Social and Biological Consequences of Nutritional Adaptation: Do the Costs Outweigh the Gains?

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Social and Biological Consequences of Nutritional Adaptation: Do the Costs Outweigh the Gains?

Keywords
nutrition, adaptation, stature, malnutrition

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Recent debates have centred on whether humans are able to adapt to the environment in which they live and on the amount of food which they eat. Discussion has also arisen concerning the extent to which these "adaptations" benefit the individual and the population as a whole. Aspects of this controversy have been brought into light in the last decade, most prominently through an article by David Seckler, entitled "Small but Healthy". In order to decide whether or not decreases in stature can be seen as an adaptation and as truly beneficial to the individual or the population, it is necessary to look at Seckler's hypothesis itself, the different physiological and social responses which are brought about by under-nutrition, the consequences for humans due to these adaptations, and whether or not the costs of these adaptations outweigh the gains. Questions such as these are especially important since the conclusions that are arrived at can be crucial in influencing policies on aid and development in many less developed countries and malnourished sectors of populations.

Seckler's hypothesis on mild to moderate malnutrition, which has elicited controversy, centres around the argument that people who are short in stature due to nutrient deficiencies are healthy nonetheless and well-adapted to an environment where food is scarce (Seckler in Pelto and Pelto, 1989:11). Seckler believes that in childhood the body adjusts to a low nutrient intake by remaining smaller helping the body's physiological functions remain in equilibrium. He believes that individuals suffer no impairments other than a reduction in height. This "no cost adaptation" will help these individuals as they encounter similar situations many times in their lives when food is scarce. He believes that since these individuals are adapted to their environments, food and nutrition programs should not be directed towards them, only towards those with severe malnutrition (Seckler in Pelto and Pelto, 1989:11.). These statements have caused a great outcry from people who disagree with his hypothesis, and although they may disagree on what constitutes a true adaptation, and on what the costs of these adaptations may be, they all agree that Seckler's hypothesis was short sighted and erroneous in many of its assumptions.

Although, there are many disagreements on what constitutes an adaptation, and whether the changes which take place due to under-nutrition are true adaptations or accommodations, there can be little doubt that changes do take place in order to prolong the life or health of individuals in malnourished states. Adaptations for humans due to stressful environments have been well documented in other research, such as the adaptation of oxygen transport in high altitudes, and the maintenance of heat transfer and a relatively constant body temperature in hot climates (Waterlow, 1985:392). With these as examples, many find it not so hard to believe that humans may adapt to low protein calorie diets as well. Whole populations are consuming an average of 10-20 percent less calories than what has been recommended for their requirements, and often the intake is far less than this average (Scrimshaw, 1985:211). Although their caloric intake is substantially less, the majority of these populations are not seriously malnourished or dying. This is due to the many different physiological and social changes which an individual experiences, which many consider to be adaptations. Physiological adaptations, or accommodations, encompass such things as: decrease in stature, a decrease in the basal metabolic rate, and the ability to maintain body nitrogen content. Social changes which have been shown to take place focus around a diminished level of physical activity (Ferro-Luzzi, 1985a:395).

There have been several theories suggested which deal with the response of a decrease in body size for dealing with nutritional deprivation. One hypothesis has proposed a genetic response, where the process of natural selection favours those individuals with a genetic potential to be smaller in situations where food is scarce. This theory postulates that malnutrition exerts selective pressures on children which have a potential to have greater growth as they would have greater nutritional requirements than smaller children. In times of food shortages, these larger children would be at a selective disadvantage, and at a greater risk for dying. Populations who are small for genetic reasons, therefore, would be better able to handle the stress of under-nutrition (Martorell, 1985:13., Nickens, 1976:37). Although sounding reasonable, there is actually no evidence to support the theory that larger children are more likely to die in famines. In fact, studies have shown the opposite, that it is larger children who survive (Martorell, 1985:13., Nickens, 1976:37).

Instead of seeing reduction in stature as a genetic adaptation, many see it as a physiological adaptation which occurs after birth to an environment where adequate nutrition is scarce. Common examples of this are given for societies changing from hunter-gatherer subsistence economies to more sedentary, farming lifestyles. Not only do the changes in diet affect people's health, for instance relying too heavily on one crop, but also the dramatic increase in infections which accompanies a more sedentary lifestyle will also adversely affect their health (Nickens, 1976:31). Studies done with the !Kung in Africa, societies in Mexico, Central America and in prehistoric Mesoamerica have all shown correlations between sedentary lifestyles and an increase in dietary deficiencies. (Nickens, 1976:32). A reduction in body size has clearly been shown to reflect nutritional stress, and, as nutritional levels improve, it has been shown that body size will increase. These fluctuations in body size can be shown to be the result of human plasticity or adaptation rather than due to genetic changes within populations. This can be shown as a child taken out of such an environment when quite young, before the age of three preferably, and given sufficient nourishment will reach growth levels consistent with those expected for a well nourished individual from that population. The fact that this decrease in stature can be stopped, or reversed if adequate nourishment is supplied before permanent changes have taken place, shows that it is not a genetic response, rather an
adaptation to the levels of nutrients the child was receiving (Beaton, 1989:35., Martorell, 1985:17).

Studies on nutritional variation within populations have also shown that differences cannot strictly be related to genetics. As higher social classes do not show these adaptations to nutritional stress, the evidence that these changes are due to the environment is stronger. The variations between different social classes are several times greater than that which can be attributed to genetics (Martorell, 1985:16). These adaptations are said to benefit populations as the low caloric intakes which prevail in many countries are more adequate to sustain small-bodied people. A greater number of people could be supported on less resources than it would take to sustain a larger bodied populace (Orlove, 1987:482., Seckler, 1980:225). When children are faced with chronic, but moderate, deficiencies in nutrients, they will grow less in weight and height and become small adults. If their nutrient intake does not deteriorate, they will manage to maintain normal proportions of weight-for-height, therefore, becoming stunted, not wasted (low weight-for-height) which is characteristic of severe malnutrition. They will show the physical capacities and metabolic responses for someone of that height, even though they had the physical capacity for greater stature (Waterlow, 1985:20, Desai et al., 1984:143).

Basal metabolic rates have also been shown to change when an individual is experiencing severe nutritional stress. The basal metabolic rate drops with energy deprivation. This change in basal metabolic rate has been postulated to save up to 15 percent on energy expenditure (Ferro-Luzzi, 1985b:61., Payne, 1985:71). These decreases in metabolic rates can be seen in Figure 1 (Ferro-Luzzi, 1985a:398).

The reasoning behind the changes in basal metabolic rates rests on the observation that various organs and tissues have highly different respiratory rates for their weight. Visceral organs such as liver, brain and kidneys contribute almost 56 percent of total basal heat production, while muscle only contributes 18 percent (Ferro-Luzzi, 1985a:397). There is strong evidence that different organs are also altered in size by nutritional stress, therefore, if the weight of one's visceral organs was to drop from 4.7 percent of the total body weight to 3.5 percent of the total body weight, this by itself would cause a 14 percent drop in the basal metabolic rate (Ferro-Luzzi, 1985a:397). Such decreases in size can account for a saving of up to 200 kcal a day in a small-sized person, or up to 10 percent of their total energy expenditure (Ferro-Luzzi, 1985b:61). The result is that the absolute cost of a given task is assumed to be smaller for smaller people.

A further example of metabolic adaptation has to do with the body's ability to maintain a body nitrogen balance. This has to do with a decrease in the body protein turnover rate, which is associated with the reutilisation of amino acids for the resynthesis and production of new proteins (Waterlow, 1985:5). When proteins are being synthesised, both essential and non-essential amino acids are metabolised in the process (Young et al., 1985:190). When the supply of protein to the body becomes insufficient, protein synthesis and breakdown still continue, along with the efficient reutilisation of the amino acids which were freed when the protein was broken down. However, amino acids are still being broken down, but at a slower pace, which can be seen by the lower rate of nitrogen in urine and faeces (Young et al., 1985:190). These are the "obligatory" nitrogen losses, which are reduced when a person is faced with habitually low protein intakes. This lowered the limit at which the nitrogen equilibrium can be maintained (Young et al., 1985:190). These nitrogen losses can be shown to be fairly consistent for individuals from different countries where the protein intakes are presumably quite different (see Figure 2) (Young et al., 1985:190).

Another important aspect of this may be a decrease in the rate of protein breakdown in muscle tissue, when protein intake is itself reduced (Waterlow, 1985:5). All of these changes act to conserve body nitrogen levels.

Other mechanisms for physiological adaptation to suit nutritional stresses include; changes in hormonal levels; amino acids, such as leucine; increased efficiency in iron absorption; and the preservation of albumin in the body.

Added to these physiological alterations are changes in levels of physical activity. While for many, changes such as these may seem undesirable, these modifications might actually be the best for preserving energy. If an individual dropped their physical activity level from 1.86 (as measured by physical activity level and total energy expenditure over basal metabolic rate) to 1.50 this would probably allow the individual to survive at an acceptable maintenance level while still being able to perform a reasonable amount of physical work. This change would save approximately 500 kcal a day (Ferro-Luzzi, 1985a:397-98). Societies in Guatemala can be shown to exhibit this particular response as when they finish their work for the day, they become almost completely inactive. This can be seen as an adaptation, since after their food intakes were increased, their level of activity increased (Pellett, 1987:171). This decrease in activity levels produces an important reduction in the metabolic demand for nutrients (Stini, 1980:132).

Both these physiological and social changes are necessary adaptations for dealing with nutritional stress, and although they are able to help the individual to some degree, they do not stop all of the adverse consequences which occur when an individual is deprived nutritionally. A reduction in stature, although, embodying some advantages to a malnourished individual, also carries many consequences. The process of becoming small begins at birth, where it has been shown that small, undernourished mothers give birth to babies with low birth weights (Behar, 1977:176). Low height-for-age (stunting) is a sign of chronic under-nutrition, whereas low weight-for-height (wasting), can be seen as a sign of severe, current, malnutrition since the best way to assess sub-clinical protein calorie malnutrition is through the rate of growth in children as is expected for their age (Behar, 1977:176). The importance of stunting can be seen in respect to famines. Children who are stunted are often balanced between adequate nutrition for their shortened stature, and being malnourished, and any additional stress that they might receive could break this equilibrium and result in a famine. Chronic malnutrition may be a very good indicator of future problems, and cannot be ignored (Behar 1977:177).

Although small body size may require less food to live, and, therefore, be at an advantage when performing light work tasks, a small body will be at a disadvantage when having to deal with moderate or heavy work loads. The ability to carry out physical work is a function of the lean body mass, muscle mass, and oxygen transport capacity. Taller people tend to have greater abilities to do heavy work as they have a larger lean body mass, and a greater aerobic capacity (Martorell,
helps to cause high infant and mortality rates. These that a child is most susceptible to nutritional stress and diseases (Watkins and Van de Walle, 1985:20). It has been food increases the susceptibility to, and the lethality of nutritional disease in the malnourished, and malnutrition child experiences a catch-up in their growth (Nickens, reserves, it is harder for them to recover from illness. A lack of infestations contribute significantly to nutritional drain (Pelto, infections due to their poor immunological capabilities. This helps to cause high infant and mortality rates. These immunological defects can last until late childhood, even if the child experiences a catch-up in their growth (Nickens, 1976:37., Stini, 1988:43). There is a synergistic effect between infections and under-nutrition. Infec- tions precipitate nutritional disease in the malnourished, and malnutrition worsens the consequences of infection. Infections and parasitic infesta- tions contribute signifi- cantly to nutritional drain (Pelto, 1987:532). If a person does not have adequate nutritional reserves, it is harder for them to recover from illness. A lack of food increases the susceptibility to, and the lethality of diseases (Watkins and Van de Walle, 1985:20). It has been shown that the time during which a child is weaned is the time that a child is most susceptible to nutritional stress and infections. This is a time where fast growth rates call for greater nutritional requirements, and where there is a high susceptibility to diarrhoeal diseases and other infections. It is a time of great stress for an infant. At this stage in life, severe infections often precipitate severe malnutrition as they are stresses which can upset the precarious balance that the child's body has achieved (Martorell, 1985:20-21).

Infections contribute to under-nutrition in several ways; increased tissue catabolism, nitrogen loss in urine, reduced appetite, vomiting, decreased absorption of nutrients, protein loss through such things as diarrhoea, and the loss of nutrients being used to produce antibodies and other host-protective factors. Diarrhoeal disease in particular is an important cause of under-nutrition. Absorption of protein has been reported to be decreased by 20-30 percent, carbohydrates 73-77 percent, while fat excretion is increased by 6-14 percent (Gabr, 1985:63). Common cultural practices of withholding food during times of infections, especially ones that cause diarrhoea, only compound the problems of malnutrition. The synergistic effects of malnutrition and disease are easy to see. Death from measles is 200-400 times greater in malnourished children than in Western nations, and complications of measles have been reported in over 60 percent of malnourished children in countries such as Nairobi (Gabr, 1985:63). Under-nutrition also interferes with the body's immune system, causing the skin of the malnourished infant to be thin and break easily.

The epithelium of the eye becomes defective, gastric acidity is impaired, and many of the natural, cellular and hormonal factors responsible for immunocompetence are impaired. Protein energy malnutrition also causes a decrease in the haemolytic complement, reduces transferrin levels, and impairs antigens needing the help of T-lymphocytes or macrophages (Gabr, 1985:63). All of the above responses to undernutrition greatly affect cell-mediated immunity, thereby, allowing malnourished children to be more susceptible to infectious diseases. Although, these effects can easily be seen in severe malnutrition, they can also be seen, to a lesser degree, in moderate or marginal malnutrition. Malnutrition is the single most important associated factor responsible for the high mortality rate in developing countries. This can be seen in countries such as Latin America where malnutrition is associated with approximately 55 percent of infant mortalities (Gabr, 1985:64).

It has been shown that severe malnutrition affects cognitive development, along with motivational factors including: attention, persistence and self-confidence. Under-nutrition also has an impact on activity level, attention to novel stimuli and social responsiveness (Desai et al., 1984:143., Gabr, 1985:64). Lasting behavioural problems may result from chronic malnutrition, including specifically socio-emotional competence. Effects of this can be seen in general social interaction with peers and adults, response to the physical environment, affection, and their physical environment. A child which has not received adequate nutrition is apathetic, non-responsive, impulsive, fails to respond normally to social interactions, and has difficulty dealing with stress (Grantham-McGregor, 1985:69). These characteristics of malnourished children have been shown to change the way in which the child's family, especially the mother, respond and act toward it. There is a tendency for the child to be responded to less frequently and with less enthusiasm than would be a well nourished child. The apathetic responses of the child lead others to respond to it in a similar manner. As it does not cry out or demand attention, so little is given towards it. Due to this, malnourished children withdraw from social interaction (Gabr, 1985:65., Grantham-McGregor, 1985:69., Cravioto, et al., 1966:358).

Marginal levels of malnutrition affect the ability to perform complex work functions such as precision control, multi-limb coordination, arm/hand steadiness, finger dexterity, reaction time and aiming (Malina et al., 1987:497-498, Gabr, 1985:65). These impairments, combined with socioeconomic factors, greater risks of infection, and decreased physical capabilities, interfere with the learning process. Malnutrition affects children's education, not only because the child's ability to learn and concentrate are impaired, but also due to the fact that they are absent from school because of frequent illnesses (Gabr, 1985:65).

**CONCLUSION**

Although, it can be shown that there are significant adaptations which occur due to protein-calorie malnutrition, there are many unwanted consequences which occur as well in response to these nutritional deficiencies. Even though we can say that none of these consequences are desirable, it is important to look at the situation and decide if the advantages conferred upon these populations outweigh the costs, or if the ...
costs are just too high. The idea that adaptations to nutritional stress are successful adaptations, is in part social and behavioural, as well as biological. Biologically, stunting can be viewed as a successful adaptation only to the extent that it helps children to survive in adverse conditions. The consequences of stunting are not in themselves desirable, and neither is the process in which people are stunted. There is no one who could say that stunting is a sought after condition. Preferable is a state where stunting would not have to occur at all. If a child adapts to a low calorie diet by reducing their energy expenditure, it reduces the child's social interaction, curiosity, and learning ability as well as their productivity. Not only does this adversely affect the child's chances for self-improvement, it also has unfavourable effects on their country. Due to the fact that these individuals will not be able to produce as much, or work as hard, they will not be contributing as much to the economy as well nourished individuals would be. Although, these adaptations do have negative effects for children's ability to learn, this might not necessarily impose problems for the child or their family. Studies in Guatemala have shown that, although, children are affected, either directly on cognitive abilities, or indirectly on the way these cognitive abilities are utilised, the levels of education that children achieved were not affected by health or the nutritional environment (Bogin and MacVean, 1987:611). The reason for this had to do with the importance that families attributed to school. In the society where this study took place, education past the second grade was not viewed by the majority as necessary, the child was needed at home to help around the house. After grade two it is expected that the child will start learning a craft and be apprenticed (Bogin and MacVean, 1987:612). Due to the needs of the society, adverse cognitive development imposed by under-nutrition are not seen to impose restrictions on an individual as they are not detrimental to the society or the family.

Many believe that even though stunted individuals cannot work to the same capacity as well nourished individuals, if the jobs they are doing never call for this increase in physical ability, then the individuals are well adapted, since their ability is not exceeded by the demands placed upon them. Unfortunately, this view does not take into account the numerous individuals who cannot work since the work does exceed their capabilities. This view also does not take into consideration that many individuals, in order to work, must sacrifice other activities to maintain their strength. Yet it is these extra activities that are needed for the development of social structures in the community and for home improvements (Scrimshaw, 1985:211).

Another effect which occurs has to do with the child replacement hypothesis, that parents are motivated to "replace" a child's death with a new child. As more children die in environments where undernutrition is prevalent, parents are constantly driven to have more children. Because of this, parents in malnourished sectors of the economy will be less responsive to family planning services. For economic and emotional reasons they will aspire to have large families (Pelto, 1987:532). This is an example of an indirect effect of malnutrition on the population, through its influence on a family's decision to have more children or not. There are many consequences, for individuals and for populations, associated with undernutrition. Although, they are not all negative, there are few adaptations which can be truly said to be positive for the individual.

Although, Seckler was correct in his assertion that humans adapt to their environment, and that stunting helped to preserve human lives, he was by no means correct when he asserted that it was a "no cost" adaptation. No adaptation can be without a cost, as can be seen through the effects stunting and under-nutrition have on such things as the immune system and other biological functions, on interpersonal interaction, on cognitive abilities, and on job opportunities. There is no way that the adverse effects experienced by those who are undernourished can be said to be beneficial or well adapted. To say that being small is a virtue, as Seckler and others seem to postulate, is to say that these malnourished people are well adjusted, and are in no need of help. "To keep people small, they must be kept poor, sick and poorly fed" (Martorell:26). While those who are severely malnourished seem to be those who are in the worst situation, those that are moderately malnourished, and stunted, are a substantially larger portion of the population. They may also present a greater problem, as was mentioned earlier, due to the fact that any additional stress in the environment could disturb their equilibrium, and famines or epidemics could easily ensue. Adequate nutrition for the entire population should be seen as a human right, and under-nutrition should not be heralded as a great adaptation which allows more people to live on less resources. Stunting should not be seen as a desirable outcome, instead it should be viewed as something that we need to eliminate from all populations. Everyone has the same rights to live comfortably with adequate resources, and although this may not be possible at the present time, we should not accept the adaptations people experience to nutritional stress as a solution to the problem.
Figure 1 (Ferro-Luzzi 1985a:398)

Postulated effects of adaptation to low energy intakes in adult males.

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>'Adapted'</th>
<th>for BMR</th>
<th>for SIZE</th>
<th>for SIZE &amp; BMR</th>
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<tr>
<td>Height</td>
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<td>BMR</td>
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<td>1750(7.32)</td>
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<td>1597(6.68)</td>
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</tr>
<tr>
<td>Adapted BMR</td>
<td>kcal(MJ)/d</td>
<td></td>
<td>1470(6.15)</td>
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<tr>
<td>Expenditure at 1.86 PAL*</td>
<td>kcal(MJ)/d</td>
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<td>3255(13.6)</td>
<td>2734(11.4)</td>
<td>2970(12.4)</td>
</tr>
<tr>
<td>Net energy saving</td>
<td>kcal(MJ)/d</td>
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<td>521(2.18)</td>
<td>285(1.19)</td>
<td>761(3.18)</td>
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<tr>
<td>over 'normal'</td>
<td>kcal(MJ)/d</td>
<td></td>
<td></td>
<td>1264(5.74)</td>
<td>1373(5.74)</td>
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<tr>
<td>Net energy for work</td>
<td>kcal(kJ/kg</td>
<td>21(88)</td>
<td>12(50)</td>
<td>23(96)</td>
<td>19(79)</td>
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</table>

*Physical activity level

Figure 2 (Ferro-Luzzi 1985a:398)

Obligatory urinary nitrogen losses in adult males,

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<th>Mean wt (kg)</th>
<th>Urinary N (mgN/kg/day)</th>
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<td>74</td>
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<td>63</td>
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<td>Uauy et al. (1982)</td>
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