not surprisingly, most studies drew control and test groups from already existing groups: attenders and non attenders to a preschool [10], separate villages [6, 8, 9, 18], separate health care cen-

ters [5], separate classes within a school [12] or separate schools [7, 11]. Within these groups, in some studies the test subjects were those willing or permitted to participate rather than all members of the group [10, 18].

Moreover, none of the above studies [5-12, 18] report either what percentage of the group intended for study remained in the study, or what characteristics those not studied had with respect to those studied. In general, very little effort, other than comparing test and control subjects in terms of initial height, weight and age was done to assure comparability of the experimental groups. Therefore, these studies [5-12, 18] did not control either through their designs or data collection, for possible differences in factors which may affect growth and which potentially may explain the findings such as morbidity (4), socio-economic status and home dietary intake as well.

A minority of studies carried out in orphanages randomly alloted subjects to test and control groups from matched pairs on the basis of initial height and weight [16, 17]. These studies, however, did not control for actual intake; thus, the bulkier control diet may have been consumed in lesser amounts than the high-protein diet (see Table 1).

In conclusion, the evidence reviewed suggests that protein-calorie nutrition is at least related to changes in growth. Though there may be strong reasons to doubt the conclusions of individual studies, when all these experiments are viewed in total, negating the hypothesis that protein-calorie nutrition affects growth may require that the same source of bias act similarly across all studies. This is very improbable as is the possibility that a very complicated combination of biases act in each of the reviewed studies.

B. *How Does the Impact on Physical Growth of Supplemental Foods Vary with Changing Protein-Calorie Compositions of the Supplement and of the Home Diet?*

The issue to be dealt with is that proteins, calories or both will have an impact on physical growth depending upon which nutrient is limiting in the home dietary intake. In this respect,

(4) Gopalan *et al.* [8] report that there was a measles epidemic during the study which was associated with reduced growth in the control but not in the experimental subjects. However, differences between control and experimental groups, given the presence or absence of measles, were still evident.

TABLE 1 - MAIN CHARACTERISTICS OF SOME PROTEIN-CALORIE SUPPLEMENTATION STUDIES

REFERENCE AND POPULATION	DIETARY INTAKE	PROTEIN-CALORIE CONTENT OF TREATMENT. (SAMPLE SIZE IN PARENTHESIS).	DISTRIBUTION AND MEASUREMENT OF SUPPLEMENT INTAKE	FINDINGS
Bancroft & Bailey (5) New Guinea. Infant 6-12 months of age. Study lasted 12 months	Staple is sweet potato. Breast milk intake is 600 cc (320 cal & 5g protein). Author estimates total intake to be 300-1000 cal (40.5-135.1 cal/kg) and 5-10g protein per day (0.7-1.4g/kg) Protein-calorie deficient.	Groups drawn from health care clinics Cal. Prot. 1. (13) 101 10.1 (skimmed milk) 2. (19) 284 11.4 (peanut butter) 3. (16) 134 9.8 (soya bean meal) 4. (18) -- -- (control) 5. (15) -- -- (control)	- Weekly supplies delivered or picked up by parents. - Direct consumption not verified - Cases whose mother missed 15 or more weeks excluded	Yearly increments ($\bar{X} \pm$ S.E.) Weight(kg) Height(cm) 1. 2.16 ± .18 11.3 ± .75 2. 2.39 ± .13 11.4 ± .30 3. 2.46 ± .23 11.0 ± .61 4. 2.30 ± .11 11.0 ± .41 5. 2.24 ± .18 11.5 ± .54 No effect of protein calorie supplementation. Growth increments of all groups fairly similar to those of well nourished populations.
Baertl et al (6) Perú. Children 0.5 to 18 years of age. 6 year study	Not Detailed	Four populations with large sample size: 1. Control 2. Control 3. 250 cal and 7.5g/day (wheat noodles) 4. 250 cal and 12.5g/day (wheat noodles with fish protein)	- Indirectly to mothers - Intake not reported - Replacement not reported	Results suggest that protein calorie supplementation did not influence growth.
Bailey (7) Indonesia Children 7 to 13 years of age. 12 months study	Mostly cassava. 1006 cal (44cal/kg) and 9.8 g of protein per day (0.4g/kg). Protein-calorie deficient	7 Groups draw from 3 schools Cal. Prot. 1. (66) 0 0 (iron-control) 2. (75) 180 1.5 (sugar) 3. (74) 195 12 (green gram + sugar) 4. (71) 90 10 (skimmed milk) 5. (74) 170 10 (soya bean milk) 6. (73) 80 12.5 (soya) 7. (71) 50 10 (velvet bean)	- Central, on school days - Intake not reported - Replacement not reported	No clear significant effect is produced by any of the treatments but there is a tendency for gains in height and weight to be correlated with the caloric value of the supplements (Spearman respectively 0.86 and 0.75, $p < .01$)
Gopalan et al (8) India. Children 1 to 5 years of age. 14 months study.	700 cal and 18.5g per day. 1.1 gm ref. protein/kg. Mainly calorie deficient.	Two groups drawn from 9 villages. Not clear how chosen. Controls matched for age, sex, height and weight. Cal. Prot. 1. (109) 310 3 (wheat + sugar + oil) 2. (306) -- - (control)	- Central, 6 days/week - 85% attendance - Intake not reported - Dietary surveys before and during experiment (n/40) reveal no replacement)	14 months increments Age Weight (kg) Height (cm) Exp Control Exp Control 1-2 2.35 1.74 9.3 6.5 2-3 2.34 1.71 9.5 7.8 3-4 2.04 1.58 9.1 7.4 4-5 1.86 1.38 8.4 7.3 All comparisons highly significant. Suggests a caloric effect.

TABLE 1 - (CONT'D)

REFERENCE AND POPULATION	DIETARY INTAKE	PROTEIN-CALORIE CONTENT OF TREATMENT. (SAMPLE SIZE IN PARENTHESIS)	DISTRIBUTION AND MEASUREMENT OF SUPPLEMENT INTAKE	FINDINGS
Guzman et al (9); Some data drawn from (14,15). Guatemala. Children 0 to 5 years of age. 5 year study.	687 cal and 19.2 g protein/day in children (0-4 years) of feeding village. Approx. 68.7 cal and 1.92 g protein per kg per day. Mainly calorie deficient.	3 villages: control, medical care, and feeding village. Large samples. Treatment approx. 15 g protein and 350 cal/day (Incoparina, skim milk, sugar, banana)	- Central, 6 days/week - Ad libitum, variability in intake not taken into account - Replacement not reported	More rapid growth in both height and weight for children of feeding village. Relative to the 2 other villages the treatment resulted in a net diff. of 3 cm in height and 1 kg of weight by 5 years of age. Results suggest a protein-calorie effect.
Kamtenathan et al (10) India. Children 2.5 to 5 years of age. 6 months study	Home diet of control group: 486 cal(49.6 cal/kg) and 13.7g protein per day (1.4 g/kg). Mainly calorie deficient.	Experimental Group (25) Cal. Prot. Treatment 898 26.4 Home diet 283 8.9 Total 1181 35.4 Supplement: mixture of sesame, groundnut and horsegram. Controls were other village children not willing or permitted to participate	- Central - Frequency not stated - Intake not reported - Treatment meant to partly replace dietary intake	Semestral Increments ($\bar{X}$) Weight (kg) Height(cm) Exp 2.23 2.71 Control 1.23 1.94 p / .01 p / .01 Only 15 children of the experimental group were included for analysis; these were of similar initial heights and weights as control children. Results suggest a protein-calorie effect.
King et al (11) Haiti. Children 4 to 18 years of age. Study lasted 261 days	Based on a previous study, the per capita intake is estimated at 1580 cal and 37g of protein per day. This includes subjects of all ages.	Three groups, each a separate school Cal. Prot. 1. (223) 391 12.7 (enriched bread and jelly) 2. (145) 391 13.4 (same but with lysine) 3. (111) -- -- (control)	- Central, 150 feeding days. - Intake not reported - Replacement not reported	Groups 1 and 2 show better growth than 3 particularly in weight growth. This is suggestive of a protein-calorie effect. There is a fairly constant tendency throughout the age range for group 2 to show better growth than group 1. This suggests that protein quality may also be related to growth.
Malcolm (12) New Guinea. Children 6 to 16 years of age. 13 week study.	Staples are taro and sweet potato. 1610 cal (73.2cal/kg) and 12g protein per day (0.5g/kg). Protein deficient.	Groups drawn from different classes within a school. Cal. Prot. 1. (31) 270 25 (skim milk) 2. (22) 270 -- (margarine) 3. (22) 660 5 (2 extra meals of basic diet) 4. (25) -- -- (control)	- Central, 5 days/week - Intake not reported - Replacement not reported. Author suspects replacement in Group 3.	13 week increments ($\bar{X} \pm$ S. E.) Weight (kg) Height (cm) 1. 1.21 ± .10 2.32 ± .11 2. 1.05 ± .18 0.96 ± .11 3. 0.47 ± .14 1.54 ± .13 4. 0.50 ± .13 1.10 ± .12 Height and weight of protein-calorie group is best. Calories effect weight but not height growth. Height of group 3 better than that of groups 2 and 4 possibly due to extra protein. Study suggests a protein effect.

TABLE 1 - (CONT'D)

REFERENCE AND POPULATION	DIETARY INTAKE	PROTEIN-CALORIE CONTENT OF TREATMENT. (SAMPLE SIZE IN PARENTHESIS)	DISTRIBUTION AND MEASUREMENT OF SUPPLEMENT INTAKE	FINDINGS
Rajalaksnmi et al (13) India. Children 2 to 6 years of age. 6 month study	900 cal (75cal/kg) and 23g of protein per day (1.92g/kg) Calorie deficient	Groups drawn from a rural play center Controls matched for age, height and weight. Cal. Prot. 1. (11) 185 6.7 (wheat + Bengal gram) 2. (13) 245 9.2 (the above + greens) 3. (10) 320 11.8 (all of the above + lime) 4. (9) --- --- (control)	- Central - Ad libitum. Individual records kept. Intakes reported are group means. - No differences between and within groups in home dietary intake.	Six months increments ($\bar{X}$ + S.E.) Weight (kg) Height (cm) 1. 1.1 + .09** 3.0 + .24* 2. 1.2 + .12** 3.1 + .11** 3. 1.5 + .08** 3.2 + .30** 4. 0.2 + .01 2.0 + .17 T-test vs control: * $p < .05$, ** $p < .01$. Results suggest a protein-calorie effect
Subramanyan et al (16) India Girls 4 to 11 years of age. 6 month experiment	Baseline data not reported. Likely to be similar to that of reference (17)	Groups drawn from an orphanage. Random assignment to groups from matched pairs on the basis of initial height and weight. Cal. Prot. 1. (21) 1311 35.4 (groundnut, sugar, milk) 2. (21) 1311 25.2 (diet isocaloric by means of corn starch and sugar).	- Central, daily - Intake not reported - Replacement not reported	Six month increments ($\bar{X}$) Weight (kg) Height (cm) 1. 1.16 2.42 2. 0.58 1.59 Diff: $p < .01$ $p < .01$ Results suggest a protein effect
Suorahmanyan et al (17) India. Girls 4 to 12 years of age. 5 month study.	970 cal (51.3 cal/kg) and 24.4 g of protein/ day (1.2g/kg). Mainly calorie deficient	Groups drawn from an orphanage. Random assignment to groups from matched pairs on the basis of initial height and weight. Cal. Prot. 1. (23) 220 20.6 (groundnut, Bengal gram, vitamins and calcium) 2. (23) 220 --- (maize starch and sugar)	- Central, daily - Intake not reported - Replacement not reported	Five month increments ($\bar{X}$) Weight (kg) Height (cm) 1. 1.16 2.42 2. 0.45 1.31 Diff: $p < .01$ $p < .01$ Results suggest a protein effect
Swaminathan et al (18) India. Children 1 to 5 years of age. 12 month study.	Previous dietary surveys in the area estimate 700 cal (64 cal/kg) and 18g of protein per day (1.6g/kg). Calorie deficient	Experimental group drawn from two villages, controls from nearby ones. Cal. Prot. 1. (159) 300 10g (wheat flour, green grain, groundnut, sugar). 2. (200) --- --- Experimental group were those willing to participate.	- Distribution in charge of villagers. - Central, daily - Intake not reported - Dietary surveys in 40 test and 40 control children show no evidence of replacement.	Attained height and weights of experimental subjects consistently better than those of control subjects. Baseline data are however, not reported. Results suggest a protein-calorie effect.

two facts should be kept in mind. First, growth in weight, which includes growth in fat, may be responsive to caloric supplementation even when calories are not limiting; growth in height, however, which is more closely related to growth in muscle mass, will not. Secondly, growth in height may be responsive to caloric supplementation when energy is limited; this stems from the fact that under conditions of caloric limitations, some of the protein may be diverted to satisfy energy needs [22].

Therefore, the expected effect on growth in height and weight, given the nature of the supplements and the characteristics of the home diet, will be as follows:

Characteristics of the home diet		Characteristics of the nutritional intervention		
Main limiting nutrient(s)	Nearly or totally satisfactory	Calories	Protein	Both protein and calories
Protein	Calories	*	Yes	Yes
Calories	Protein	Yes	Yes	Yes
Both	——	Yes	Yes	Yes

* Effect on growth in height, but not in weight.
Yes Effect on growth in height and weight expected.
No No effect expected.

This scheme is seemingly hard to test given the following. In most populations, deficiencies generally involve both proteins and calories; diets being exclusively deficient in calories but not proteins or inversely in proteins and not calories are hard to find. Secondly, only one of the situations, deficiency in protein and supplementation with calories, would predict no effect, and this only in height. However, till recently, most nutritionists would have predicted that calories alone would not have an effect on height growth given that protein was thought to be the main limiting factor in most malnourished populations.

With the exception of the two studies which gave negative results under conditions where an effect would have been expected [5, 6], all other studies, as mentioned previously, suggest an association between protein-calorie supplementation and physical growth [7-18].

Of the studies reporting associations, all but two [16, 17] are in agreement with the proposed hypothesis. Thus, regardless of the limiting nutrient, giving proteins and calories is associated with better growth [7, 10, 11, 18].

The best designs to test the hypothesis are those of Gopalan *et al* [8] and Malcolm [12]. In the former, calories were given to

calorie-deficient children while in the latter, protein and calories were given to protein-deficient children and compared to similar children receiving a supplement containing the same amount of calories but no protein (Table 1).

Gopalan's *et* al study [8] found that under caloric limitations, calories will improve not only growth in weight but in height as well. In contrast, Malcolm's study [12] suggests that when not calories but proteins are limiting, protein supplementation will affect growth in height and weight while calories alone will affect growth in weight but not height.

The experiments of Subrahmanyan *et al* [16, 17] and that of Bailey [7] raise an important consideration. Given a situation of protein-calorie limitations, would additional protein holding the caloric intake constant produce an effect of proteins? The first studies seem to indicate that they do while the second does not. However, the degree of caloric limitation in Bailey's study [7] is more acute than in Subrahmanyan *et al*'s studies [16, 17] suggesting that as calories become more limiting, additional protein has no effect unless given in very high quantities [23, 24]. King's *et al* study [11] also suggests that improving the protein quality in children with some degree of caloric limitation will also improve growth.

CONCLUSIONS

The experiments reviewed were shown to have a whole series of limitations which left many alternative hypotheses open. In spite of this, the evidence reviewed suggests that variation in protein and calorie intake are related to physical growth in mild-to-moderately malnourished children and that the true nature of this relationship is causal.

Moreover, the data reviewed suggest that the relative contribution of calories and protein to the association is dependent upon which nutrient is limiting in the home diet.

The problem of growth retardation is a pervasive one in poor societies of developing nations [3]. The corrective measures usually undertaken in the past have taken the form of expensive high-protein supplementation. In this regard we would like to reinforce the need to investigate which nutrients are most limiting in the home diet before such programs are instituted. We believe that in many areas of Latin America, increased consumption of the home diet, which would mean increases in both proteins and calories, would produce important improvements in growth.

RESUMEN

SUPLEMENTACION PROTEINICO-CALORICA Y CRECIMIENTO FISICO POSTNATAL: REVISION DE HALLAZGOS EN LOS PAISES EN DESARROLLO

Este trabajo constituye una revisión de la literatura referente a los efectos de la suplementación con proteínas y calorías sobre la velocidad de crecimiento en peso y en talla. Sólo se incluyen estudios de campo de países en vías de desarrollo, en niños con desnutrición moderada. Se plantean dos preguntas:

1. **¿Ha sido posible probar que existe una relación causal entre cambios en la ingesta de proteínas y calorías y cambios en la velocidad de crecimiento, y**
2. **¿Varía el impacto de la suplementación alimenticia dependiendo de la cantidad de proteínas y calorías suministradas por el suplemento y por la dieta hogareña?**

Se encontró que aun cuando los experimentos revisados tienen una serie de limitaciones, sí se puede inferir de estos estudios que la suplementación con proteínas y calorías está relacionada causalmente con el crecimiento físico. Además, se concluye que la contribución relativa de proteínas y calorías a esa relación depende de cuál de los dos nutrientes es más limitante en la dieta hogareña. En otras palabras, si las proteínas son las limitantes, éstas y no las calorías son las que producen un mejoramiento en la velocidad de crecimiento. Por el contrario, si las calorías son las limitantes, éstas por sí solas inducen una mayor velocidad de crecimiento. Estos hechos sugieren que antes de implementar programas costosos de suplementación, primero se debe investigar cuáles son los nutrientes más limitantes en la dieta.

BIBLIOGRAPHY

1. Béhar, M. Prevalence of malnutrition among preschool children of developing countries. In: *Malnutrition, Learning and Behavior*. N. S. Scrimshaw and J. E. Gordon (Eds.). Cambridge, Mass., The MIT Press, 1968, p. 30-42.
2. Jelliffe, D. B. *The Assessment of the Nutritional Status of the Community (with special reference to field surveys in developing regions of the world)*. Geneva, Switzerland, World Health Organization, 1966, 271 p. (WHO Monograph Series Nº 53).
3. Habicht, J-P., R. Martorell, C. Yarbrough, R. M. Malina & R. E. Klein. Height and weight standards for preschool children: how relevant are ethnic differences in growth potential? *Lancet, 1:* 611-615, 1974.
4. Martorell, R., A. Lechtig, J-P. Habicht, C. Yarbrough & R. E. Klein. Normas antropométricas de crecimiento físico para países en desarrollo: ¿nacionales o internacionales? *Bol. Of. San. Pan., 79:* 525-529, 1975.

5. Bancroft, T. & K. V. Bailey. Supplementary feeding trial in New Guinea highland infants. *J. Trop. Pediat., 11:* 28-34, 1965.
6. Baertl, M. J., E. Morales, G. Verastegui & G. G. Graham. Diet supplementation for entire communities. Growth and mortality of infants and children. *Am. J. Clin. Nutr., 23:* 707-715, 1970.
7. Bailey, K. V. Rural nutrition studies in Indonesia. IX. Feeding trial on schoolboys. *Trop. Geogr. Med., 14:* 129-139, 1962.
8. Gopalan, C., M. C. Swaminathan, V. K. K. Kumary, D. H. Rao & K. Vijayaraghavan. Effect of calorie supplementation on growth of undernourished children. *Am. J. Clin. Nutr., 26:* 563-566, 1973.
9. Guzmán, M. A., N. S. Scrimshaw, H. A. Bruch & J. E. Gordon. Nutrition and infection field study in Guatemalan villages, 1959-1964. VII. Physical growth and development of preschool children. *Arch. Environ. Hlth, 17:* 107-118, 1968.
10. Kamalanathan, G., G. Nalinakshi & R. P. Devadas. Effect of a blend of protein foods on the nutritional status of preschool children in a rural Balwadi. *Indian J. Nutr. Dietet., 7:* 288-292, 1970.
11. King, K. W., W. H. Sebrell Jr., E. L. Severinghaus & W. O. Storvick. Lysine fortification of wheat bread fed to Haitian school children. *Am. J. Clin. Nutr., 12:* 36-48, 1963.
12. Malcolm, L. A. Growth retardation in a New Guinea boarding school and its response to supplementarp feeding. *Brit. J. Nutr., 24:* 297-305, 1970.
13. Rajalakshmi, R., S. S. Sail, D. G. Shah & S. K. Ambady. The effects of supplements varying in carotene and calcium content on the physical, biochemical and skeletal status of preschool children. *Brit. J. Nutr., 30:* 77-86, 1973.
14. Scrimshaw, N. S., M. A. Guzmán, J. J. Kevany, W. Ascoli, H. A. Bruch & J. E. Gordon. Nutrition and infection field study in Guatemalan villages, 1959-1964. II. Field reconnaissance, administrative and technical; study area; population characteristics; and organization for field activities. *Arch. Environ. Hlth, 14:* 787-801, 1967.
15. Scrimshaw, N. S., W Ascoli, J. J. Kevany, M. Flores, S. J. Icaza & J. E. Gordon. Nutrition and infection field study in Guatemalan villages, 1959-1964. III. Field procedure, collection of data and methods of measurement. *Arch. Environ. Hlth, 15:* 6-15, 1967.
16. Subrahmanyan, V., S. Kumari-Reddy, M. N. Moorjani, G. Sur, T. R. Doraiswamy, A. N. Sankaran, D. S. Bhatia & M. Swaminathan. Supplementary value of vegetable-milk curds in the diet of children. *Brit. J. Nutr., 8:* 348-352, 1954.
17. Subrahmanyan, V., J. Kantha, T. R. Doraiswamy, R. M. Narayana, A. N. Sankaran & M. Swaminathan. The effect of a supplementary multipurpose food on the growth and nutritional status of school children. *Brit. J. Nutr., 11:* 382-388, 1957.
18. Swaminathan, M. C., D. H. Rao, R. V. Rao, M. V. V. L. Narasimhan & N. S. Dumo. An evaluation of the supplementary feeding programmes for preschool children in the rural areas around Hyderabad City. *Indian J. Nutr. Dietet., 7:* 342-350, 1970.

19. Lechtig, A., C. Yarbrough, R. Martorell, H. Delgado & R. E. Klein. The one-day recall dietary survey: a review of its usefulness to estimate protein and calorie intake. Submitted to *Arcr. Latinoamer. Nutr.*
20. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences.* New York, Academic Press Inc., 1969.
21. Martorell, R., J-P. Habicht, C. Yarbrough, G. Guzmán & R. E. Klein. The identification and evaluation of measurement variability in the anthropometry of preschool children. *Am. J. Phys. Anthropol., 43:* 347-352, 1975.
22. Oldham, H. & B. B. Sheft. Effect of caloric intake on nitrogen utilization during pregnancy. *J. Am. Dietet. Assoc., 27:* 847-854, 1951.
23. Lechtig, A., C. Yarbrough, H. Delgado, J-P. Habicht, R. Martorell & R. E. Klein. Influence of maternal nutrition on birth weight. *Am. J. Clin. Nutr., 28:* 1223-1233, 1975.
24. Lechtig, A., R. Martorell, C. Yarbrough, H. Delgado & R. E. Klein. Influence of food supplementation on the urinary urea/creatinine (U/C) ratio of the child. Submitted to *J. Trop. Pediat. Environ. Child Hlth.*