

Malnutrition: long-term consequences and nutritional recovery effects

ANA LYDIA SAWAYA

Health, nutrition and life conditions

NOWADAYS, it's ever clearer that, for a real understanding of the diseases and their consequences, the anthropological aspects, the psychological dynamism and the social diagnosis of the physically frail people must be considered. For example, the physiological evidences that it's necessary to see man as an integrated phenomenon instead of as independent parts among itself, have increased. A reasonable amount of scientific papers offers ever more examples of that integrality, such as the studies on the effects of happiness on the person's health by the end of his or her life. A study carried out in the United States, for example, concluded that, within a sample of catholic nuns, writings with a positive emotional content at 22 years old were associated with health and longevity at 60 years old (Danner et al., 2001).

Therefore, as far as physiology is concerned, what goes on with a person who considers him or herself happy? There are strong relationships between that kind of statement, life expectancy and the frequency and intensity of chronic diseases, such as cardiovascular, inflammatory and self-immune ones (Steptoe et al., 2005). Such studies identified an inversely correlate biological marker to that happiness declaration: cortisol, the stress hormone. The higher its levels in the saliva when the person wakes up, the greater the stress level and the worse is the life quality in the long-term. It has become increasingly difficult to separate the human being into pieces... The life quality of the human being depends on what he feels and on the meaning he gives to things, and both are associated to his physiological status.

Those same mechanisms are activated when the person receives insufficient feeding in quantitative terms, or inadequate feeding in qualitative terms (when there's a lack of necessary nutrients, such as vitamins and minerals), mainly early in life. The organ that controls all our metabolic activity, the nervous system, permanently "programs" itself to save energy in the form of fat and to reduce growth, in order to guarantee survival in adverse

conditions. One of the essential hormones for that is cortisol. That situation is called malnutrition, and the hormone that regulates it, along with others, is, for that reason, the stress hormone.

The vicious circle made up of inadequate food intake/ diseases increase is also well-known: weight loss, deficient growth, low immunity, damage to the gastrointestinal mucous membrane, appetite loss, bad food absorption, important metabolic alterations. And we always come back to the stress hormone – high cortisol –, which will later play a very important role in the association of malnutrition with chronic diseases in the adult phase.

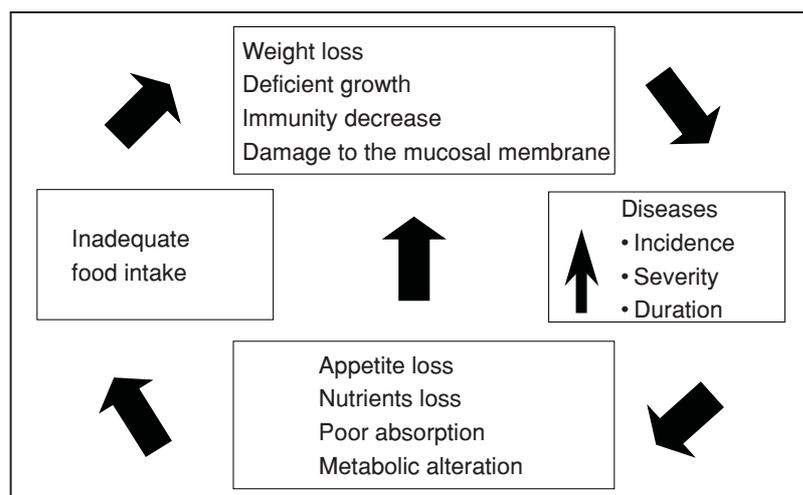


Figure 1 – Inadequate food intake/diseases increase vicious cycle.

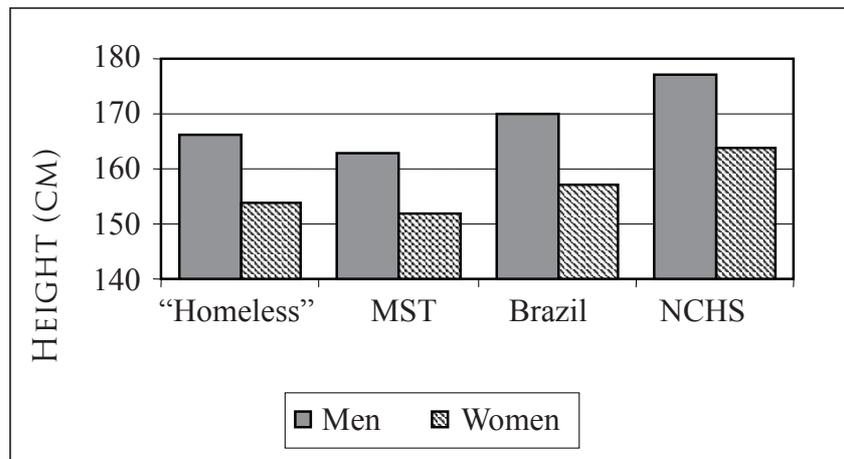
Malnutrition is responsible for 55% of children’s deaths worldwide. It’s associated with many other diseases and still today it’s considered the most deadly disease for children under 5 years old.

Worldwide and also in Brazil, the prevailing type of malnutrition corresponds to stunting, which has been standing out as an indicator not only of malnutrition, but also of poverty, since it’s currently known that the environmental factor is much more significant than the genetic one to determine the individual’s final height.

There are several causes for stunting: insufficient nutrition of the mother, intra-uterine malnutrition, lack of breastfeeding until the child is six months old, late introduction of complementary foods, inadequate quantity and quality of complementary foods, nutrient absorption impaired by infections and intestinal parasitic diseases.

Graph 1 shows the importance of height as an efficient and direct poverty marker. Here we have the average height of three adult populations over 18 years old: the population of a rural MST camp (Landless Rural Workers’ Movement), a population of slum dwellers (Homeless) in Maceió, Alagoas, the Brazilian average for men and women and the American reference

population. The poorest group – and with the lowest average – is the landless one. Therefore, height is a great poverty indicator.



Graph 1 – Average height of the adult population (>18 years old).

It is estimated that, in São Paulo city, between 11% and 15% of the population live in slums. In Maceió, for example, 50% of the population lives under such conditions. The slum dwellers' annual growth rate has systematically been greater than the urban one. In São Paulo state, in the year 2000, that rate was 2.97%, while that of the city was 0.78 (Marques & Torres, 2005). According to data from the São Paulo City Hall, the city has 2,018 slums of a significant size, the greatest concentration of which is located in the Southern Zone, with 1,107 slums (ibidem).

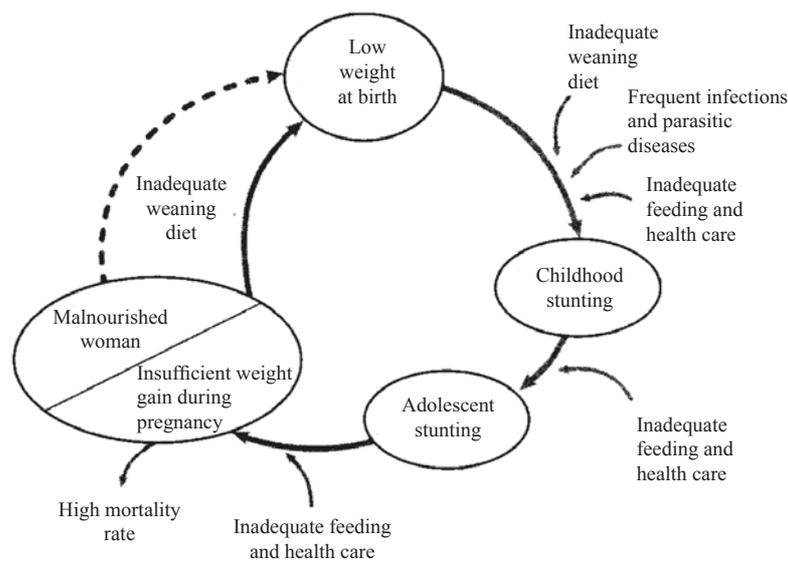
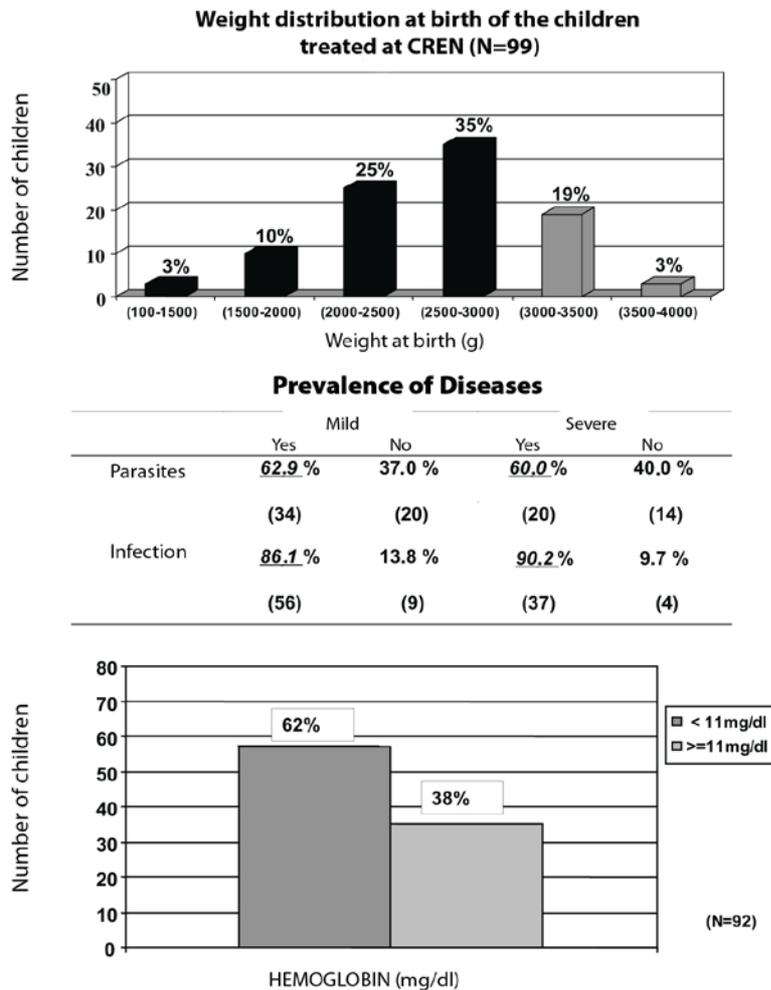


Figure 2 – Inadequate foods intake/ diseases increase vicious cycle.

Therefore, the unhealthy living conditions are the main cause of the inadequate foods intake cycle, which leads to a diseases increase: low weight at birth, inadequate weaning diet, frequent infections and inadequate feeding that lead to childhood stunting, as has been seen. If the inadequate feeding continues in the adolescence and in the adult phases, there will be insufficient weight gain during pregnancy and, for that reason, the child will be born underweight and already malnourished.

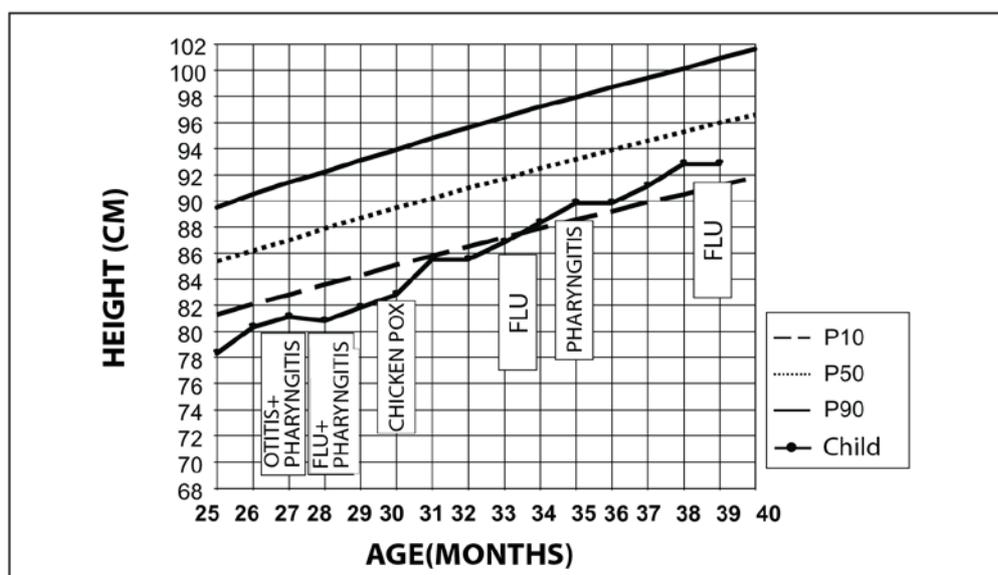
Data of malnourished children treated at the Center for Recovery and Nutrition Education (CREN), in São Paulo (for further details, see Sawaya et al., 2003), show that over 70% of them are born with low or insufficient weight. The malnutrition scenario in the poor communities in São Paulo, mainly in the slums, already starts to be outlined before birth. Among those children there is also a strong presence of childhood diseases. In fact, those are the main factors that determine the severity of malnutrition.



Graph 2 – Weight distribution at birth, prevalence of diseases e anaemia in children treated at CREN.

Data from CREN shows that, among the moderately malnourished children being treated, about 80% had at least one infectious episode in the last month, and, among the severely malnourished ones, that prevalence raised to about 90%. Therefore, the difference refers mainly to the rate of infections. Besides, 60% of them had parasites. And another very common occurrence is anaemia, verified in 62% of them.

Still concerning infections, it's important to point out that they are often very simple situations, which would have no big consequences in a normal child, but which can jeopardize not only weight gain but also height in malnourished children. That is confirmed by the work developed in CREN, where the recovering children stay all day (from 7h30 to 17h30), eat five balanced meals per day, receive adequate treatment for the infections, and where both them and their families have the necessary medical and psychological care. Even so, we verified that an otitis, a pharyngitis, or a flu jeopardize their growth. If they were at home, with no access to that kind of care, they would hardly overcome the curve (P10) below which a child is considered malnourished (Graph 3).



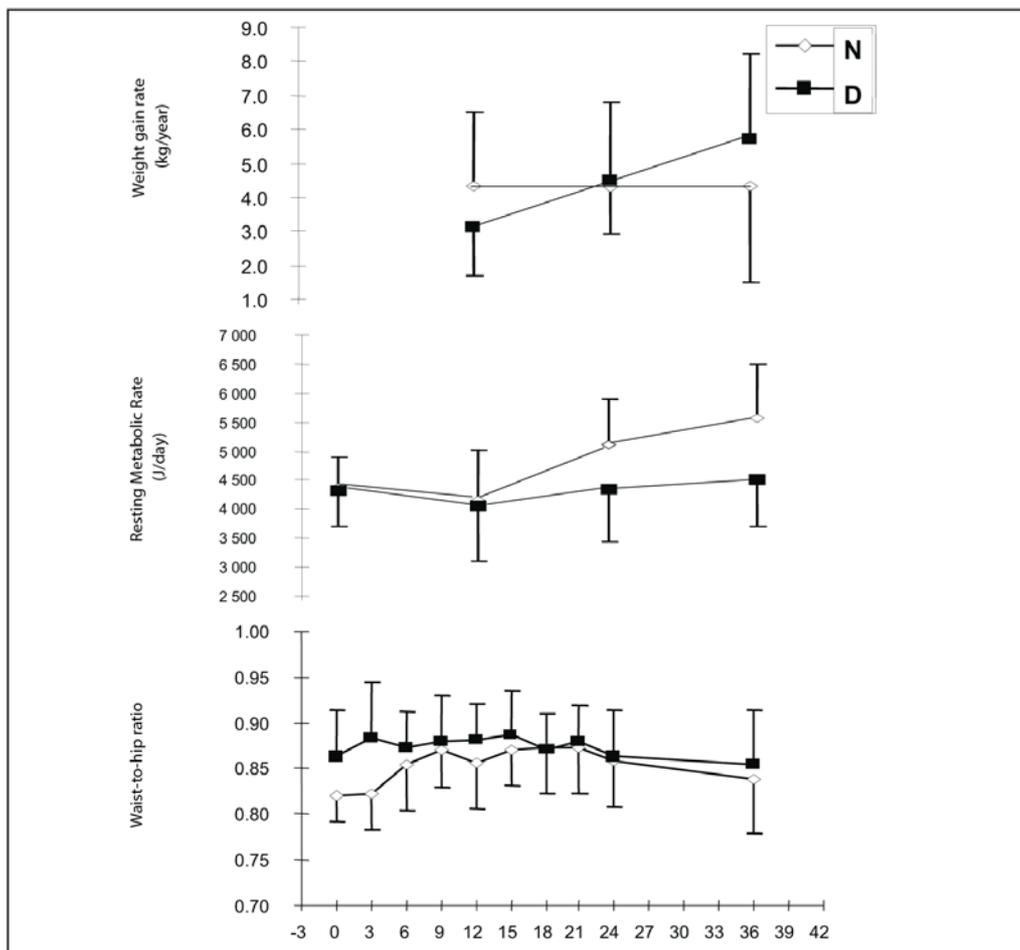
Graph 3 – Height distribution of a child treated at CREN.

What are the long-term consequences of malnutrition?

We have previously shown (Sawaya et al., 2003) that children who have been malnourished and who have not recovered in terms of height present a greater respiratory quotient than those who have never been malnourished. That means that their organism is physiologically prone to accumulate body fat. A greater respiratory quotient means that the fat oxidation in the body is lower. Therefore, the child will grow less, will have a lower fat-free mass, will

have impaired bone growth, and will tend to use the energy ingested for fat accumulation. Such findings are also associated with a greater susceptibility to accumulate body fat when the malnourished children consume a diet richer in fats (Sawaya et al., 1998).

By comparing weight gain rate of stunted adolescent girls (D) to a control group (N), a longitudinal study (Graph 4) showed that the malnourished girls presented faster weight gain, at the expense of a reduction in energy expenditure. How do they do that if they're not eating well, and since malnutrition result necessarily from inadequate /insufficient feeding? By reducing the resting metabolic rate throughout the growth period. That reduction in energy expenditure to gain weight is associated to an increase of body fat, mainly in the waist region, where fat accumulation is most dangerous, since it is closely related to chronic diseases, such as diabetes and cardiovascular diseases in the adult life.



Graph 4 – Weight gain rate, resting energy expenditure and waist-to-hip ratio in female adolescents living in slums. Follow-up for 36 months. ANOVA: $p < 0.001$.

In another study that compared stunted adolescents to controls without stunting, we observed a reduction in insulin production by the beta pancreas cells (HOMA β), and as a response to that deficiency, a greater insulin sensitivity (HOMA S). Those alterations may lead to a pancreatic failure and to a greater risk of diabetes in the adult life (Table 1).

Table 1 – Glucose and insulin levels, insulin resistance and β cells function in stunted adolescents.

	Control (n=30)	Stunted (n=20)
Glucose (nmol/l)	4.45 \pm 0.34	4.36 \pm 0.29
Insulin (pmol/l)	58.39 \pm 31.66	32.08 \pm 15.51***
HOMA S (log)	1.97 \pm 0.23	2.18 \pm 0.19***
HOMA β (log)	2.11 \pm 0.14	1.97 \pm 0.11***

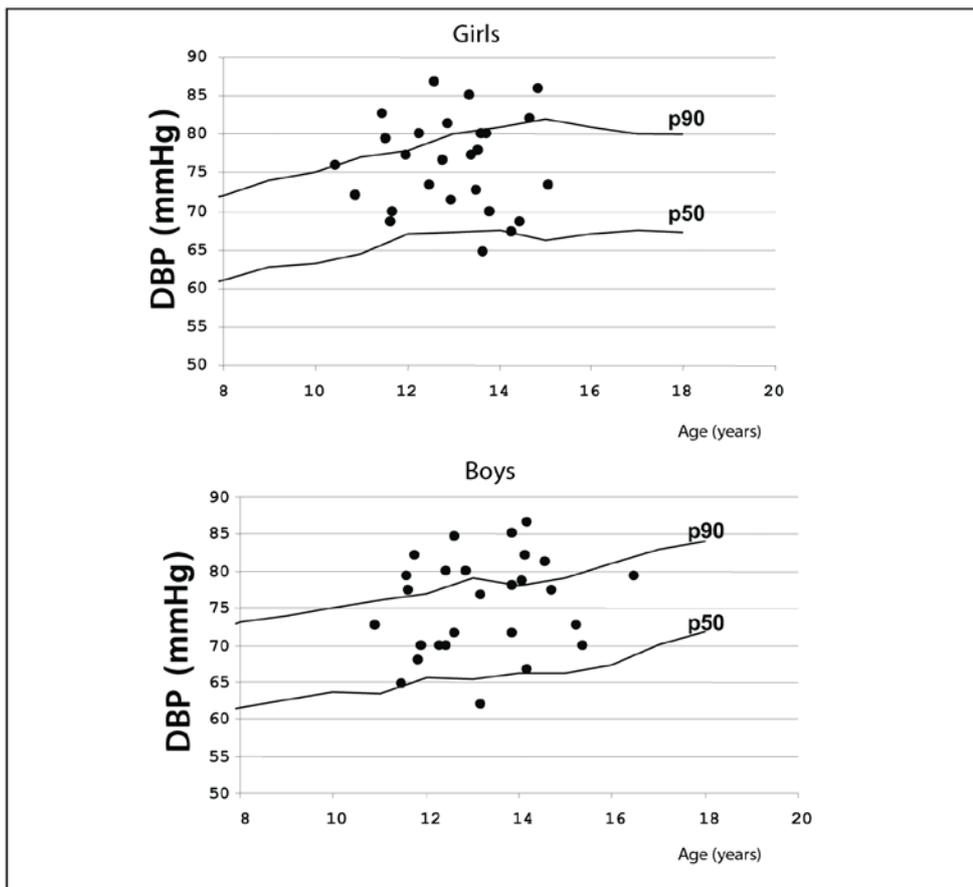
Values expressed in average \pm DP

*** Significantly different from the control group, $p < 0.001$

Our studies also showed higher diastolic blood pressure levels (almost the entire sample studied was above the 50th percentile that is, above the majority of the reference population) in boys and girls living in slums, which indicated greater risk of hypertension and cardiovascular diseases in the adult life (Graph 5).

Combining all that information (Figure 3), we can then say that insufficient consumption during the growth period causes a stress in the organism, leading to an increase of the cortisol-to-insulin ratio. As we have seen, malnutrition is a powerful stress stimulator and causes an increase in the cortisol levels and its catabolic action. Besides, food deficiency reduces the anabolic action of tissue synthesis that depends on insulin. That hormonal balance leads to the reduction of the hormone responsible for growth, insulin-like growth factor-1 (IGF-1). Studies in laboratory animals have shown that those hormonal alterations cause vascular (reduction of the vessel elasticity) and renal (reduction of the number of nephrons) alterations, which might also be going on in malnourished children and be the cause of the alterations verified in blood pressure and in the pancreas.

The high cortisol-to-insulin ratio and low IGF-1 also reduces muscle mass gain and linear growth, besides increasing the waist-to-hip ratio and reducing body fat oxidation, as we have seen. If the child in that life condition starts to ingest a modern diet and presents physical inactivity, an excessive in fat gain increase will take place, which can result in an association between stunting, obesity, hypertension and diabetes. Increasing data in the literature have shown evidences of that association in the adult population (Rosmond, 2002; Florêncio et al., 2004).



Graph 5 – Diastolic blood pressure of adolescents living in slums.

What happens after nutritional recovery?

If there's an adequate malnutrition treatment in hospital-day, the most severely malnourished children recover faster, their growth curve speed up. Their physiological growth potential registers that they must “hurry up” and recover their height. In fact, at CREN, children recover height faster than weight. We have been verifying recovery of about one standard deviation among the most severely malnourished per year. Another important data is that the children with low weight at birth often recover even better than the others. The organism is potentially prepared to recover what was lost in the beginning of life, in intra-uterine malnutrition. Graphs 6 and 7 show the average recovery standard verified.

Recently, when we studied the children who recovered from malnutrition and were discharged from CREN, we observed normal body composition, unlike what was verified in the malnourished children never treated and who remained stunted throughout their childhood and until their adolescence. Among the recovered girls, the lean mass and the body fat mass

were similar to what was observed in the control group, made up of children who had never been malnourished. Bone mineral density had also recovered and become normal. Among the boys, body composition was normal, even though their values were lower to those of the control group children. Bone mineral density had also become normal (Neves et al., 2006).

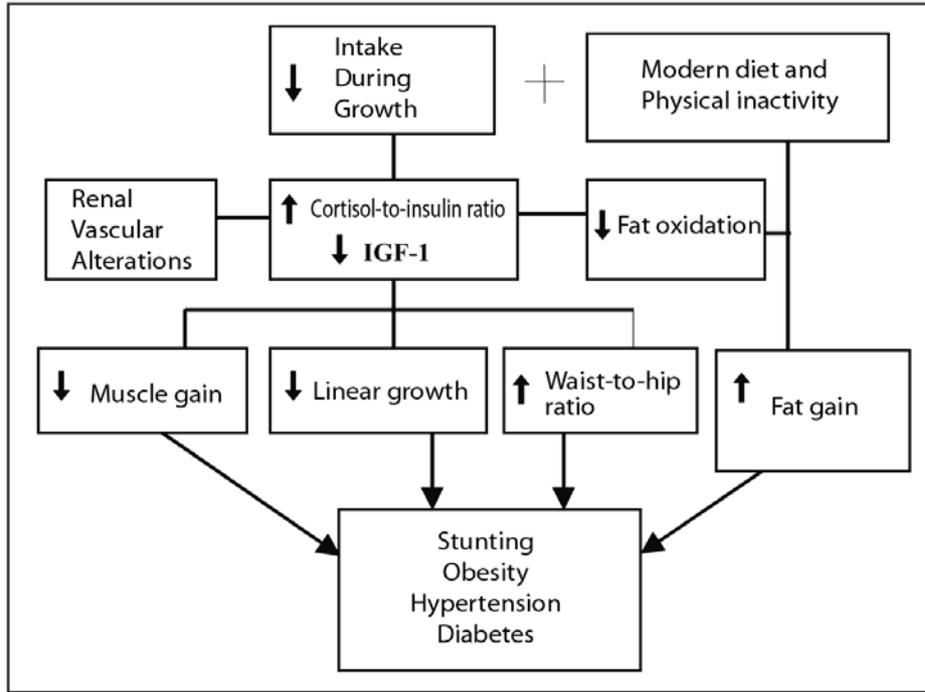
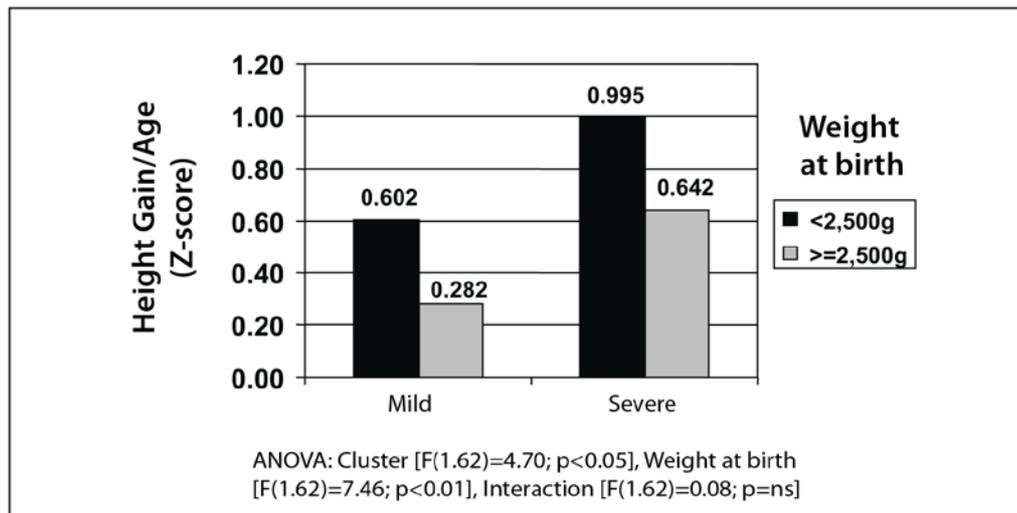
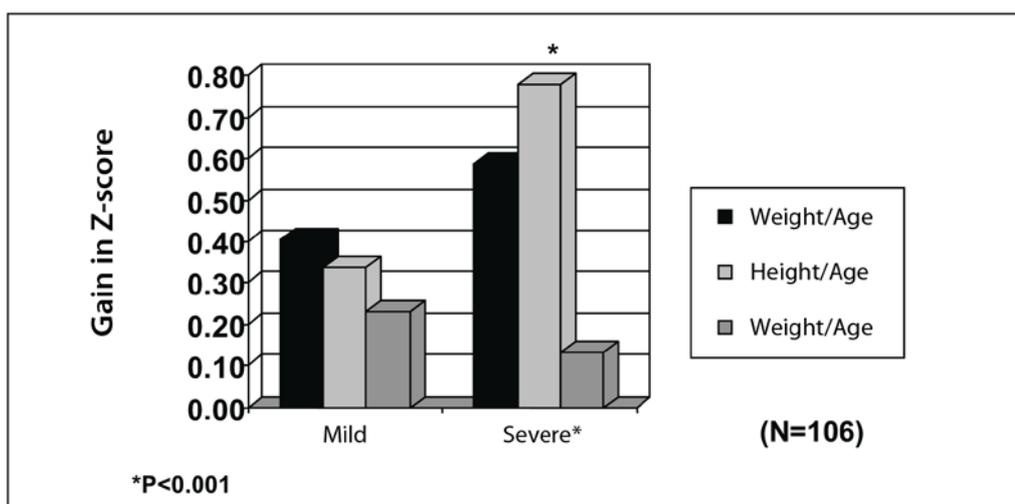


Figure 3 – Association between stunting, obesity, hypertension and diabetes.



Graph 6 – Height recovery of malnourished children treated at CREN.



Graph 7 – Height and weight recovery of malnourished children treated at CREN.

Those results are very important, since they show that height recovery fosters a normalization of the body composition, it avoids fat accumulation described above and, therefore, it reduces the risk of chronic diseases in the adult life for previously malnourished children.

Our proposition to face malnutrition in Brazil is organized in three great directions. The first one has to do with the qualification and education to face malnutrition, with investment in the practitioners and social actors who already work in governmental and private bodies – communication media, outpatient clinics, nurseries, infantile education centers, schools, etc. It's in those environments that one must act to make nutritional education effective. Second, it's necessary to create education and nutritional recovery reference centers, preferably tied to local universities, to foster courses of professional qualification and of community leadership, centralization and data analysis and evaluation of intervention programs (which has been very irregular in Brazil). Those centers would also have specialized outpatient clinics, with an inter-consultation system (including doctors and nutritionists). With that kind of experience we have verified much better results in a short period of time, and with a good cost-benefit relation. Third, it's also necessary to create day-hospitals to treat malnutrition, funded by SUS, a structure similar to the nurseries or to the pre-school and multidisciplinary attendance made by pediatricians, nutritionists, psychologists and social workers. Those teams could attend more than one health unit (Sawaya et al., 2003).

The origin of those propositions is the work performed at CREN. We have verified that a single structure can develop a new culture to face malnutrition in the area where it acts. CREN, located in Vila Mariana neighborhood, in São Paulo, attends directly more than 1,300 children per

year, and one of the most important aspects of the project is the qualification of practitioners – for example, for family health programs. With a single center it was possible to give malnutrition a focused approach, at a feasible cost and in a much more effective manner than if it had to do with a structure not clearly identified with the feeding and nutrition problems.

Professor José Eduardo Dutra de Oliveira, who is a member of the Study Group on Nutrition and Poverty of IEA, likes to say: “We must *undocotorize* the problem of feeding and nutrition, and we must give it a specific dignity”. The cost-benefit relation will become much more advantageous.



Pictures by Ana Paula Sawaya



At CREN, all the nutritional education is made through practical activities, of culinary practices and food manipulation workshops, with the children and their parents. The vital signs are measured daily in the children treated in hospital-day. It's essential to act quickly to avoid the energy expenditure caused by the infections. Otherwise, the child takes two, three, sometimes even four months to recover the lost weight, which can also jeopardize the height growth.

Bibliography

DANNER, D. D. et al. Positive emotions in early life and longevity: findings from the nun study. *Journal of Personality and Social Psychology*, v.80, p.804-13, 2001.

FLORENCIO, T. T. et al. Short height, obesity and arterial hypertension in a very low income population in North-eastern Brazil. *Nutrition, Metabolic and Cardiovascular Diseases*, v.14, p.26-33, 2004.

MARQUES, E.; TORRES, H. *Segregação, pobreza e desigualdades sociais*. São Paulo: Senac, 2005.

NEVES, J. et al. Malnourished children treated in day-hospital or outpatient clinics exhibit linear catch-up and normal body composition. *Journal of Nutrition*, v.136, p.648-55, 2006.

ROSMOND, R. The glucocorticoid receptor gene and its association to metabolic syndrome. *Obesity Research*, p.1078-86, 2002.

SAWAYA, A. L. et al. Mild stunting is associated with higher susceptibility to the effects of high fat diets: Studies in a shantytown population in São Paulo, Brazil. *American Society for Nutritional Sciences*, v.128, p.415S-420S, 1998.

_____. Os dois Brasis: quem são, onde estão e como vivem os pobres brasileiros. *Estudos Avançados*, Brasil, v.17, n.48, p.21-44, 2003.

STEPTOE, A. et al. Positive affect and health-related neuroendocrine, cardiovascular, and inflammatory processes. *PNAS – Proceedings of the National Academy of Sciences of the United States of America*, v.102, n.18, p.6508-12, 2005.

ABSTRACT – POVERTY and malnutrition are still very high in slums. This condition is associated with poor sanitation and stunting. Studies in adolescents with stunting showed high susceptibility to gain central fat, lower fat oxidation, lower energy expenditure, higher blood pressure and impaired insulin production, all factors linked with chronic diseases later in life. Adequate nutritional recovery in nutritional rehabilitation centers can revert the alterations in body composition.

KEYWORDS – Malnutrition, Poverty, Obesity, Diabetes, Hypertension, Nutritional recovery.

Ana Lydia Sawaya is a physiologist, associate professor of the Physiology Department of Unifesp, president of the Center for Recovery and Nutritional Education (CREN), coordinator of the Study Group on Nutrition and Poverty of the Institute of Advanced Studies of USP, member of the task force Diet, Nutrition and Long Term Health/IUNS (International Union of Nutritional Sciences). @ – alsawaya@unifesp.br

Translated by Rodrigo Sardenberg. The original in Portuguese is available at http://www.scielo.br/scielo.php/script_sci_serial/lnq_pt/pid_0103-4014/nrm_iso.

Received on 5.15.2006 and accepted on 6.16.2006.