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On Certain Statistical Issues Arising from the Use of Energy Requirements in Estimating the Prevalence of Energy Inadequacy (Undernutrition)

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SUMMARY

The energy requirement norms adopted at the international level are periodically reviewed by expert groups and consultations. The paper discusses some aspects on a recent report by FAO/WHO/UNU Expert Consultation. The expectation of the dependent relationship between intake and requirement implies that the range of variation of requirement should be regarded as a range where an observed intake is likely to be in balance with requirement. Sukhatme's cut-off point formula for the estimation of prevalence of energy inadequacy in a population has been derived and discussed. The approach taken in the Sixth World Food Survey in defining the range of variation of energy requirement has been presented.

Keywords: Energy requirements, Undernutrition, Protein requirement, Intra-individual variation, Covariance between intake and requirement, Risk free intakes, Inter-individual variation.

1. Introduction

Prescribing human energy requirements is problematic. However, if the most influential factors such as age, sex, body-weight and activity are taken into account, a reasonably accurate average for that group can be specified. Being an average, the implied variation needs to be taken into account in using the requirement for determining whether an intake is adequate or not. In view of this, the estimation of the proportion of individuals having inadequate energy intake in a population has been formulated within a probability framework. In this context, Sukhatme, in a pioneering study on the application of distributional analysis in estimating the extent of hunger and undernutrition in the world (Sukhatme [12]), had indicated that, if information in the form of a bivariate frequency distribution of intake X, and requirement Y, was available

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the proportion of individuals having inadequate intake could be formulated as follows:

$$P(U) = P(X < Y) = \iint_{x<y} f(x, y)\,dx\,dy \quad (1)$$

However, as the appropriate information, (i.e. data on the joint distribution of intake and requirement of individuals) are lacking he had derived an approach based on the frequency distributions of intake and requirement. In this connection he had argued that, as the distribution of requirement reflect the distribution of intake in a hypothetical population composed of healthy and well nourished individuals, the proportion of individuals having intakes that are below the lower limit of the distribution of requirement (i.e. the lowest or minimum requirement level) should be taken as an estimate of the prevalence of energy inadequacy in the population. Accordingly, the formula for estimating the proportion of individuals with inadequate intake reduces to:

$$P(U) = P(X < y_l) = \int_{x<y_l} f_X(x)\,dx = F_X(y_l) \quad (2)$$

where $f_X(x)$ is the frequency distribution of intake and y_l is the minimum requirement. This formulation has been referred to as the "cut-off point approach" as it boils down to the use of the minimum requirement as a cut-off point on the distribution of intake. Sukhatme had initially taken the minimum requirement (i.e. cut-off point) as corresponding to the lower limit of the 99% confidence interval of the normal distribution, i.e.:

$$y_l \cong \mu_Y - 3\sigma_Y \quad (3)$$

where μ_Y represents the mean and σ_Y the standard deviation of the requirement distribution. In subsequent studies he has, however, indicated that $\mu_Y - 2\sigma_Y$ may be more appropriate.

However, the statistical logic underlying the derivation of the cut-off point approach and its relationship with bivariate formula proved to be elusive or not sufficiently convincing to other analysts who had subsequently attempted to apply the probability approach. Of particular concern was the fact that the approach appeared to ignore the risk of inadequacy among individuals whose intakes are within the range of variation of requirement. As a result these analysts have either used the average requirement (rather than the minimum requirement) in applying the cut-off point approach (e.g. Dandekar [3]; and Reutlinger and Selowsky [10]) or have attempted to apply to bivariate approach (1) on the basis of estimates or assumptions pertaining to the parameters of the marginal distributions of intake and requirement and the co-efficient of correlation between intake and requirement (e.g. Reutlinger and Alderman [11] and Kakwani [9]). These attempts resulted in estimates of the prevalence of energy inadequacy that were invariably much higher than that what would be expected from Sukhatme's cut-off point approach.

Meanwhile, Sukhatme, following up on his earlier studies, had argued that the variation in requirement should be treated as being mainly of an intra-individual nature and therefore only those with intakes below the minimum requirement should be considered as being at risk of inadequacy (Sukhatme [13]). This interpretation, while clarifying the derivation of his formula, has been the subject of considerable debate and controversy in the nutrition literature. The debate and controversy has however focused largely on the biological rather than the statistical principles underlying his argument. As a consequence the relevance of the formula that he conceived for estimating the prevalence of energy inadequacy has not been given due attention. This article attempts to shed light on this issue and subsequently discusses the link with the approach taken in The Sixth World Food Survey (FAO [5]).

2. *Energy Requirement and its Variation: Basic Concepts and Definitions*

The human body requires dietary energy intake for its expenditure of energy which in turn is composed of several components: a) the basal metabolic rate (BMR), i.e. the energy expanded for the functioning of the organism when the individual is in a state of complete rest; b) the energy needed for digesting food, metabolizing food and storing an increased food intake; and c) energy required for performing physical activities, both work and non-work. For children the energy required for growth should be taken into account. Similarly, for women during pregnancy and lactation, the energy required for the deposition of tissue and secretion of milk need to be considered.

The energy requirement norms or standards adopted at the international level are periodically reviewed by expert groups and consultations. The most recent review was that undertaken by an FAO/WHO/UNU Expert Consultation on Energy and Protein requirements that met in 1981. The report of this consultation (FAO/WHO/UNU [6]) has defined energy requirement as follows :

> "The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when an 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".

An individual is considered to be in a state of energy balance (or a steady state) if his or her energy intake equals his or her energy expenditure (requirement). The state of energy balance is however a relative one as no one is ever absolutely in such a state. Nevertheless it is believed that day-to-day intake are regulated through processes that operate to maintain balance between intake and expenditure over a number of days (in the long-term) rather than every day (FAO/WHO/UNU [6]). In view of this, average energy requirements have been traditionally based on the mean habitual intakes (daily intake averaged over a number of days) of healthy individuals of specified age, sex, body-weight and activity (reference group). The assumption is that, because of their good health, their intakes can be taken as being equal to the requirements of individuals belonging to the same age/sex/body weight activity group. Even when the requirement calculations are based on the expenditure approach and defined as the sum of the estimated costs of various components of energy expenditure i.e. basal metabolism, physical activity, etc., as recommended for adults and adolescents by the FAO/WHO/UNU Expert Consultation, the estimated requirement can and have been validated by comparison with the mean intake of individuals in the corresponding reference groups (Beaton and Tarasuk [1]).

However, considerable variation has been noted in the habitual intakes of healthy individuals in a given reference group. As any random component in the day-to-day variation (i.e. arising from measurement errors) is expected to have disappeared through the process of averaging the observed daily intakes of each individual over a number of days to reflect the habitual concept, the implied variation in requirement has been traditionally considered to be of an inter-individual nature. The biological explanation given for this variation is that individuals differ with respect to their (metabolic) efficiency of energy utilization (i.e. some individuals use energy more efficiently than others). As normally individuals would tend to consume according to their respective efficiency of energy utilization, the variation in requirement is expected to explain at least part of the variation in the habitual intakes of individuals in a population. Hence a dependent relationship (correlation) is expected between intake and requirement.

On the other hand Sukhatme has attempted to conceptualize the variation in requirement through a sophisticated analysis of the daily energy intake and expenditure data referring to a number of healthy army recruits reported by Edholm *et al* [4]. On the basis of the analysis he has argued that most of the variation in requirement actually arise "from intra-individual variation which is stochastic in character, thereby meaning that requirement is dynamic and self regulated and not static as assumed in nutrition literature...". Thus an individual with an intake falling within the range of requirement needs to be regarded as being in balance with requirement in a "probabilistic" sense (Sukhatme [13]).

3. Probability Assessment of Intakes Under the Assumption that the Variation in Energy Requirement is of an Inter-individual Nature

The concept of intra-individual variation in requirement invoked by Sukhatme to justify his cut-off point formula for the estimation of the prevalence of undernutrition has been viewed with considerable scepticism in the nutrition literature largely because it implies that an individual has the capacity to vary his or her efficiency of energy utilization (in response to intake) within a considerable range without incurring any risk in terms of health or activity performance (James, Waterlow and Healy [7]). This phenomenon of intra-individual variation is recognized but the extent to which it can occur is considered to be small (James and Schofield [8]). Furthermore as the intake to be assessed generally refer (or is assumed to refer to) to averages over a number of days (the habitual concept), the relevance of the inference based on the day-to-day variation has not been quite understood. As a consequence the view that the variation in requirement is largely of an inter-individual nature tends to prevail.

Under the assumption that intake refers to the habitual concept, the bivariate formulation given by (1) would appear to be appropriate for taking into account the inter-individual variation in requirement and the expected correlation between energy intake and requirement. However, if the joint distribution $f(x, y)$, is assumed to be bivariate normal and the two marginal distributions have the same mean and variance, this formulation classifies 50% as undernourished even when the co-efficient of correlation is increased from zero to a value as high as 0.93 (Beaton and Tarasuk [1]). This apparent insensitivity to the effect of a correlation between intake and requirement seems to have led Beaton, who has been a strong advocate of the application of the probability approach in the assessment of nutrient inadequacy, to take the view that "there is at present no satisfactory way of estimating the prevalence of inadequate energy intakes" (Beaton [2]). His interpretation of the problem is as quoted below:

> "A critical assumption of the simple probability assessment is that intakes and requirements are not correlated when examined within

strata of the population (e.g. young children) and when factors potentially affecting both are controlled (e.g. when thiamine is examined as mg per kcal rather than mg per day). In the case of energy, there is strong reason to believe that over moderate time periods, energy intake and energy expenditure ("requirement") are strongly correlated as part of a regulated energy balance. This violates the core assumption of the probability approach" (Beaton [2]).

The fact of the matter is that the attempts made to evaluate the bivariate formulation have failed to take into account the following: firstly, requirement is a given rather than observed variable (since in the present context requirement is normatively specified) and therefore the effect of correlation should be considered in the conditional framework where intake (X) is assumed to depend on requirement (Y); and secondly the range of variation of intake is likely to be wider than that of requirement.

If the above are taken into account, the "probabilistic" argument underlying Sukhatme's cut-off formula can be made even in the context of inter-individual variation. The key to this argument lies in the fact that a fundamental principle underlying the conditional distribution of X on Y is that the event X = Y exists with probability 1 when X is in the range of Y. In other words the dependent relationship implies that the probability for intakes falling within the range of requirement to be in balance with requirement is high.

In order to illustrate the above argument it is necessary to consider that, as the range of variation of intake is likely to be wider than that of requirement, the limits of the intake distribution are likely to extend beyond the limits of the requirement distribution (as portrayed in Figure 1). It is thus obvious that, for intakes below the lower limit of the requirement distribution, the probability

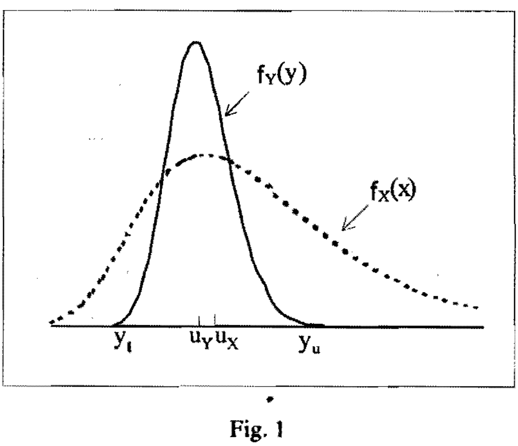

Fig. 1

of inadequacy, i.e. $P(X < Y)$ is 1 and for intakes above the upper limit, it is zero. As a consequence, it is only when determining the probability of inadequacy for the intakes falling within the requirement limits of y_l and y_u that the issue of dependence of intake on requirement or correlation arises.

If intake is expected to be independent of requirement (i.e. no correlation) it is clear that, the event $X = Y$ does not exist and therefore the two events $X < Y$ and $X > Y$ are equally likely. This means that for the intakes falling within the range of requirements,

$$P(X < Y) = P(X > Y) = 0.5 \tag{4}$$

On the other hand if a dependent relationship is expected, the implied covariance needs to be taken into account. As the dependent relationship is in terms of X and Y, the expectations E(XY) and E(X), involved in the determination of the covariance, will be taken over the distribution of requirement, $f_Y(y)$. This means that:

$$\mathrm{Cov}(X, Y) = \sigma_{XY} = E(XY) - E(X)E(Y) = E(Y^2) - (E(Y))^2 = \sigma_Y^2 \tag{5}$$

In other words the range of variation of requirement becomes the range of covariation between intake of requirement[1]. Expression (5) implies that for the intakes falling within the range of requirements :

$$E(X) = E(Y) = \mu_Y \tag{6}$$

and

$$\sigma_X^2 = E(X^2) - (E(X))^2 = E(Y)^2 - (E(Y))^2 = \sigma_Y^2 \tag{7}$$

so that

$$\mathrm{Var}(X - Y) = \sigma_Y^2 + \sigma_Y^2 - 2\sigma_Y^2 = 0 \tag{8}$$

The above implies that $P(X = Y) = 1$ (and hence $P(X < Y) = P(X > Y) = 0$) for intakes falling within the range of variation of requirement (Cauchy-Schwartz inequality).

Thus it follows that the expectation of the dependent relationship (correlation) between intake and requirement implies that the range of variation

1 It may be noted that, as the covariance is expected to be equal to σ_Y^2, the co-efficient of correlation in the population is given by $\rho = \sigma_Y^2/\sigma_X\sigma_Y = \sigma_Y/\sigma_X$, where σ_X is the standard.derivation of intake in the whole population. In other words, the greater is σ_X as compared to σ_Y, the smaller is the co-efficient of correlation.

of requirement should be regarded as a range where an observed intake is likely to be in balance with requirement. This has in fact been recognised by the FAO/WHO/UNU Expert Consultation in making the following statement:

> "Most people have the ability to select their food intake in accordance to their requirement over the long term, since it is believed that regulatory mechanisms operate to maintain balance between energy intake and energy requirement over long periods of time. This implies that one would expect there to be a correlation between energy intake and energy requirement among individuals if sufficient food is available in the absence of interfering factor..... If self-selection is allowed to operate, it is to be expected that individuals will make selections according to the energy need and the probability of inadequacy or excess will be low across the whole range (of requirement)... If the average intake of a class, were equal to the average requirement of the class almost all individuals would be at low risk because of processes regulating energy balance and the resultant correlation between intake and requirement" (FAO/WHO/UNU [6]).

The above statement, which was made in the context of explaining the condition underlying the use of average energy requirement as the descriptor of the requirement level for a group, is very pertinent to the present discussion also from another point of view. By regarding the risk of inadequacy or excess for intakes falling within the range of requirement as being low rather than zero, it provides a more realistic interpretation of the mathematical condition underlying the concepts of statistical dependence and linear correlation. The latter in essence imply that if an individual's habitual intake is within the range of requirement, it is likely to be meeting his or her own requirement. However, it is also likely that due to food constraints, the individual may have had to adjust his or her energy expenditure (requirement) from an originally higher level within the range to achieve energy balance at a lowered intake. This type of intra-individual adjustment of expenditure within the range in response to energy availability or intake, is not considered to be free of any risk to health or physical activity performance (see Section V). Nevertheless, as the lowered intake is still within the requirement range, the risk may be considered to be *sufficiently* low to be acceptable. In view of this it may be more appropriate to consider the range of requirement as a range of "acceptable" rather than "risk-free" intakes; the argument being that it represents a range within which the intakes of healthy and active individuals eating according to their needs will be located. This seems to be the argument that Sukhatme originally used to justify the cut-off point approach (Sukhatme [12]).

4. Derivation of Sukhatme's Cut-off Point Formula for the Estimation of the Prevalence of Energy Inadequacy in a Population

It follows from the above discussion that the probability or risk of inadequacy, i.e. $P(X < Y)$, does not decrease monotonically with intake, but is discretely assigned to intakes depending on whether they are below, within, or above the requirement range. Thus the prevalence of food inadequacy in the population, P(U), can be formulated as the average of the three assigned probabilities of inadequacy with the probability of a randomly selected individual's intake falling in the respective intake ranges as weight. Accordingly, if $P(X < Y)$ is represented by $P(u_1)$ for the intakes below y_1, by $P(u_2)$ for intakes from y_l to y_u and by $P(u_3)$ for intakes above y_u, the prevalence of energy inadequacy in the population can be written as

$$P(U) = P(u_1) \int_{x<y_l} f_X(x)\,dx + P(u_2) \int_{y_l}^{y_u} f_X(x)\,dx + P(u_3) \int_{x>y_u} f_X(x)\,d(x) \quad (9)$$

If a correlation is expected between X and Y then, as indicated earlier,

$$P(u_1) = 1 \text{ and}$$

$$P(u_2) = P(u_3) = 0$$

so that

$$P(U) = \int_{x<y_l} f_X(x)\,dx = F_X(y_l) \quad (10)$$

This formulation is graphically portrayed in Figure 2.

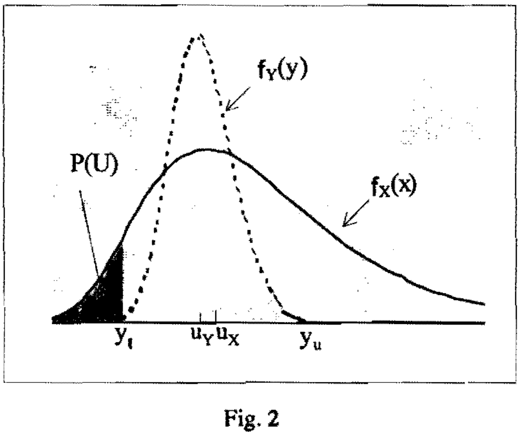

Fig. 2

On the other hand if no correlation is expected then, as stated earlier,

$$P(u_1) = 1$$
$$P(u_2) = 0.5 \quad \text{and}$$
$$P(u_3) = 0$$

so that

$$P(U) = \int_{x < y_l} f_X(x)\,dx + 0.5 \int_{y_l}^{y_u} f_X(x)\,dx \tag{11}$$

Now let us consider the second term on the right hand side of (11) which indicates that 50% of the individuals with intakes falling within the range of requirement are undernourished. The distribution of intake within this group can be assumed to be the same as that of requirement. Therefore if the requirement distribution is assumed to be symmetric around μ_Y, it follows that the second term can be written as $\int_{y_l}^{\mu_Y} f_X(x)\,dx$ so that (11) can be written as

$$P(U) = \int_{x < y_l} f_X(x)\,dx + \int_{y_l}^{\mu_Y} f_X(x)\,dx \tag{12}$$

$$= \int_{x < \mu_Y} f_X(x)\,dx = F_X(\mu_Y)$$

This formulation is shown graphically in Figure 3.

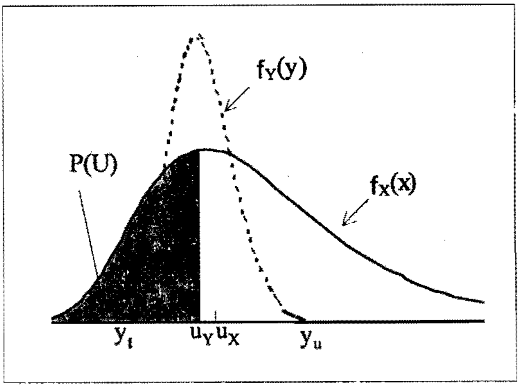

Fig. 3

The above indicate that the cut-off point approach is relevant even when intake is assumed to be independent of requirement but with the average rather than the minimum requirement taken as the cut-off point. Thus, if following Sukhatme, the lower limit of the requirement distribution is expressed as $\mu_Y - 2\sigma_Y$, but with σ_Y referring to the square root of the covariance, σ_{XY}, the cut-off point formula can be generalized by expressing it as

$$y_c = \mu_Y - 2\sqrt{\sigma_{XY}} \qquad (13)$$

In this way it becomes clear that the reduction of the cut-off point to the minimum requirement level represents the effect of dependence of X on Y.

As noted in the FAO/WHO/UNU Expert Consultation's statement quoted earlier, the average requirement, μ_Y represents the average intake norm for a population on the assumption that all the individuals are consuming energy according to their needs as represented by the range of requirements. As such it represents the average intake level that the group classified as having inadequate intakes (i.e the individuals with intakes below the cut-off point) should reach in order that, assuming a distribution in proportion to needs, all the individuals in the group could meet their needs. Thus, given the average intake of the undernourished, the average requirement enables the calculation of the energy deficit (food gap). By relating this deficit to the available energy supply as reflected by the observed average intake of the population, the relative inadequacy of the available energy supply can be calculated. Thus if $\bar{x}$ is the average energy intake of the population, P(u) is the proportion of the population inadequate intakes and $\bar{x}_u$ is the average intake of the undernourished, the relative inadequacy of the available energy supply would be given as

$$R = P(U)(\mu_Y - \bar{x}_u)/\bar{x} \qquad (14)$$

5. A Pragmatic Definition of the Range of Variation of Energy Requirements: The Approach Taken in The Sixth World Food Survey

FAO's latest estimates of the prevalence of energy adequacy and the relative inadequacy of energy supply in the developing world have been presented in The Sixth World Food Survey (FAO [5]). The methodology for estimating the prevalence of energy inadequacy, as in the case of the Third, Fourth and Fifth World Food Surveys, is based on Sukhatme's cut-off point approach i.e. using an estimate of the minimum energy requirement as the cut-off point on the distribution of intake. The intake distribution in the Sixth World Food Survey is derived on the basis of estimates of the mean and the coefficient of variation which is a measure of the inequality in distribution.

The mean is represented by the per caput dietary energy supply figure estimated through the food balance sheet approach. This means that the unit of analysis in this exercise is not an individual of a given sex-age group or a household but the "average individual" in a population that is implicit in the usual expression of national aggregate income or consumption data on a "per caput" basis or "per capita". In view of this, the minimum requirement (needed for estimating the prevalence of energy adequacy) and the average requirement (needed for calculating the food deficit) also have to refer to the "average individual" concept. In order to arrive at these averages, estimates of the minimum and average energy requirements have to be made for each of the relevant sex-age groups and then aggregated using the relative shares of the population in the different sex-age groups as weights. The procedures used in this connection have been described in detail in Appendix 3 of The Sixth World Food Survey but here the principles underlying the definition of the range of variation in requirement, in so far as they are related to the subject under discussion, are highlighted.

The variation in requirement has so far been discussed under the assumption that factors such as body-weight and activity (in addition to age and sex) have been taken into account. However, it may be recalled that the FAO/WHO/UNU Expert Consultation has defined requirement as the level of intake "that will balance energy expenditure when the individual has a body-size and composition and level of physical activity consistent with good health and that will allow for the maintenance of economically necessary and socially desirable activity". This definition implies that energy requirement should be derived on the basis of normatively specified body-weight and physical activity level rather than the actual body-weight and activity level of the individual.

However, the Expert Consultation has recognized that given height, there is a range of body-weights that are consistent with good health. Similarly there is a range of physical activity levels (PAL) that may be considered to be consistent with performance of economically necessary and socially desirable activity. In view of this the variation in requirement has been defined in terms of the range of energy expenditure resulting from the application of the different combinations of acceptable body-weight-for-height and physical activity level. The lower limit of this range may be taken as the energy expenditure based on the lowest acceptable body-weight and the lowest acceptable activity allowance and the upper limit on the basis of the highest acceptable body-weight and the highest acceptable activity allowance. The average requirement could in turn be derived on the basis of some intermediate body-weight and activity allowance within the respective acceptable ranges.

The different energy expenditure levels within the above defined range represent the acceptable variation in the intake level at which energy balance can be achieved. The only biological explanation for considering this variation as "acceptable" is that it reflects the expected inter-individual variation in the efficiency of energy utilization (Payne, Philip; personal communication).

The above procedure of defining the range of variation of requirement for individuals in a given sex-age group was however not applied with respect to children below age ten as the FAO/WHO/UNU Expert Consultation report did not contain any recommendation for children concerning the range within which weight or height for a given sex-age group may be regarded as satisfactory. In view of this the minimum requirement has been set close to but below the average requirement. In other words the variation was assumed to be small.

As a matter of fact the portrayal of the variation in requirement in terms of the acceptable variations in body-weight and activity reflects the risk or cost as one moves from one intake level to another within the requirement range. For example, in any particular situation, the way in which an individual adjusts or respond to progressive decreases in intake will follow a strategic sequence of different types (weight loss, lowered activity, etc.). At each point in the sequence of responses, choices will be made which have implications for the relative costs or risks of sacrificing different types of expenditure. These costs may be of two kinds: (i) loss of physiological health, productivity, etc.; (ii) incurring social costs, loss of cultural participation, loss of status, ability to meet obligations, etc. With respect to increase in intake from a steady state of risk is mainly associated with the effect of obesity.

If, as before, the minimum requirement or acceptable energy intake is denoted by y_l and the maximum as y_u, the risk in terms of health and function as one moves from one intake level to another can be illustrated with the help of Figure 4.

Thus, as the availability of energy is progressively reduced, so also is the freedom of choice of strategy. As the lower point y_l is approached, the risk of social costs begins to increase to an unacceptable level and the scope for avoiding these social costs by making further physiological adjustments decreases. As the point y_l is passed, the risk that any further reduction will

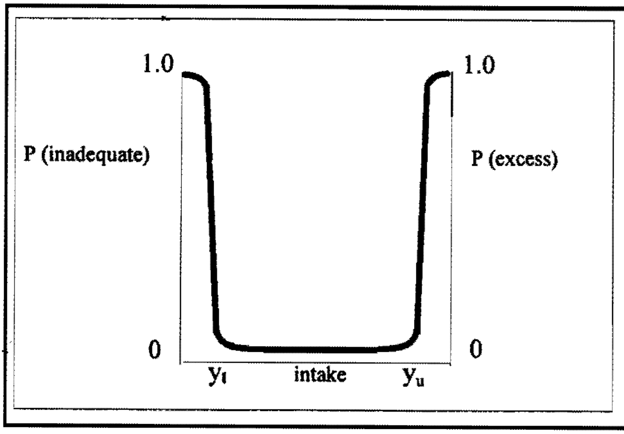

Fig. 4

result in loss of physical health and activity, begins to increase sharply. The same is true for increases in intake beyond y_u.

The intakes between y_l and y_u are however considered to be subject to low or acceptable risk of either inadequacy or excess as they represent a range within which the intakes of healthy and active individuals are expected to be located when they have an unconstrained access to food. Therefore, individuals whose access to food or to choice of economically or socially desirable levels of physical activity is subject to constraints, can adjust so as to accommodate to these constraints down to the level represented by y_l. At levels below y_l the combined risks to physical health and activity are considered to be unacceptable. Conversely, for individuals subject to increased intake, the risk to health and function is considered to be unacceptably high at levels above y_u. It therefore follows that an individual's intake can be considered to be inadequate only if his or her intake is below y_l. Conversely his or her intake can be considered to be excessive only if it is above y_u.

6. *Concluding Remarks*

Sukhatme's basic argument that an energy intake falling within the range of variation of requirement need to be taken as being in balance with requirement in the probability sense remains valid even if one does not agree with his concept of intra-individual variation. However, in the context of inter-individual variation, this does not imply that movements from one intake level to another within the range carries no risk in terms of health or activity performance. In view of this it is more appropriate to consider the range of variation in requirement as a range of acceptable intakes.

The above implies that the lower limit of the range is the appropriate cut-off point for assessing the prevalence of energy inadequacy. This means that for the purpose of practical evaluation it is important to define in operational terms the range of variation of requirement for individuals in different sex-age groups. A big step forward in this direction has been made by the FAO/WHO/UNU expert consultation on energy and protein requirement by introducing the concepts of range of acceptable body-weight for height and range of acceptable physical activity levels (PAL). However, these need to be better defined and operationalized, particularly with respect to children, in order to improve the rather approximative approach taken in The Sixth World Food Survey in arriving at the cut-off point.

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