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Is Satisfactory Energy Balance Possible on Low Energy Intakes?

J.V.G.A. Durnin

'Low' energy intakes in population groups are, or have been, notoriously common among the Indian poor, as far as much published work is concerned (eg: Reports of the National Nutrition Monitoring Bureau of India; the Annual Reports of the National Institute of Nutrition from Hyderabad; and data from many individual authors). However, assessing the real meaning of these 'low' intakes is complex and fraught with traps for the superficial and unwary analyst.

Basics For Assessment Of Energy Intakes

The first thing might be to be clear about what values we should be assessing. An intake of 1500 kcal/d arouses much more of a reaction in many of us than 1750 kcal/d — even though the body sizes of the two groups might be such that the intake of 1500 kcal is relatively the higher of the two. We need, therefore, to consider energy intakes on some sort of basis which takes account of relative body size. It is easy, for instance, to appreciate that the resting energy metabolism of a 40 kg woman is going to be very different from that of a 80 kg man but when it comes to comparing two groups of individuals with rather less extreme a contrast, it becomes rather critical to use a comparable unit. What that unit should be is not a question which can be given a straightforward answer. The obvious unit is per unit body mass; and we can usually make a comparison on this basis: i.e. so much energy intake per kg body weight. However, we should remember that this is a method of comparing individuals or groups which has limited validity.

In an analysis of a considerable amount of data on both energy intakes and expenditure, much of which we had obtained in our own studies but to which was added other published results as well[1], the correlation coefficient of either energy intakes or energy expenditure to body weight was seldom higher than 0.4 in any of the groups of individuals. Gross body weight is therefore obviously not a very satisfactory unit but it is probably the best we have.

We might, of course, appear to be more precise and scientific by using the fat-free mass, i.e. the mass of all the tissues and organs of the body excluding chemical lipid (or lean body mass as it is often, and incorrectly, called) but there are two problems here. Firstly, although simple measures of fatness and fat-free mass can be made by skinfold thicknesses in any field situation, this is very seldom done in nutritional studies; and secondly, the use of a unit of fat-free mass may not convey any real advantage. This is because the fat mass of the body cannot simply be dismissed as being metabolically inactive; it has a higher oxygen consumption, for example, than bone or skin (both of which are tissues of considerable size), and which is not very much lower than skeletal muscle which comprises about 50 percent of the fat-free mass of the body. Because of the metabolic activity of adipose tissue, theoretically as well as practically, there will often be virtually no advantage in using fat-free mass as our unit of reference over the gross body weight. There is probably an occasional exception to that generalisation in that if we were comparing a very obese population to a lean one, then fat-free mass might be the unit of preference. However, in the present context of population with low energy intakes, and especially here in India, the likelihood of dealing with groups of very obese people is not high.

We have to reconcile ourselves, therefore, to assessing the implications of energy intake data by relating the values to the body weight of the persons, but remembering that we need to have reservations about the validity of this approach.

Appropriate Sample Size

Another very important point we need to consider is the appropriate sample size of our population. This varies enormously in the nutritional literature, mostly dependent on the technique being utilised for the actual measurement of energy intake. If it is a 24-hour recall, many papers are published quoting results on hundreds of individuals. In general, I do not trust this sort of infor-

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mation, and even if there is no better way of obtaining the data, an attempt should at least be made to validate the data by measuring a smaller sub-sample by better techniques. However, if this is done, or if one of the more complex methods of measuring food intakes is utilised (such as the weighed individual inventory, or the precise weighing techniques), the number of individuals to be studied becomes critical. This is because the variability both within and between individuals is such that to obtain an adequate power for the statistical evaluation of the data entails measurements which continue for a certain minimum number of days and cover a minimum number of individuals. These can both be estimated with some precision, knowing the approximate variation in energy intakes from day-to-day and from period-to-period within and between individuals. We have made some calculations in relation to this problem, using longitudinal data we have obtained from repeated periods of measurements on 180 healthy young adult women. From the intra- and inter-individual standard deviation of energy intakes, it is possible to make calculations for both longitudinal and cross-section studies of how many individuals need to be studied for how many days in order to detect differences of stipulated amounts of energy — for example, a difference between groups of, say, 200 kcal/d. Figures 1-3 give some examples of these.

It seems to be important that we remember and utilise this information. I am sure much confusion exists in the minds of many nutritionists because of untenable conclusions made on the basis of quite inadequate numbers of individuals studied.

Low Energy Intakes

There are many studies in published literature which purport to show the existence of low energy intakes with little indication of undesirable adaptive processes occurring simultaneously – such as low levels of physical activity; but these studies do not always satisfy the essential statistical requirements we have mentioned. We should therefore, in my opinion, have some reservation about accepting these statements at face value.

Let me deal with what is meant by 'low' energy intakes in a basic critical fashion. Firstly, the 'low' intake has to represent a situation which is not just a temporary one. Anyone, or any group, can exist for a certain time on a 'low' but inadequate energy intake so long as this period is followed by one where the energy intake can go into a state of excess to counterbalance the defective period. This represents a supposedly relatively common situation in some developing countries where seasonality in the availability of food leads to temporary deficiencies in energy intake with its attendant consequences to the people concerned. The most frequent consequence is a loss of body weight. Reports have been published showing losses in body weight of as much as 5 kg during the lean or poor season.

I should say that although such reductions in body weight have been reported as if they were a regular occurrence year after year, in a study in which I have been involved for the past four or five

Figure 1

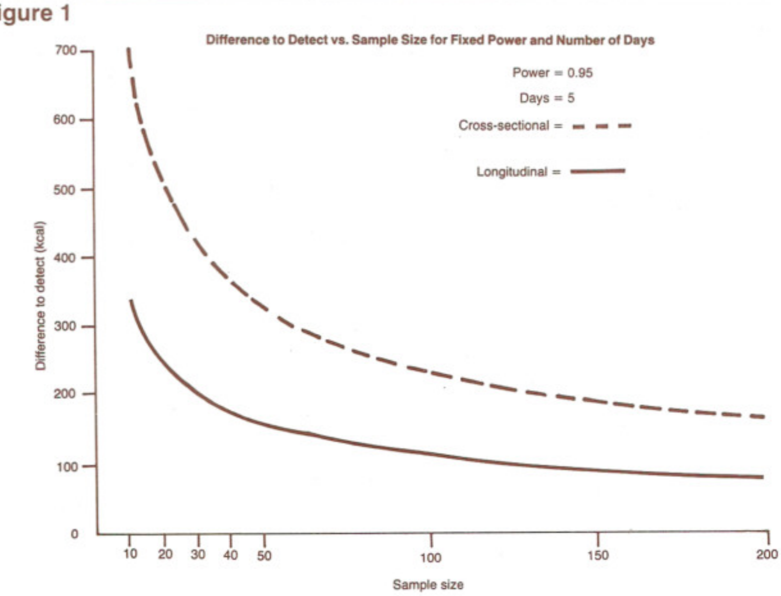


Figure 2

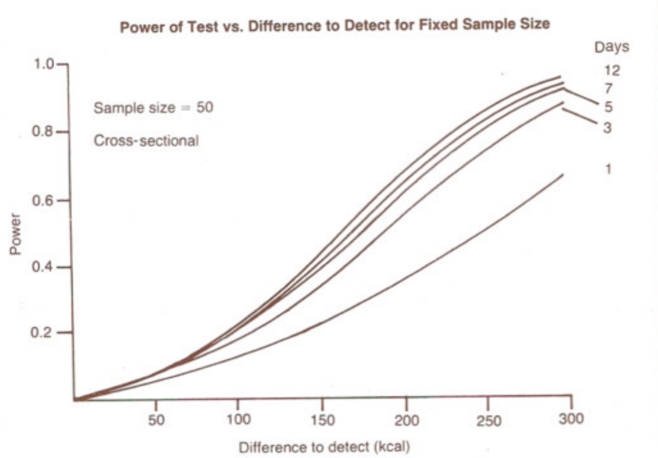
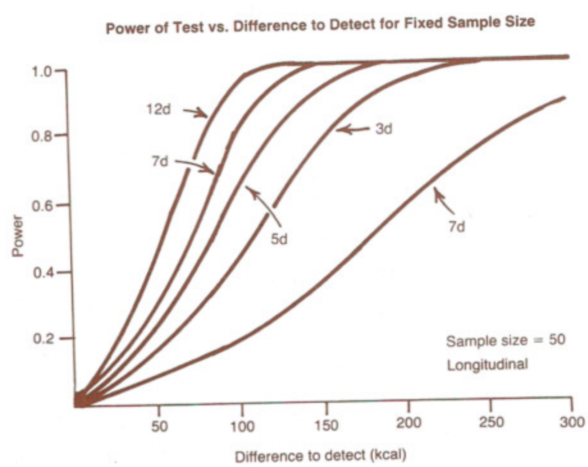


Figure 3



years with Professor Anna Ferro-Luzzi from Rome, and Professor Jo Hautvast from Holland, where we have been very actively searching for these type of populations, we have been quite unable to discover any groups with anything like this loss of body weight. Part of my own study was done here in India in collaboration with Dr. Satyanarayana and the population we studied ended up by having a seasonal weight loss of less than 1 kg. Indeed, it is difficult to envisage a situation where weight losses of 5 kg could occur other than with people who start off in a rather satisfactory nutritional state with adipose tissue stores large enough to allow this weight loss to occur. In an average poorly-fed community where most of the population is lean with very low fat stores, such weight losses – were they really to take place – would pose a severe problem for any sort of existence other than one of complete lassitude.

However, for the sake of argument, let us calculate how much benefit would accrue to the energy balance from a weight loss of 5 kg over a period of, say, four to six months. Let us also assume we are dealing with people who initially have adequate stores of adipose tissue so that the weight loss will consist mainly of adipose tissue. Because if this is not the case, then the loss of other tissues will provide less energy and will therefore be less effective in supplying some replacement of energy. If the weight loss is entirely adipose tissue, each kg lost will make available to the body about 7000 kcal. Five kg will therefore supply about 35000 kcal during these four to six months. 35000 kcal in four to six months represents 8500 to 6000 kcal per month, or 250-200 kcal/d. This may be an important quantity but will usually not raise the energy supply by proportionately a great deal. If the weight loss is more likely to be realistic at, say, 2-2.5 kg, the extra energy available to the body will then be a mere 100-125 kcal/d.

We can do some calculations which will represent the general and specific activity levels which may be present in people subsisting on low intakes and the difference that would ensue if extra energy was being supplied from the utilisation of energy stores at something like the previously suggested levels.

Firstly, let us take some levels of energy expenditure which are supposedly representative of people with low activity levels. The current FAO/WHO/UNU (1985) Report suggests that BMR should be the basis of calculating energy requirements — such that, for example, 1.5 × BMR might represent a fairly sedentary existence and 2.0 × BMR would betoken a fairly active one. In this FAO/WHO/UNU document, 1.2 × BMR purports to represent a minimal existence level and 1.4 × BMR some sort of a 'maintenance' level, and one which is just tolerable in a free-living society. Let us examine exactly what this implies, since it seems to be that this was not done comprehensively before the report was published. Perhaps the easiest way to illustrate the situation is to take some hypothetical (but potentially realistic) examples.

Suppose we take a more or less average woman, living in a poor village in India. She weighs 50 kg and her BMR will therefore be about 1260 kcal/d (Schofield, etc.). Table 1 shows her likely life style at this intake.

To explain this table, if her BMR equals 1260 kcal/d and she is existing at this minimal level of activity, then 1.2 × BMR equals 1512 kcal/d. The energy required for dietary induced thermogenesis (DIT) is approximately 10 percent of the energy intake – i.e. 150 kcal/d. Therefore, the energy left over for all the physical activity of the day is the total energy intake (1512 kcal) minus BMR (1260 kcal) minus DIT (150 kcal), which is equal to 102 kcal/d. This would be the equivalent of 204 min where the energy expended would be 0.5 kcal/min over and above the BMR, which would represent that amount of time spent standing with minimal movement. That is, in an average day, this woman would have to remain lying down resting quietly for about 20.5 hours in the day, and standing with little movement and no walking around whatsoever for the remaining 3.5 hours. This certainly betokens a minimal existence and is not one to be found in any other than moribund populations.

Let us move up one stage and analyse the equivalent situation if we are dealing with the so-called maintenance level of 1.4 × BMR, and let us take as an example still this woman living in an Indian village and weighing 50 kg. Her BMR (Table 2) is 1260 kcal/d, therefore 1.4 × BMR is 1764 kcal/day (these

Table 1

'Activity' of an Individual Whose Energy Expenditure is Equivalent to BMR × 1.2

BMR for 50 kg woman	= 1260 kcal
Therefore BMR × 1.2	= 1512 kcal
DIT at 10% of intake	= 150 kcal
Thus total energy intake (1512) minus BMR (1260) minus DIT (150)	= 102 kcal

i.e. 102 kcal available for activity = 204 min × 0.5 kcal over BMR

i.e. equivalent to about 3.5 h of standing with very gentle movement, and 20.5 h of lying down or sitting virtually without movement.

Table 2

'Activity' of an Individual Whose Energy Expenditure is Equivalent to BMR × 1.4

BMR for 50 kg woman	= 1260 kcal/d
Therefore BMR × 1.4	= 1764 kcal
DIT at 10% of intake	= 176 kcal
Total energy intake (1764) minus BMR (1260) minus DIT (176)	= 328 kcal

i.e. 328 kcal/d available for activity
= 220 min (approx. 3.5 h) standing at 0.5 kcal/min over BMR
= 110 kcal

Plus 2 h housework at 2.5 kcal/min or 1.5 kcal/min over BMR = 180 kcal

Remainder is 39 kcal or 0.5 h walking.

i.e. Average day's activity is

2 h housework
3.5 h quiet standing
0.5 h walking
18 h lying down or sitting quietly

values are just the arithmetic calculation and I am, of course, not suggesting that there is any real significance to the final two digits of the 1764). Her DIT will thus be about 176 kcal and the energy to be expended in physical activity is the total energy intake (1764 kcal) less the BMR (1260 kcal) and DIT (176 kcal), leaving a total of 328 kcal. If we allow her about 3.5 hours of quiet standing this will entail an extra energy cost of 110 kcal, leaving 218 kcal. If she spends two hours in the day doing routine housework, cooking, looking after the children (and I know this is a nonsensically small amount of time but this is only for purposes of calculation) the energy cost will be about 2.5 kcal/min, or at least 1.5 kcal/min over BMR, so that these two hours represent 180 kcal. We are then left with 38 kcal, which would allow, say, less than half an hour of walking. This woman's daily pattern of activity will therefore consist of

2 hours of housework
3.5 hours of quiet standing
0.5 hours of walking
18 hours of lying down or sitting very quietly.

What could be further removed from an average day spent by a woman living in a poor Indian village! Yet that is the amount of activity allowed for someone of 50 kg body weight whose average intake of energy is 1760 kcal, and how often do we see values reported in the literature of that amount or less! Tables 3 and 4 give the values for 1.2 × BMR and 1.4 times BMR for women and men of a range of body weights.

If we are more sensible and take as a realistic level of minimal energy expenditure at 1.5 × BMR, Tables 3 and 4 also give these values for a range of women and men.

Therefore it seems to me that when we come across values of energy intake significantly less than this, we should be treated by the authors (which virtually never occurs) to a series of possible explanations:

- the methodology is faulty — let us assume it never is!
- the results represent a time of seasonal shortage and they will be counterbalanced by periods when the energy intake will be at least proportionately higher than the average (because while we can utilise our fat stores with maximum efficiency, replacing them later requires a proportionately greater quantity of energy);
- the sample size of the population is statistically inadequate;
- the results may be correct but, for various reasons which may be cultural or psychological, they are not representative because of an artificially low intake of food.

I think we need a new and fresh outlook on the part of both the investigators who find these low energy levels and of ourselves as readers of the scientific articles, and all of us might benefit by being perhaps a little more sceptical of such data.

Conclusion

I feel I have to conclude by suggesting that satisfactory energy balance is *not* attainable on what are commonly supposed to be low intakes. Intakes of these levels are really not tolerable in a society with the minimal amounts of activity which are compatible with an acceptable way of life. We need a new attitude to desirable energy intakes which, I suggest, requires a reassessment of the energy requirements of many population groups, particularly in rural situations where physical activity of at least moderate levels is necessary. This reassessment will not, naturally, be received with enthusiasm by economists nor possibly by people involved in national food policy. Nevertheless we, as nutritionists, have a responsibility to ensure that our findings are based on good science. Energy intakes which are impossibly low simply serve to encourage deductions to be made about food requirements which end up as prolonging the unsatisfactory situation which exists for so many poor populations in this, and in many other countries.

The author is a Professor at the Institute of Physiology, University of Glasgow,

Based on the 13th Gopalan Oration at the Annual Meeting of the Nutrition Society of India, Trivandrum held in November 1989.

Reference

1. Durnin, J.V.G.A., Food Intake And Energy Expenditure: Guidelines For Fieldwork, in "Human Nutrition", Proceedings of the 4th Asian Congress of Nutrition, Bangkok, 1984, pp. 53.

Table 3
Energy Expenditures in Women of Differing Body Weight

W(kg)	35	40	45	50	55	60
BMR (kcal/d)	1130	1180	1220	1260	1310	1350
BMR × 1.2	1360	1420	1460	1510	1570	1620
BMR × 1.4	1580	1650	1710	1760	1830	1890
BMR × 1.5	1700	1770	1830	1890	1970	2030

Table 4
Energy Expenditures in Men of Differing Body Weight

W(kg)	50	55	60	65	70	75	80
BMR (kcal/d)	1460	1520	1580	1630	1690	1750	1810
BMR × 1.2	1750	1820	1900	1960	2030	2100	2170
BMR × 1.4	2040	2130	2210	2280	2370	2450	2530
BMR × 1.5	2190	2280	2390	2445	2535	2625	2715

FOUNDATION NEWS

- The meeting of the General Body of the Nutrition Foundation of India was held at the India International Centre on March 6, 1990.
- The meeting of the Advisory Committee for the project 'Health/Nutrition Education of Rural Adolescent Girls' was held at the India International Centre on March 9. The following participants were present: Prof. K.N. Agrawal, Dr. S.N. Chaudhri, Dr. Shanti Ghosh, Dr. Tara Gopaldas, Dr. Sharda Jain, Mr. Harish Khanna, Dr. Sumati Mudabmi, Mr. T.K. Parthasarthy, Dr. Mrunalini Puar, Dr. Amita Verma, Ms. Suminder Kaur, Dr. C. Gopalan.

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Low Energy Intakes

C. Gopalan

In his paper on "...low energy intakes", which appears elsewhere in this issue, Durnin suggests that the reported values for energy intakes in poor communities, that are now available in the literature, are probably underestimates attributable to methodological errors. Durnin bases his conclusion on his assessment that with such reported low energy intakes, it will just not be possible for human beings engaged even in 'moderate' work to achieve energy balance. Durnin does not obviously (and rightly in our view) subscribe to the newly-floated postulates that individuals and communities can successfully achieve 'costless' (without physical and functional impairment) adaptation to such low energy intakes. Durnin's concern is that the reported low intakes (which, in his opinion, are underestimates of actual intakes) could encourage unwarranted deductions of food requirements which might result in "prolonging the unsatisfactory situation which exists for many poor populations...".

Diet surveys have often to be carried out under difficult field conditions and are heavily dependent on the cooperation of the households. For this reason, diet survey data, even when collected by competent teams, could suffer from inaccuracies caused by methodological errors. Such errors could either underestimate or overestimate the habitual dietary intakes of families and communities. The NNMB diet surveys in India are being carried out by competent teams under the supervision of the National Institute of Nutrition; the data from such surveys can, therefore, be expected to be generally reliable. Even so, as a general rule, the need to build into diet survey operations appropriate procedures for checking the validity of the data will not be disputed. Especially in situations where surveys reveal unusually low or high intakes, repeat surveys in representative sub-samples, preferably by a different group of investigators, would be desirable. The NNMB data, for instance, consistently reveal a much *higher* level of energy intake among poor rural populations of Karnataka as compared to those of other States in India covered in the NNMB operation. Such relatively high energy intakes in the rural Karnataks are not apparently being reflected in any significant superiority in their nutritional or anthropometric status. There has, thus far, been no satisfactory explanation for this phenomenon.

While the note of caution sounded by Durnin is valid, it will seem not justifiable to infer that *all* diet survey data from developing countries, which point to low energy intakes, are underestimates and are, therefore, to be viewed with scepticism. This may be too sweeping a generalisation to make. In making such a generalisation, we have to assume that too many people in too many places are making the same mistakes too often. In pockets of abject poverty and in certain seasons, very low energy intakes, of the levels that have been reported, must be an unfortunate reality. Populations subjected to such energy deprivation must be responding to their lot through restricting their activity to the absolute minimum levels necessary for them to keep "their body and soul together". Reports from parts of Orissa in India, for instance, would show that this is by no means a far-fetched scenario. It must also be remembered that estimates of energy expenditure are at least as much (if not more) subject to methodological errors as those of energy intakes. Among poor populations, energy intakes ranging from very low levels to moderately low levels must be expected. All the same, Durnin's note of caution is important. It will certainly be desirable to build greater scientific rigour into diet survey operations.

Possible Misinterpretation

It would be unfortunate, however, if Durnin's well-meant note of caution is misinterpreted in a manner that ends up doing just the very thing he cautions against – namely "prolonging the unsatisfactory situation which exists for so many poor populations in this and in many other countries" and in thus perpetuating the status quo. There are, today, international groups which have been arguing that the hungry of the Third World are not so hungry after all! Hunger itself is now sought to be redefined. Like India's "poverty line" which was sought to be repeatedly adjusted by its erstwhile planners, in a manner that would reduce India's problems of poverty to "manageable proportions", there are international groups which now seek to redefine not just the "hunger line" but the very concept of undernutrition itself. Others go even further and suggest that populations, which, as a result of nutritional deprivation, are stunted and suffer from functional impairments of various kinds could still be considered as "culturally adapted" if their reduced functional competence is adequate to enable them to carry out the limited functions which are in consonance with their own milieu of poverty and underemployment – *their culture!* All this appears to be part of a growing trend in some international circles to play down the gravity of the problem of undernutrition in the Third World; "survival" (not optimal health/nutrition) is to be the Third World's new target! Durnin's well-meant observations could be misinterpreted in a manner that may provide grist to this mill. It could now be argued that low energy intakes reported in poor populations in many parts of the world are unreliable underestimates. So if energy intakes are not, after all, "that bad", and if poor populations are "culturally adapted" to their prevailing levels of intakes, why disturb the status quo? It is to be hoped that Durnin's remarks which are well-taken will not be subjected to such unwarranted misinterpretation.

Energy Requirements

While Durnin has cautioned against possible errors of underestimations of energy intakes of poor population groups, we must also be concerned about possible errors of underestimations of energy requirements of these same population groups. The new procedure whereby energy requirements are computed on the basis of estimates of energy expenditure, and the latter in turn are derived on the basis of the assumption of a constant fixed relationship between BMR and energy cost of activities (irrespective of the level of BMR) could result in underestimation of energy requirements for work of poor population groups (with lower average BMR levels).

This new formula could give the impression that for the performance of *identical tasks* (of *identical* nature, intensity, duration and final output), the energy cost in the case of populations with relatively low BMR (like, say, Indians) will be less than in the case of other populations (like, say, Europeans or Americans). If this were really the case, Indians would have reason to feel gratified over their special gift of superior work efficiency! Unfortunately this impression would appear to be not justified. It is quite understandable that the energy cost for basal metabolism, for locomotion and bodily movements would be less in subjects with lower body weights (and lower BMR); but according to all known principles of physics, the actual energy cost of a given piece of manual work, like, say, lifting a given heavy load or breaking a block of stone within a stipulated period (in which the body weight component would make only marginal differences), would call for nearly the same order of energy expenditure (if the factor of training is uniform).

A Canadian lumberman and his Indian counterpart engaged in cutting timber for a given duration, or a Norwegian fisherman and his Kerala counterpart engaged in deep sea fishing over a specified period of time (if they are all equally trained for their respective jobs) may perhaps incur energy cost which may roughly correspond to what the new formula suggests. In such a case, the actual energy cost incurred by the Indian workers would be significantly less than that of their foreign counterparts. What is important and must be clearly recognised is that if the energy expenditure is thus less, the actual output (productivity) from these operations will also be correspondingly less in the case of Indians.

The new formula which links energy cost of work to BMR is perhaps no more than a recognition of the reality that the general limit of intensity and output of work (strenuous or moderate and perhaps even sedentary) will be less in the case of populations with lower body weights and lower BMR, and would therefore call for a lower energy allowance for work for such populations. This also implies the tacit acceptance of the view that stunting and poor body build which results from childhood undernutrition leaves a lasting impairment of physical stamina and productivity. Small is *not* healthy.

With respect to adult populations already stunted and of poor body build, all that we can perhaps now hope to achieve is that their energy intakes are such as to permit maximal activity in their respective vocations. Because of their impaired stamina, the output from even this maximal activity, and therefore the energy requirement for it, may be expected to be less than in the case of adult populations who have been fortunate enough to escape the ravages of early childhood malnutrition. But this situation must not be accepted as inevitable for all time. Our objective must be to achieve for at least our next generations a level of nutrition and development which will permit the full expression of their genetic potential.

This implies that there can be no compromise now at least with respect to energy requirements of children and adolescents; there can be no double standards as between poor children and rich children at least in this regard.

The new procedure for computing energy requirement has been proposed by a team of workers, who are undoubtedly knowledgeable in this field and therefore certainly merits attention. Even so, the validity of the new formula, related as it is to a subject of far-reaching and basic importance to developing countries, would need verification under different field conditions.

Concluding Comments

Vast sections of poor populations around the world are, today, subsisting on diets which are poor and inadequate according to generally accepted standards. The levels of activity and the occupations in which these populations are currently engaged may be sufficient for their bare existence and survival in the present poverty situation. These populations may be in energy balance even with their present poor diets. The overall productivity, and quality of life, of these populations are, however, low. There is no reason to think that these populations are genetically incapable of better achievements. That these populations are now being subjected to dietary, socio-economic and environmental constraints which grossly limit their inherent capabilities cannot be denied. Our efforts must be directed to the removal of these oppressive constraints (including dietary constraints) so that these populations can stretch themselves to their full stature (literally and metaphorically), and find expression to their innate genetic potential. If we have failed to do this with the present generation, we must at least ensure that this will become possible for succeeding generations. Their diets and their nutritional status must be such as will enable them to do so.

It is one thing to identify the minimal energy requirements of poor, stunted populations, which would enable them to survive and function at their present low level of productivity and remain "culturally adapted" to their current status. It is quite a different thing to put a seal of scientific approval on such minimal "survival" levels of energy allowances and to project them as acceptable national norms for our populations.

NUTRITION NEWS

The Sasakawa Award

Dr. B.N. Tandon, Dean and Professor of Gastroenterology and Nutrition at the All India Institute of Medical Sciences, New Delhi, has been awarded the prestigious Sasakawa Award of WHO for the year 1990 for his valuable contribution towards one of India's (indeed one of the world's) largest child health/nutrition/development programmes, namely the ICDS. As Chairman of the Technical Coordination Committee connected with the ICDS, Dr. Tandon had played, for several years, a notable leadership role in bringing about active involvement of the country's medical academia in the implementation and monitoring of the ICDS programme. Such involvement has been, on the one hand, a valuable learning experience to the staff and students of the Departments of Preventive Medicine and Paediatrics of the participating medical colleges; on the other hand, it has also served to inject professionalism and scientific expertise into a major public health programme which could have otherwise remained a purely bureaucratic operation.

It is rarely, indeed, that outstanding clinicians evince keen and sustained interest in public health and preventive programmes and are willing to devote their time and energy for them. The Nutrition Foundation of India congratulates Dr. Tandon on the well-merited distinction that has been conferred on him.