HUMAN NUTRITIONAL REQUIREMENTS

R M K Ratnayake

T W Wikramanayake

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Dr R M K Ratnayake
B A (Hon) (Ceylon), M Sc (Wales).
Ph D (London)
Secretary, Ministry of Samurdhi, Youth Affairs & Sports

Prof. T W Wikramanayake
MBBS (Ceylon) Ph D (Glasgow)
Emeritus Professor of Biochemistry
University of Ceylon

Ministry of Samurdhi, Youth Affairs & Sports
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CONTENTS

LIST OF TABLES

APPENDICES

ACKNOWLEDGMENT

This book is an attempt to provide the basic knowledge needed to understand issues relating to food policy and food security. The new concepts introduced may be useful in estimating food requirements at national level.

Students studying Food and Nutrition issues may find the publication useful in outstanding the complex issues relating to the calculations of food needs in respect of different sexes and ages. Further, this will be useful for Policy-makers in determining the national food production needs and the food policy, in particular. The material has been presented in a simple form to facilitate easy reading and understanding.

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R M K Ratnayake
T W Wikramanayake

FOREWORD

Nutritional assessment is one of the best indicators of ascertaining the degree to which the social distributive policies of governments have produced the desired impact. This measure is indicative of the nature of economic development which has taken place and its implications, if any, on the social welfare of the population.

Although measuring nutritional status has been a subject of research interest for a long time among many nutritionists, the debate continues on the appropriateness of different measurements in diagnosing those actually `at risk' of malnutrition. Currently two proxy measurements are widely used in measuring nutritional status of populations. Firstly, as measured by the determination of a balance between energy intake and output. The definition of malnutrition based on dietary evidence is objectively determined and has been the subject of a long controversy. Secondly, anthropometric measurements, are used for assessing nutritional status particularly of young children. The anthropometric measurements are then compared with reference standards and set cut-off points. Both these methods however, are inadequate in identifying those who are at nutritionally at risk sufficiently.

As the record shows, Sri Lanka's investment on free education, free health care and subsidized food, which led to its high position in the global Physical Quality of Life Index (PQLI) in the 1970's, was founded also on democratic forms of government both at the central and local level, based on universal adult franchise. These were made in the context of a strong central direction of the economy.

By 1983 it had become clear that the key to reducing nutritional deficiencies lay in increasing domestic food production. With this end in view, the government formulated a National Food and Agricultural Strategy (NAFNS) which was published in 1984.

In undertaking the necessary analysis of the socio-economic determinants of the nutrition status of the population, particular attention was paid to the relationship of the malnourished population to the agricultural production system.

While undernutrition is largely related to the general availability of food in the markets, the purchasing power of the households, food distribution among family members as well as the living conditions of the people, in particular the level of environmental quality, also have significant impacts on nutrition.

In this publication, an attempt has been made to assets the energy requirements of Sri Lankan population. The vital information indicated in this publication could be a ready platform for planners and others working in the field of nutrition.

HUMAN NUTRITIONAL REQUIREMENTS

Availability of food suitable for human consumption in adequate quantities is a pre-requisite for maintaining national food security. Though the national food availability is a necessary but not a sufficient condition for the food security at household level, adequate availability might stabilize the market prices of food, which will be beneficial to the consumer. Household food security refers to the ability of the household to secure, either from its own production or through purchases, adequate food for meeting the dietary needs of its members. Food adequacy at national level is determined by the quantity of food produced locally and the amount food imported to satisfy the effective demand.

Although the food policy in an open market works at the inference of demand and supply, for the preparation of an indicative plan, effective demand for food may not be the only criterion determining the food adequacy of a country. In many countries, human nutritional requirements in relation to its population has been used in the preparation of indicative plans for food production, and for maintaining buffer stocks which would be useful in regulating the fluctuations of market prices. A food policy based on nutritional requirements may require promotion of certain food crops which may be beneficial for improving the nutritional status of the community although they may not have a high market value.

In this paper, an attempt has been made to develop a methodology based on currently available knowledge on human nutritional requirements to estimate the food adequacy for the Sri Lankan population. These adequacies may be useful for planning and in making decisions on matters relating to food policy.

It is assumed that energy adequacy is a necessary though not a sufficient condition for total nutritional adequacy. It has been observed that the regular diet of most of Sri Lankans provide sufficient protein, vitamins and minerals, so that a diet which fulfils the satiety of a person may also provide most nutritional needs. Such a diet will be able to meet the most important nutritional problem in the country namely, that of protein energy-malnutrition (PEM).

This paper is divided into two parts. The first discusses the current theoretical knowledge on the food adequacy norms in populations. In the second an attempt is made to construct a table of food requirements for the Sri Lankan population.

__Nutritional Requirements__

The current theory of energy requirements as proposed by FAO/ WHO/UNU (1985), is based on energy balance criteria, where the energy requirement is defined as; **`The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition and level of physical activity consistent with long term good health; and that will allow for the maintenance of economically necessary and socially desirable physical activity. In children and pregnant or lactating women, the energy requirement includes the energy needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health'.**

The new FAO/WHO/UNU (1985) dietary recommendations consider body size as the major determinant of the absolute requirements for energy. The basal metabolic rate (BMR) i.e. energy expended for the function of human organs when a person is in a state of complete rest, has been recommended as a basis for determination of energy needs of individuals. To predict the BMR of individuals a set of regression equations has been developed. As the technical difficulties of assessment of energy requirements in children under 10 years of age have not yet been resolved, the committee decided to continue with the methodology followed previously (in 1977) in assessing energy needs of children.

In developing equations to predict BMR, four different age categories (10-18, 18-30, 30-60 and > 60 years), have been used to accommodate the effect of age on the metabolic rate. The energy expenditure for each age group and sex were then calculated by multiplying BMR by appropriate factors described as **`activity indices'**. Three types of activities and an inactivity group were considered in the estimation of daily energy requirement of adults; (a) light work, (b) moderate work, (c) heavy work, (d) inactive with no productive work.

The base line for daily energy requirement or the energy cost of survival suggested by FAO/WHO/UNU is 1.27 times BMR. This level of energy need has been worked out by assuming that a person, on average, sleeps 8 hours a day during which energy cost equals the basal rate (1.0 x BMR) and is engaged in light activity for 16 hours, the energy cost of which is considered to be 1.4 x BMR. Assumptions have also been made on the proportion of time spent in different activities, e.g. light activity, 16 hr (2/3 x 1.4 BMR) and sleep 8 hr (1/3 x 1.0 BMR). Such a level of energy allows for minimal movements such as standing, washing, dressing, eating etc., and is therefore not compatible with long-term health and makes no allowance for energy needed to earn a living or prepare food. It is a requirement for only short periods or for **`crisis'** situations.

The energy needs for daily occupational activities are identified under three different categories of work intensity i.e. **light, moderate and high.** The average values suggested for light, moderate and high intensity activities for men were 1.7, 2.7, and 3.8 times BMR and for women 1.7, 2.2 and 2.8 times BMR. The total energy expenditure (TEE) for an individual for a day was estimated by (a) determining the proportion of time spent on each activity, (b) multiplication of the proportions by energy cost of each activity, and (c) addition of the energy costs of the different activities.

This new estimation procedure for determining energy requirements, like its predecessor suffers from many deficiencies (Rivers and Payne 1982), deficiencies that may apply to any methodology that attempts to analyse on a global scale situations with unknown amounts of variation.

The ability to estimate energy expenditure of individuals under free living conditions using the newly available method of doubly labelled water technique has furthered the understanding of human energy requirements. Prentice et al., (1985) measured energy expenditure of a group of free living women in Cambridge , U K., engaged in sedentary activities using the doubly labelled water technique. Their energy expenditure on average amounted to 1.34 times BMR and varied within a range of 1.2 to 1.4 times BMR. This is much closer to the currently suggested survival level of 1.27 times BMR.

These results have been confirmed, using a different measurement technique, in another study from Lausanne, Switzerland (Schutz and Jeqier 1986). The results suggest that the energy requirement for survival, determined by FAO/WHO/UNU (1985), may be an over-estimate.

The FAO/WHO/UNU (1985) energy requirement estimates rely heavily on the accurate estimation of basal metabolic rates of individuals using prediction equations, which have been developed using linear regressions. However, they apparently fail to estimate accurately the BMR of Indian subjects with smaller body weights (McNeill 1986).

In recent analysis of world wide data on BMR, Schofield and James (1985), and Schofield (1985) considered Indians as a separate group and found that they had lower basal rates per unit weight than North Americans or Europeans with similar body weights. Considering the small size of the Indian sample compared to the total observations, Schofield speculated that it may have arisen due to the data being non-representative or containing errors. The observed deviation of the BMR of Indians from prediction estimates were about 11.8% for men and 9.9% for women. However, different studies carried out on BMR of Indian subjects confirmed the existence of a common negative deviation from the values of western subjects in the order of 10 to 12 percent. McNeill (1986) studying BMR of South Indians also found, that the difference between measured and predicted BMR were around 12 percent.

McNeill et al. (1985) suggest that these discrepancies between actual and predicted BMR of Indian subjects may have arisen as a result of allometric, climatic or ethnic differences between population groups. The influence of ethnicity for the observed differences in BMR had been ruled out in the FAO/WHO/UNU (1985) report. However, some evidence suggests that observed differences in basic metabolic rates and energy expenditure between different groups when controlled for other factors, may be attributed to racial differences (Mason et al., 1964, Geissler et al., 1985, Henry and Rees 1988).

Implied in developing a new procedure to estimate level of energy requirement of individuals is the acceptance of the inaccuracy or shortfall of the methodologies adopted previously in estimating energy needs in man. However, a closer scrutiny suggests that the recommended energy needs of a reference man and woman engaged in moderate activity, were not much different whether the estimations are either carried out using earlier (FAO/WHO 1973), or current methodology (FAO/WHO/UNU 1985). Many similarities have been pointed out by Payne (1987).

The energy requirement of an individual as suggested in the FAO/WHO/UNU report (1985) was allowed to fall in response to changes in (a) BMR and/or (b) changes in activity patterns. Fluctuations in body weight may reduce/increase energy requirement in response to the proportional reduction/increase in the BMR. These changes will set in motion a process of adjustment of factors that determine energy expenditure, until a new balance is achieved. The process of moving from one energy balance state to another in response to variation in intake/expenditure is defined as `adaptation' (FAO/WHO/UNU 1985).

Next to be taken into account is the variability of requirement for individuals of a given age, sex, body weight and activity level. Requirement levels may be derived accommodating the one or the other of two reasons put forward to account for this variability. Thus, if the hypotheses of intra-individual variation and `costless' adaptation are accepted, the lower limit of the range of variation in the maintenance requirement is the appropriate level to use. As already reported, results of recent measurements of energy expenditure over 24 hours with a specified minimal-activity programme showed a coefficient of variation of about 7 percent in both male and female subjects of the same bodyweight (Garby, 1985). Assuming normal distribution and taking the usual 95 percent confidence interval as the range of intra-individual variation, the lower limit of the maintenance requirement corresponds to the average (i.e 1.4 BMR) minus twice the standard deviation. On this basis, the lower limit to account for variability under this hypothesis is 1.4 BMR - (2x0.7x1.4 BMR) = 1.2 BMR. If, on the other hand, the view is accepted that variability largely reflects fixed inter-individual genetic differences, 1.4 BMR would be the appropriate level to use.

Additional requirements for pregnancy were based on an allowance of 280 kcal/day for nine months recommended by the 1981 FAO\WHO\UNU Expert Consultation (WHO 1985). This figure, when applied to the distribution of pregnancies by month during a calendar year, results in an average allocation of 138 kcal\day on a calendar year basis. The total number of pregnant women, when estimated indirectly on the basis of the crude birth rates accepted by the United Nations National Population figure, will yield a reasonable estimate of pregnancies resulting in live births.

The total number of pregnancies may be calculated by adding to this figure an estimate of still- births, found in empirical studies to be of the order of 40 per thousand live births. Data are scarce concerning the proportion of lactating women, the duration of the lactating period, progressive and abrupt weaning, etc., and therefore no attempt has been made to estimate a lactation allowance. The requirements is however incorporated in the requirements for infants.

Deriving Energy Requirements of Adults

The 1981 WHO/FAO/UNU Consultation derived equations for computing BMR of males and females of different age groups. Their study incorporated 1100 measurements on individuals of both sexes of different ethnic groups in both developed and developing countries. It included adults of different heights and different weight for height. No ethnic differences in BMR were found other than those related to nutritional status and climatic conditions.

Table 1 indicates the BMR in adult men and women in relation to height and medium acceptable weight for height. Since BMR depends on both age and body weight, the adults have been divided into 4 age groups, 10-18, 18-30, 30-60 and 60 + above.

Within each age range, values of BMR have been obtained from minimum desirable body weight (W) by applying the following equations:

TABLE - 1

ESTIMATION OF BASAL METABOLIC RATE

AGE RANGE	MALE	FEMALE
	KCAL/DAY/CAPUT	
10-18	17.5 w + 651	12.2 w + 746
18-30	15.3 w + 679	14.7 w + 496
30-60	11.6 w + 879	8.7 w + 829
60+	13.5 w + 487	10.5 w + 596

The next component to be included is the energy required for digesting and metabolising a meal. It is difficult to measure the energy expenditure involved in this component in isolation from any activity, since the very act of eating involves some activity. Instead, what is measured is the total energy expenditure, which will include, in addition to dietary thermogenesis, the energy cost of minor movements and activities such as eating, dressing and washing and some allowance for muscle tone. The 1981 Consultation estimated that a figure corresponding to 1.4 x BMR for each age-sex groups would meet the requirements. A recent study in which 16 males and 11 females, who adhered to an activity schedule set out in Table 2 below, under laboratory conditions, has shown that the mean energy requirements level for both genders was 1.4 BMR, with a coefficient of variation of 7%.

To estimate the energy needs of active persons other factors have to considered. The requirement will vary with the type of occupation, the time spent in doing the task and the size of the individual concerned. Estimates of requirement per minute for various occupations are available and have been used by the WHO Consultation to arrive at factors expressed as multiples of the specific metabolic response to food.

Occupational activities, namely, those essential for the individual and community, have traditionally been classified into those which involve light, moderate and heavy physical activity. These have been listed by the WHO and the gross energy expenditure in these activities have been expressed in terms of the BMR multiplied by a metabolic constant.

TABLE - 2

TIME ALLOCATION IN A MINIMAL ACTIVITY PROGRAMME

ACTIVITY	TIME MIN/DAY
Sleeping	450
Resting, lying	95
Sitting awake	815
Washing, dressing	10
Walking and moving weights	5
Standing	10
Walking with intermittent	
Knee bending	55
	1440

For instance, if energy expenditure when sleeping is BMR x 1.0, energy needs of sitting at a desk is 1.3 BMR, of clearing ground for agriculture, 2.9 to 7.9 x BMR, depending on the type of land, of motor vehicle repairs 3.6 BMR and so on. On this basis one can estimate the gross energy expenditure on occupational work at light, moderate and heavy levels of activity as 1.7, 2.7 and 3.8 times BMR in young men, and 1.7, 2.2 and 2.8 times BMR in young women. Care is needed to ensure an accurate description of the activity and the time spent on it. The energy demands of specific jobs will vary enormously, depending on the degree of mechanization. The energy of traveling to work should also be considered. Essential tasks carried out by older children and women in agriculture, rearing livestock and looking after younger children are important contributions to the economy and viability of the household and should be included under occupational activities, when estimating household energy requirements.

Physical activity desirable for the well-being of the community and the health of individuals and populations, earlier referred to as `leisure-time' activities are more appropriately termed `discretional' activities. They may be divided into 3 categories: occupational household tasks such as repairing the home or gardening, specially desirable activities such as attending committee meetings, games festivals and walking to health centre or place of workshop, and activities for physical fitness or leisure time exercise. Some activities will be short-lived but require considerable rates of energy expenditure whereas other have only modest costs but are undertaken for longer periods.

Once the separate components of energy expenditure have been identified and evaluated the total requirement can be calculated.

The daily average energy requirements for men and women of different ages recommended by the WHO/FAO/UNU Committee are given in Tables A1 - A6.

The values of BMR/kg are presented to enable those who wish to use different BMR factors .

Adult groups in different parts of the world show substantial differences in height, and weight variations are common within countries and ethnic groups. height alone does not affect health, but body weight, when expressed in relation to height, does. Height has little effect on energy or protein requirements independently of its relation to weight, except in the very young and the elderly. A range of desirable or acceptable weights for heights, derived from actuarial analyses and prospective epidemiological studies in Western communities, have been used by the WHO (Table 11). The upper limit of the acceptable range, at which there is an increased risk to health, has been reasonably well defined. The same cannot be said for the lower limit. At present the average weight of adults in many countries is below the mid-point of that range, and sometimes even below the lower limit. There is no direct evidence that this in itself is beneficial or harmful.

In tables of energy requirements, age ranges (ex. 5 to 6 yr) are specified. The range 5-6 starts at 5 yr, up to but not including 6 yr. The age ranges 0-3, 3-10, 10-18, 18-30, 30-60 + reflect the physiological characteristics of men and women, including the continual changes in rate of growth, body composition, physical activity and pattern of food intake.

TABLE - 3

THE AVERAGE AND THE RANGE OF DESIRABLE WEIGHTS FOR HEIGHT IN ADULT (HEIGHT WITHOUT SHOES; WEIGHT WITHOUT CLOTHES)

HEIGHT (M)	DESIRABLE AVERAGE RANGE	DESIRABLE WEIGHT	OBESE	DESIRABLE AVERAGE RANGE	WEIGHT	OBESE
1.45	-	-	-	46.0	42-53	64
1.48	-	-	-	46.5	42-54	65
1.50	-	-	-	47.0	43-55	66
1.52	-	-	-	48.5	44-57	68
1.54	-	-	-	49.5	44-58	70
1.56	-	-		50.4	45-58	70
1.58	55.8	51-64	77	51.3	46-59	71
1.60	57.6	52-65	78	52.6	48-61	73
1.62	58.6	53-66	79	54.0	49-62	74
1.64	59.6	54-67	80	55.4	50-64	77
1.66	60.6	55-69	83	56.8	51-65	78
1.68	61.7	56-71	85	58.1	52-66	7980
1.70	63.5	58-73	88	60.0	53-67	83
1.72	65.0	59-74	89	61.3	55-69	84
1.74	66.5	60-75	90	62.6	56-70	86
1.76	68.0	62-77	92	64.0	58-72	89
1.78	69.4	64-79	95	65.3	59-74	
1.80	71.0	65-80	96			
1.82	72.6	66-82	98			
1.84	74.2	67-84	101			
1.86	75.8	69-86	03			
1.88	77.6	71-88	06			
1.90	79.3	73-90	108			
1.92	81.0	75-93	112			
BMI	22.0	20.1-25.0	30.0	20.8	18.7-23.8	28.6

Infants

In 1971 the WHO Committee based their recommendations for infants up to 6 months of age on figures then available for the energy intakes of infants fed breast milk by bottle. For older children they used figures for intakes of children in the USA and UK. The 1985 recommendations are based on a much larger collection of infants, children and adolescents compiled from studies in Canada, Sweden, UK and USA. Results from developing countries were excluded to ensure that the intakes represent those groups centile of the WHO reference standard.

The means of the measured intakes at each month for the first year, from over 4000 data points, were calculated. The intakes of breast-fed infants were measured by test-weighing. Recent measurements of breast milk consumption by the deuterium oxide method suggest that test-weighing under estimates actual consumption by about 5%. The calculated energy requirement in the table is therefore the predicted intake plus 5% (Table 4.10).

There is a fall in energy intake per kg body weight between 3 and 6 months which is maintained until 9 months, and the intake then rises again towards 12 months. The reduction represents a period when a very high growth rate characteristic of the first 3 months has declined but is not yet balanced by increased physical activity.

__Young Children__

From a critical review of the recent literature the WHO Consultation obtained the mean intakes of boys and girls from 1 to 10 years based on studies in developed countries and in the more affluent groups in developing countries. A comparison with the 1971 recommendations shows a fall in the estimated intake. This may be due to a decline in physical activity during recent times, reflecting increasingly sedentary life-styles in large this in older children. Such a reduction in activity is considered undesirable and it is recommended that intakes be increased by 5% to allow for a desirable level of physical activity necessary in the formative years of a growing child. The requirements in Table 4.10 therefore represent intakes plus 5%.

The calculation of energy requirements of young children should be made in two steps: first, the requirements per kg should be obtained, according to the age range; secondly, this value should be multiplied by the actual weight of the child, or by the median weight for age. If the actual weight is not known, the median weight at the actual age could be used, obtained from reference growth standards published for international use by the WHO (Table 4.11), derived from measurements of growth rate of children in industrialised countries.

Children in developing countries are smaller at birth than those in industrialised countries and grow at a slower rate. The evidence suggests that in young children these differences are due primarily to environmental factors, including inadequate nutrition, and that genetic and ethnic factors are of lesser importance, so that young children of different ethnic groups should be considered as having the same or similar growth potential.

It has been argued that the levels of food intake and growth rates of children in Europe and North America are not without disadvantages for health; among healthy populations there is a wide range of body size in children and there is no indication that differences in size, per se, are related to health, well-being or physiological function; in certain circumstances being small might be an advantage. However, where growth is limited by environmental factors, there is an association between functional impairment and deficit in linear growth.

On the other hand, it is argued that children should be permitted to attain their full genetic potential. The basic premise here is that there is an optimal or preferred state of health, fixed for each individual and determined by his or her genetic potential for growth, resistance to disease, longevity, etc. It is assumed that everyone could and should achieve his/her full genetic potential, and that any departure from this leads to malnutrition. Human genetic potential cannot be measured. Therefore, body size and food intake of 'well-fed' or healthy children may be assumed to be near this optimum.

Recent studies of energy expenditure using the doubly labelled water method indicate that the 1985 WHO/FAO/UNU recommendations for children under 3 years of age may be an over-estimate by at least 20%, even when differences between gross energy intake and metabolisable energy intake are taken into account.

TABLE - 4

DAILY AVERAGE ENERGY REQUIREMENTS OF INFANTS AND CHILDREN AGED 3 MONTHS TO 10 YEARS

			ENERGY REQUIREMENT		
AGE YR	MEDIAN WEIGHT KG	KJ/KG	KCAL/D/KG	MJ/D	KCAL/D
Months :					
3 - 6	7	418	100	2.3	700
6 - 9	8.5	397	95	3.4	810
9 - 12	9.5	418	100	4.0	950
Year :					
1 - 2	11	439	105	4.8	1150
2 - 3	13.5	418	100	5.7	1350
3- 5	16.5	397	95	6.5	1550
Boys :					
5 - 7	20.5	377	90	7.7	1850
7 - 10	27	326	78	8.8	2100
Girls :					
5 - 7	20.5	356	85	7.3	1750
7 - 10	27	280	67	7.5	1800

TABLE - 5

WEIGHT (IN KG) FOR AGE OF CHILDREN

AGE YR	BOYS			GIRLS		
	-2SD	MEDIAN	+2SD	-2SD	MEDIAN	+2SD
0	2.4	3.3	4.3	2.2	3.2	4.0
0.25	4.1	6.0	7.7	3.9	5.4	7.0
0.5	5.9	7.8	9.8	5.5	7.2	9.0
0.75	7.2	9.2	11.3	6.6	8.6	10.5
1.0	8.1	10.2	12.4	7.4	9.5	11.6
1.5	9.1	11.5	13.9	8.5	10.8	13.1
2.0	9.9	12.6	15.2	9.4	11.9	14.5
3	11.4	14.6	18.3	11.2	14.1	18.0
4	12.9	16.7	20.8	12.6	16.0	20.7
5	14.4	18.7	23.5	13.8	17.7	23.2
6	16.0	20.7	26.6	15.0	19.5	26.2
7	17.6	22.9	30.2	16.3	21.8	30.2
8	19.1	25.3	34.6	17.9	24.8	35.6
9	20.5	28.1	39.9	19.7	28.5	42.1
10	22.1	31.4	46.0	21.9	32.5	49.2

Adolescents

There is considerable variation between individuals and groups of adolescents in the timing of the adolescent growth spurt. Further, if children have been growing slowly from infancy, by 10 years the gap between actual weight and expected weight based on that of adolescent in industrialised countries, will be very large. Whether extra food at this stage can increase the extent and duration of the pubertal growth spurt is not known.

Because of the variable timing of the adolescent growth spurt, it is recommended that estimates of requirements should be based on weight rather than age, provided the weight is within the acceptable range of weight for height. Table 4.12, showing the median weight for age and height is derived from data of Baldwin as reproduced by Jelliffee (1966). The range variation in weight at a given age is much greater than the range of variations at a given height, reflecting the variable timing of the pubertal growth spurt. The requirements in Table 4.13 are based on the WHO Consultant's estimate of desirable levels of physical activity which is so important for the development of children and adolescents.

TABLE - 6

MEDIAN WEIGHT (IN KG) FOR AGE AND HEIGHT OF ADOLESCENT

	AGE IN YEARS								
Height cm	10	11	12	13	14	15	16	17	18
Boys									
120									
125	24.2								
130	26.8	27.0							
135	29.3	29.4	29.6						
140	32.2	32.2	32.4	32.4					
145	34.9	35.7	35.4	35.8	36.3				
150	38.1	38.5	39.0	39.1	39.3	39.2			
155	41.5	42.1	42.7	43.4	43.5	44.8			
160	46.2	46.7	47.4	48.0	49.8	51.5	53.9		
165	50.9	51.4	52.3	53.1	55.1	57.1			
170	55.6	56.5	58.1	59.1	60.5				
175	59.7	60.4	61.9	63.5	64.7				
180	65.1	65.7	66.1	67.1					
185	69.5	70.3	71.3						
Girls	120	22.3							
125	24.6	24.7							
130	27.1	27.9	27.3						
135	30.1	30.1	30.7	31.5					
140	32.9	33.1	33.2	34.1	34.8				
145	36.6	36.4	36.6	37.2	39.3	41.4			
150	38.8	40.2	39.9	41.1	43.0	44.6	45.9	46.4	
155	44.0	44.8	45.0	47.0	48.1	50.2	50.4	51.4	
160	48.9	49.2	49.8	51.5	51.9	52.8	53.1		
165			52.4	53.1	54.0	54.2	54.8	55.4	55.9
170				56.8	57.6	58.0	58.9	58.9	60.1
175					60.0	60.8	61.2	61.2	62.9
180					63.1	60.2	63.0	63.0	64.4

In calculating energy expenditure it has been assumed that the energy cost of sleep is equal to the BMR. Estimates of the additional energy costs of other activities, over and above the BMR, have been assessed as follows in terms of BMR units.

TABLE - 7

ENERGY EXPENDITURE FOR SELECTED ACTIITIES

	BOYS	GIRLS
Going to school plus		
Light activity	1.6 BMR	1.5 BMR
Moderate activity	2.5 BMR	2.2 BMR
High activity	6.0 BMR	6.0 BMR

The new estimates of energy requirements (Table 4.13) are based on calculated energy expenditure. They are appreciably and consistently lower than those proposed by the WHO Committee in 1971. They are higher than the observed values of energy intake. The difference in the calculated and the observed levels for boys between 10 and

18 years corresponds exactly with the amount of energy thought desirable for children to spend in high activity (1/2 hour of 6.0 x BMR). Fulfillment of requirements as proposed is likely to be beneficial if physical activity is increased.

TABLE - 8

DAILY AVERAGE ENERGY REQUIREMENT OF ADOLESCENT AGES 10-18 YR

AGE YR	MEDIAN WEIGHT	MEDIAN HEIGHT	BMR KG-1		BMR FACTOR	DAILY ENERGY REQUIREMENT	
	KG	CM	KJ	KCAL		MJ	KCAL
Boys:							
10-12	34.5	144	152.7	36.5	1.75	9.2	2200
12-24	44	157	135.9	32.5	1.68	10.0	2400
14-16	55.5	168	123.4	29.5	1.64	11.1	2650
16-18	64	176	115	27.5	1.60	11.9	2850
Girls:							
10-12	36	145	138	33	1.64	8.2	1950
12-14	46.5	157	119.2	28.5	1.59	8.8	2100
14-16	52	161	110.8	26.5	1.55	9.0	2150
16-18	54	163	106.6	25.5	1.53	9.0	2150

Pregnancy and Lactation

During pregnancy extra energy is needed for the growth of the foetus, placenta and associated maternal tissues. BMR rises due to increased mass of active tissue (foetal, placental and maternal), the cost of increased maternal effort, for example, cardio-vascular and respiratory work, and the cost of tissue synthesis. The non-vasal energy expenditure may be lowered.

In well-nourished populations the weight gain during pregnancy is about 12.5 kg and the median infant birth weight is 3.3 Kg with a coefficient of variation of 15%. The average extra energy cost of such a pregnancy has been calculated to be about 335 MJ (80000 kcal) over the 9 month period. The WHO Committee (1971) distributed this energy cost as an extra 630 KJ (150 kcal) during the first trimester, recommendations being based primarily on estimates of energy contained within the new tissues gained during pregnancy.

Because some fat should be deposited early in pregnancy, and because appetite and periodic work requirements vary greatly, the WHO Consultation (1985) could find no justification for stating that the requirement for extra energy differs between the three trimesters. Accordingly, the recommended average addition is 1200 KJ (285 kcal) daily throughout pregnancy. Where healthy well-nourished women are able to reduce physical activity it is considered reasonable to reduce the average allowance to 840 kJ (200 kcal) daily.

There will be significant variations from these recommended intakes. Women of small stature will be in the lower range of normal weight-gains and give birth to small babies and hence will need less additional energy than the average. Those who are underweight for their height should gain more weight than the average and therefore need more dietary energy, while those who are obese need to gain less fat than slimmer women. The amount of physical activity also varies. Many women in the rural and estate sectors in developing countries must of necessity continue to labour in the field throughout the pregnancy. Such women, as well as teenagers who begin pregnancy with marginal nutritional reserves, must be provided with the full energy allowance.

The energy cost of **lactation** is the energy content of the milk secreted plus the energy needed to produce it. The allowances recommended by the WHO in 1971 were based on the assumption that about 800 ml is secreted daily, with an energy content of 3 kJ (0.72 kcal) per ml, with an 80% efficiency of conversion of dietary energy to milk energy. The average milk production was assumed to demand 3.1 kJ (750 kcal) per day. Since then the results of a WHO sponsored collaborative study of breast-milk volume and composition, carried out in Guatemala, Hungary, Philippines, Sweden and Zaire, have shown the need for revising these figures. The volume of milk ingested by infants increased between the second and third months and remained stable until 6 months. In developing countries milk consumption falls between 6 and 12 months and was reduced even further in the second year. Very few data are available from developed countries after 6 month of age. In all five populations studied, breast-milk consumption in the first few months was lower for infants whose birth-weights had been low.

Table 9 indicates the median breast-milk secretion by Swedish mothers during the first 6 months. The median milk volume is close to the mean volume. The limited data from all 5 populations for the period 6 to 12 months is also included. The average energy content of breast-milk was found to be 2.9 kJ (0.70 kcal) per ml. The consumption data have been increased by 6% to compensate for an observed under-estimation of milk secreted versus milk consumed.

TABLE - 9

MEDIAN BREAST-MILK SECRETION AND ENERGY COST OF LACTATION

MONTH	MEDIAN VOLUME	ENERGY CONTENT OF MILK		ENERGY COST OF LACTATION	
	ML/D	KJ/D	KCAL/D	KJ/D	KCAL/D
0-1	719	2105	503	2630	629
1-2	795	2326	556	2908	695
2-3	848	2485	594	3105	742
3-6	822	2405	575	3008	719
6-12	600	1757	420	2197	525
12-24	550	1610	385	2012	481

If maternal tissues have been depleted during pregnancy, every effort should be made to ensure that the additional food intake during lactation provides at least the energy computed in Table 9.

If maternal reserves have not been depleted, the additional supplement should not be higher than these values. There is no evidence yet for the suggestion that BMR is altered during lactation as occurs during pregnancy.

If the recommendations for pregnancy have been met and the woman has adequate fat reserves at the beginning of lactation, she will start with about 150 MJ (36000 kcal) in reserve. She will attain a normal, pre-pregnant body composition within 6 months by utilizing this reserve, which will therefore provide 835 KJ (200 kcal) each day. Then the additional dietary energy needed during the first 6 months of lactation would be about 2090 KJ (500 kcal) per day. These intakes will have to be adjusted according to maternal fat stores and the pattern of physical activity. After 6 months the full allowance of about 2090 KJ (500 kcal) should be provided.

These requirements will need to be increased if more than one child is being breast-fed.

Cut-off Points and Minimum Requirements

For estimating the maintenance requirement for an entire population, it is necessary to decide on a minimum requirement and determine a cut-off point for assessing the incidence of undernutrition. In the fifth world food survey (1985), the requirements for children up to age 10, which allow for normal physical activity were calculated on the basis of minimum desirable body weights. These were then combined with 2 alternative estimates of maintenance requirements of adults and adolescent, namely 1.2 BMR and 1.4 BMR being calculated also on the basis of minimum desirable body weights.

The actual cut-off points for a few selected countries used in the fifth world food survey are given in Table 10.

TABLE - 10

MINIMUM ENERGY REQUIREMENTS FOR DIFFERENT COUNTRIES

COUNTRY	1,2 BMR		1.4 BMR	
	MJ/DAY	KCAL/DAY	MJ/DAY	KCAL/DAY
Bangladesh	5.86	1401	6.50	1553
Brazil	6.35	1518	7.06	1683
Egypt	6.47	1546	7.18	1716
India	6.05	1447	6.73	1608
Indonesia	5.87	1402	6.51	1557
Sri Lanka	6.06	1448	6.76	1615
Sudan	6.24	1491	6.90	1648
Thailand	5.81	1388	6.44	1539
Tunisia	6.17	1475	6.85	1636

Estimation of Calorie Requirement of Sri Lankan Population

Although there are no recently published data, on basal metabolism of Sri Lankan population since classic study of Cullumbine (1950), the available information on Indian particularly that of South Indian subjects (Shetty, Soars and Sheela 1986) provide a better guidance to estimate the BMR of Sri Lankan population. The available data on BMR of South Indian populations, both of `old' (Mason and

Benedict 1931), and `new' (Shetty, Soars and Sheela 1986, Sears and Shetty 1987), suggests that the basal metabolic rates estimated by Cullumbine for Sri Lankan adult populations appeared to be in line with South Indian data.

In the study on basal metabolism, Cullumbine considered among other things, body weight, age and sex as major contributory factors in determining the BMR of an individual. By taking this approach developed a set of equations to predict the basal metabolic rates of the populace. The equations developed by Cullumbine in his study are shown in Table 11.

Following the equations shown in Table 11, the absolute values of basal metabolic rates of both males and females of different age and sexes are shown in Table 11.

TABLE - 11

RELATIONSHIP BETWEEN BASAL METABOLIC RATE AND BODY WEIGHT OF GROUPS OF MALES AND FEMALES

SEX	AGE (1)	$C=a,W^b$(2)	r (3)
MALE	10	$C = 3.199\ W^{0.780}$	0.99
	14	$C = 2.844\ W^{0.780}$	0.99
	18	$C = 2.234\ W^{0.234}$	0.98
	21-25	$C = 2.323\ W^{0.776}$	0.97
FEMALE	10	$C = 3.062\ W^{0.786}$	0.99
	14	$C = 2.240\ W^{0.820}$	0.91
	18	$C = 2.265\ W^{0.769}$	0.94
	21-25	$C = 2.274\ W^{0.791}$	0.98

Notes:

1. Age in years
2. C = expressed in kcal/hr, (a) constant, (W) weight expressed in kg.,(b)power function.
3. Correlation coefficient between log w and log c

These measurements (see Table-12) however are confined only to selected categories of ages and therefore cannot be used to predict metabolic rates of all sections of the population. The prediction equations suggested for the South Asian subjects may be substituted.

TABLE - 12

AVERAGE BASAL METABOLIC RATES FOR SRI LANKAN SUBJECTS OF VARIOUS AGES AND SEXES

AGE IN YEARS	SEX	AVERAGE WEIGHT	AVERAGE BMR	
		(KG)	KCAL/HR.	KCAL/DAY
10	M	24.0	38.2	916.0
	F	23.3	36.5	876.0
14	M	33.7	44.2	1060.8
	F	36.6	42.9	1029.6
18	M	47.3	48.5	1164.0
	F	40.3	38.9	933.6
21-25	M	49.6	48.1	1178.4
	F	43.8	42.3	1015.2

The Medical Research Institute (MRI) the average daily energy requirement of a male depending on age would be about 2500 kcal and for a woman would be around 2300 kcals. An average figure of 2,200 kcals has been commonly used as the average requisites for a family (Food & Nutrition Statistics 1982).

TABLE - 13

BEST ESTIMATES OF HEIGHT, WEIGHT AND BODY MASS INDEX (BMI) FOR SRI LANKAN POPULATION (weight in Kg and height in cm)

AGE	MALE			FEMALE				
	WEIGHT	HEIGHT	BMI	WEIGHT	HEIGHT	BMI	WT	HT
0+	6.6	N.A	N.A	6.2	N.A	N.A		
1+	9.3	N.A	N.A	8.6	N.A	N.A		
2+	10.9	80.2	16.9	10.5	78.9	16.8		
3+	12.4	87.3	16.2	12.1	86.3	16.2		
4+	13.9	93.3	15.9	13.4	93.0	15.4		
5+	15.5	100.6	15.4	14.6	99.0	14.8	14.7	105.4
6+	17.1	113.2	15.3	15.9	104.6	14.5	17.0	112.5
7+	18.7	118.2	15.2	17.4	109.9	14.4	17.9	115.7
8+	20.2	123.3	15.2	19.2	114.5	14.6	19.0	120.1
9+	22.5	126.4	14.9	21.3	119.6	16.9	21.9	126.4
10+	23.7	130.9	15.4	23.8	123.2	15.6	24.8	131.2
11+	26.8	134.2	15.7	26.7	128.7	16.1	28.7	137.7
12+	28.9	139.5	16.4	30.1	133.0	17.0	30.6	140.1
13+	29.7	140.7	17.5	33.5	138.9	17.3	33.5	145.6
14+	36.6	150.1	19.1	36.8	142.8	18.0	38.1	149.8
15+	39.2	163.3	20.5	39.7	146.3	18.5	40.4	161.9
16+	43.5	163.7	20.6	41.6	148.1	18.9	42.9	153.4
17+	50.7	165.0	21.1	42.7	149.4	19.1	44.9	155.7
18+	52.3	165.0	20.9	42.9	150.5	18.9	45.0	156.0
Adults		164.0*			152.5*			

Source:

Ratnayake R M K (1989) Household Food Security Health and Nutrition in a mmunity in Southern Sri Lanka 1989, unpublished Ph D Thesis, London School of Hygiene and Tropical Medicine, University of London.

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TABLE - 14

AN ESTIMATION OF DESIRABLE ENERGY ALLOWANCES FOR SRI LANKA

Age (Years)	Population ('000) (a)	Average Weight (Kg) (b)	BMR (c)	PAL (d)	Energy allowance (kcal/kg) (e)	Average Individual need (Kcal) (f)	Total Calorie 6-10 (G)
M A L E S							
0	176,000	6.6			109	719	126.6
1	175,000	9.3			108	1004	175.8
2	173,000	10.9			104	1134	196.1
3	171,000	12.4			99	1228	209.9
4	169,000	13.9			95	1321	223.2
5	168,000	15.5			92	1426	239.6
6	168,000	17.1			88	1505	252.8
7	170,000	18.7			83	1552	263.9
8	175,000	20.2			77	1555	272.2
9	181,000	22.5			72	1570	284.1
10	188,000	23.7	1099	1.76		1934	363.1
11	194,000	26.8	1194	1.72		2054	398.4
12	197,000	28.9	1281	1.69		2165	426.5
13	196,000	29.7	1433	1.69		2422	474.7
14	193,000	36.6	1451	1.65		2394	462.1
15	189,00	39.2	1523	1.62		2467	466.3
16	185,000	43.5	1628	1.60		2605	481.9
17	181,000	50.7	1652	1.60		2643	478.4
18-29	1,908,000	55.0	1586	1.76		2791	5,325.9
30-59	3,051,000	59.0	1554	1.76		2735	8,344.6
> 60	753,000	57.0	1178	1.51		1779	1,339.4
	8,961,000					**2,322**	**20,805.9**

a) Population for 1993 - Dr A P T L Abeykoon, unpublished estimates.
b) Mohd. Ismail Noor - (1993)
c) ibid
d) ibid
e) Below 9 years e x 6, and above 9 years d x 6.

TABLE - 15

AN ESTIMATION OF DESIRABLE ENERGY ALLOWANCES FOR SRI LANKA

Age (Years)	Population ('000)	Average Weight (Kg)	BMR	PAL	Energy allowance (kcal/kg)	Average Individual need (Kcal/kg)	Total Calorie, 10⁴
	(a)	(b)	(c)	(d)	(e)	(f)	(G)
FEMALES							
0	169,000	6.2			109	676	114.2
1	170,000	8.6			113	972	165.2
2	170,000	10.5			102	1,071	182.1
3	169,000	12.1			95	1,150	194.3
4	167,000	13.4			92	1,233	205.9
5	167,000	14.6			88	1,285	214.6
6	167,000	15.9			83	1,320	220.4
7	169,000	17.4			76	1,322	223.5
8	173,000	19.2			69	1,325	229.2
9	179,000	21.3			62	1,321	236.4
10	185,000	23.8	1061	1.65		1,751	323.9
11	191,000	26.7	1153	1.62		1,868	356.8
12	193,000	30.1	1180	1.60		1,888	364.4
13	192,000	33.5	1256	1.58		1,984	381.0
14	188,000	36.8	1284	1.57		2,016	379.0
15	183,000	39.7	1300	1.54		2,002	366.4
16	178,000	41.6	1307	1.52		1,987	353.6
17	173,000	42.7	1365	1.52		2,075	358.9
18-29	1,816,000	52.0	1202	1.64		1,971	3,579.8
30-59	3,030,000	52.0	1288	1.64		2,112	6,400.3
> 60	730,000	52.0	1116	1.56		1,741	1,270.9
	8,759,000					1,840	16,120.7

Note: Allowances for breast-milk production and cost of are not includes for the

The energy requirements as estimated in Tables 14 and 15 shows that the average for males are 2322 kcals while for females 1840 kcals with an overall average of 2081 kcals for entire population.

The new evidence and the methodology suggested by FAO/WHO/UNU (1985) shows that the requirements of the Sri Lankan population is less than what the MRI has suggested. As we don't have adequate published data on Basal Metabolism in this country, we depend much on the other Asian data for our estimates. As many South Asian living conditions represents more similarities in human, until we develop our own measurement, the South Asian data may be considered appropriate in determining the population requirements of energy for the Sri Lankan community.

As shown by Cullumbine (1950) and the fifth World Food Survey (1985) the basically requirements of the Sri Lankan population is low. However, this has some nutritional and other healthy related cost though not easy to correct over a shorter period of time.

These changes have to come from the improvement general well being of the population which is mostly relating to the economic development of the country and the spillover of benefits to the more vulnerable segment of households in the society.

The evidence shown in the fifth world food survey suggest that the measurement used to identify malnutrition in adults in Sri Lanka should be 1615 Kcal which is 1.4 times the estimated Basic Metabolic Rate.

As shown in Tables 14 and 15, the estimated population for 1993 was 17,720,000, (Abeykoon 1993) and the estimated total calories requirements of the population, has been $36,925 \times 10^6$

As discussed earlier this however is a higher estimate compared to the fifth world food survey through the average per-capita requirement is about 2091 Kcal compared to the previous recommended value of 2200 kcal per person a day. Further knowledge on actual body weights and activity requirements is required for any improvement in this estimation.

As shown in food balance sheets and the socio-economic survey data, a sizeable proportion of energy for life is obtained through consumption of a few major commodities such as rice, wheat flour (and bread and other wheat flour preparations, other grains such as kurakkan, maize and sugar, coconut, coconut oil, pulses beef, milk, fish and vegetables.

The observed values of nutrient requirements thus may be converted to various food groups taking into account the dietary energy availability from each of these food items.

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APPENDICES

TABLE - A1

DAILY AVERAGE ENERGY REQUIREMENT FOR MEN AGED 18-30 YEARS

DAILY REQUIREMENT						
WEIGHT KG	BMR/KG		1.4 BMR		1.6 BMR	
	KJ	Kcal	MJ	Kcal	MJ	Kcal
50	121.3	29.0	8.6	2050	9.6	2300
55	115.1	27.0	8.8	2100	10.0	2400
60	110.8	26.5	9.4	2250	10.7	2550
65	108.7	26.0	9.8	2350	11.3	2700
70	104.6	25.0	10.3	2450	11.7	2800
75	102.5	24.5	10.7	2550	12.1	2900
80	100.4	24.0	11.1	2650	12.8	3050

TABLE - A2

DAILY AVERAGE ENERGY REQUIREMENT
FOR MEN AGED 30-60 YEARS

DAILY REQUIREMENT						
WEIGHT KG	BMR/KG		1.4 BMR		1.6 BMR	
	KJ	Kcal	MJ	Kcal	MJ	Kcal
50	121.3	29.0	8.6	2050	9.8	2350
55	115.1	27.5	8.8	2100	10.3	2450
60	108.1	26.0	9.2	2200	10.5	2500
65	104.6	25.0	9.6	2300	10.9	2600
70	100.4	24.0	9.8	2350	11.3	2700
75	98.3	23.5	10.3	2450	11.7	2800
80	94.1	22.5	10.7	2550	12.1	2900

TABLE - A3

DAILY AVERAGE ENERGY REQUIREMENT
FOR MEN OVER THE AGE OF 60 YEARS

DAILY REQUIREMENT						
WEIGHT KG	BMR/KG		1.4 BMR		1.6 BMR	
	KJ	Kcal	MJ	Kcal	MJ	Kcal
50	96.2	23.0	6.9	1650	7.7	1850
55	94.1	22.5	7.1	1700	8.2	1950
60	90.0	21.5	7.5	1800	8.8	2100
65	87.9	21.0	7.9	1900	9.2	2200
70	85.8	20.5	8.4	2000	9.6	2300
75	83.7	20.0	8.8	2100	10.0	2400
80	81.6	19.5	9.2	2200	10.5	2500

TABLE - A4

DAILY AVERAGE ENERGY REQUIREMENT FOR WOMEN AGES 18-30 YEARS

DAILY REQUIREMENT						
WEIGHT KG	BMR/KG		1.4 BMR		1.6 BMR	
	KJ	Kcal	MJ	Kcal	MJ	Kcal
40	113.0	27.0	6.3	1500	7.1	1700
45	106.6	25.5	6.7	1600	7.7	1850
50	102.5	24.5	7.1	1700	8.2	1950
55	98.3	23.5	7.7	1850	8.8	2100
60	96.2	23.0	8.2	1950	9.2	2200
65	94.1	22.5	8.5	2050	9.6	2300
70	92.0	22.0	9.0	2150	10.3	2450
75	90.0	21.5	9.4	2250	10.7	2550

TABLE - A5

DAILY AVERAGE ENERGY REQUIREMENT
FOR WOMEN AGED 30-60 YEARS

DAILY REQUIREMENT						
WEIGHT KG	BMR/KG		1.4 BMR		1.6 BMR	
	KJ	Kcal	MJ	Kcal	MJ	Kcal
40	123.4	29.5	6.9	1650	7.9	1900
45	115.1	27.5	7.1	1700	8.2	1950
50	106.7	25.5	7.5	1800	8.6	2050
55	100.4	24.0	7.7	1850	8.8	2100
60	94.1	22.5	7.9	1900	9.2	2200
65	90.0	21.5	8.2	1950	9.4	2250
70	85.8	20.5	8.6	2050	9.6	2300
75	83.7	20.0	8.82	2100	10.0	2400

TABLE - A6

DAILY AVERAGE ENERGY REQUIREMENT OF WOMEN OVER THE AGE OF 60 YEARS

DAILY REQUIREMENT						
WEIGHT KG	BMR/KG		1.4 BMR		1.6 BMR	
	KJ	Kcal	MJ	Kcal	MJ	Kcal
40	100.9	22.5	5.9	1400	6.9	1650
45	98.3	23.5	6.3	1500	7.1	1700
50	94.1	22.5	6.5	1550	7.9	1800
55	90.0	21.5	6.9	1650	7.9	1900
60	85.8	20.5	7.1	1700	8.2	1950
65	81.6	19.5	7.5	1800	8.6	2050
70	79.5	19.0	7.7	1850	9.0	2150
75	77.4	18.5	8.2	1950	9.2	2200

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