

# Reviews Analyses

## Use and interpretation of anthropometric indicators of nutritional status\*

WHO WORKING GROUP<sup>1</sup>

*Studies carried out during the last decade have led to a better understanding of the value of anthropometric indicators of nutritional status. The present report concentrates on data concerning 0-5-year-old children and examines the indices of weight and height and the biological significance of "wasting" and "stunting". The need for a reference population as well as for a standard or target is recognized and the advantages and disadvantages of local versus international reference populations are discussed. In the analysis of data, preference is given to the use of standard deviation (SD) scores and to the presentation of whole distributions. Cut-offs, for example -2SD, are needed for comparison of prevalences and for screening of populations. Sequential or serial measurements and the increasing use of growth velocities are discussed and their uses and difficulties are outlined.*

### INTRODUCTION

It is widely accepted that for practical purposes anthropometry is the most useful tool for assessing the nutritional status of children. Admittedly almost any illness will impair a child's growth, but in practice in developing countries growth deficits are caused by two preventable factors, inadequate food and infections. In general, infections influence body size and growth through their effects on metabolism and nutrition. The classical use of anthropometry as the most readily available method of assessing nutritional status is therefore logical although other methods, such as biochemical and immunological tests, are being increasingly used in clinical practice.

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<sup>1</sup> The members of the Working Group are listed on p. 939.

However, a deficit in growth is not necessarily the most sensitive indicator of inadequate nutrition; for example, a marginally inadequate energy intake may cause a reduction in physical activity before there is any impairment of growth (1). It is also recognized that the extent to which genetic factors, both within and between populations, may affect growth cannot be ignored. With these caveats, we may continue to accept the central role of anthropometry in nutritional assessment, particularly of children in groups or communities.

At first sight the assessment of nutritional status by anthropometry may seem to be a simple matter, in which the main constraints are practical, such as the availability of equipment and personnel and, in many cases, the difficulty of reaching the sample to be covered. However, anthropometric data are collected in order to be used, and experience shows that, in addition to the problems of data collection, there are important considerations in the presentation, analysis and interpretation of the data.

In a 1977 report on this subject (2), the following proposals were made:

(1) Anthropometric measurements should be reported in relation to international reference values. For this purpose it was recommended that the reference population defined by the US National Center for Health Statistics (NCHS) should be used (3), a recommendation subsequently endorsed by WHO (4).

(2) The basic data are age, sex, weight and height. In most circumstances separate indices should be constructed of weight-for-height and height-for-age, in addition to or in place of the classical index, weight-for-age.

(3) For statistical reasons, measurements of a study population should be related to the reference population by standard deviation scores (Z-scores) rather than as a percentage of the median of the reference, which had been the general practice up to that time.

(4) All anthropometric data on children should be presented for separate age groups; recommendations were made about appropriate age ranges.

Most workers seem to have accepted these proposals in principle, if not always in practice, and there does not seem to be any need to modify them. However, experience since 1977 in making use of the results of anthropometric surveys has revealed a number of problems which were not considered in the earlier report (2). Anthropometric assessment is useful in many different contexts, ranging from national planning to the identification of individuals at risk. Depending on the purpose there will be differences in the measurements that are most useful, in the indices and indicators that are most appropriate, and in the method for presenting the findings. There will also be differences in the practical constraints on data collection and analysis. Some examples of the choices that may be appropriate in particular situations are discussed below in more detail (see pp. 936-937).

The object of this paper is to discuss some principles based on the experience gained in the last few years. Just as the 1977 report (2) laid the groundwork for the WHO manual *Measuring change in nutritional status* (4), so it is hoped that this present paper will form the basis of another text for practical use. As before, we have considered only the three basic measurements—age, weight and height—in assessing the nutritional status of children. No attempt is made here to discuss the usefulness of other measurements, such as skinfold thickness, mid-arm circumference (AC) or head circumference (HC). As has often been pointed out, skinfold thickness gives information about body composition which is additional to that given by weight. On the other hand, AC and HC measurements are generally

regarded as proxies for weight and height. Their usefulness in particular situations is largely determined by practical considerations. It is also outside the scope of this paper to examine in detail the use of anthropometric measurements to assess the nutritional status of subjects other than children. However, some problems in the assessment of adolescents, adults and pregnant women are identified below (see pp. 937-939) for further study.

#### TERMINOLOGY

Frequent utilization of the terms *measurements*, *indices* and *indicators* in this text makes it useful to be able to distinguish between them:

—The basic *measurements* to be considered are age, weight and height.

—*Indices* are combinations of measurements. Thus, it is evident that a value for weight alone has no meaning unless it is related to age or height. Indices have two functions: they are necessary for the interpretation of measurements and for grouping them. They may take different forms; for example, the relationship of weight to height may be expressed arithmetically, e.g., by the Body Mass Index (BMI) of Quetelet ( $Wt/Ht^2$ ), or by relating the weight to that of a reference subject of the same height.

—The term *indicator* relates to the use or application of indices and the indicator is often constructed from them. Thus the proportion of children below a certain level of weight-for-age is widely used as an indicator of community status. Sometimes an index and an indicator may be the same. For example, the infant mortality rate is an index (ratio of deaths to births), but it is also used as an indicator of the state of public health.

An index may be thought of as a biological concept; one can usefully discuss the different biological meanings of indices such as weight-for-height and height-for-age (see below, p. 932). An indicator would represent a social concept; one can discuss its value, e.g., its sensitivity and specificity, for a particular application. These distinctions, although apparently academic, may sometimes avoid confusion. Other terms will be defined, as needed, throughout the text.

#### BIOLOGICAL SIGNIFICANCE OF INDICES OF WEIGHT AND HEIGHT

When it began to be recognized that it may be important to distinguish between deficits in weight-for-height and in height-for-age (2, 11-13), it was necessary to find names to describe these two deficits

and the processes which cause them. The words "wasting" and "stunting" were proposed, as they are purely descriptive of what is observed (12).

Other words which could fulfil the same function and which are more readily translated are thinness (for wasting) and shortness (for stunting). Terms such as "acute" malnutrition (for wasting), "chronic" malnutrition (for stunting) and "acute-on-chronic" for the combination of wasting plus stunting, are not direct observations but deductions which may not always be correct. In particular, the word "chronic" is unsatisfactory, because it is sometimes used to mean "long continuing", at other times to mean "a residue of the past". (It may be noted that strictly speaking in the English language, "wasting" and "stunting" represent processes, while "wasted" and "stunted" represent end-results, determined according to the criteria defined below.)

*Wasting* indicates a deficit in tissue and fat mass compared with the amount expected in a child of the same height or length, and may result either from failure to gain weight or from actual weight loss. It may be precipitated by infection or some other household crisis and usually occurs in situations where the family food supply is limited and the food intake of children is low. The determinants will differ in different environments. Very often there are seasonal episodes of wasting, related to variations either in food supply or in disease prevalence. One of the main characteristics of wasting is that it can develop very rapidly, and under favourable conditions can be restored rapidly (14).

*Stunting* signifies slowing in skeletal growth. The growth rate may be reduced from birth, but a significant degree of stunting, representing the accumulated consequences of retarded growth, may not be evident for some years. Stunting is frequently found to be associated with poor overall economic conditions, especially mild to moderate, chronic or repeated infections, as well as inadequate nutrient intake.

There are several obvious biological differences between wasting and stunting. In the first place, one can fail to gain height but one cannot lose it. Secondly, linear growth is a slower process than growth in body mass. A child should treble its weight in the first year, but only double its height; in consequence, a significant degree of stunting takes longer to be established. Thirdly, although catch-up in height undoubtedly can occur, as shown by the effects of treatment in severely stunted children with coeliac disease (15), it takes a relatively long time even with a favourable environment.

Wasting and stunting are frequently combined; nevertheless, analysis of a number of representative population groups shows no statistically significant

association (16). The two deficits show different patterns at different ages and in different populations (17). The prevalence of wasting is greatest between 12 and 24 months of age, when dietary deficiencies are common and diarrhoeal diseases more frequent, and tends to decrease later on. By contrast, the prevalence of stunting increases over time up to the age of 24 or 36 months and then shows a tendency to level off.

It follows from these age-related differences in prevalence that, as pointed out earlier, for the proper interpretation of surveys on children, the results should be analysed separately according to age. Useful age ranges were provided in the 1977 report (2). Since, as pointed out above, wasting may be established and restored quite rapidly, the prevalence of wasting at one point of time may be a reasonable indicator of the incidence of the process that is causing weight deficit. However, this is certainly not the case for stunting. Thus, it is totally incorrect to suppose that because the prevalence of stunting in a population of children is greater at 4 years than at 2 years, more 4-year-old children are "malnourished". The prevalence is greater simply because the process of retardation has been going on for a longer time (18).

There are not only age-related differences in the prevalence of wasting and stunting, but also differences in geographical distribution. In some groups there is a relatively high prevalence of wasting with a relatively low prevalence of stunting, whereas in other areas the opposite is found (17, 19). For these comparisons prevalences were derived from the proportion of children below the conventional cut-off points of  $-2SD$ , or 80% of the reference median weight-for-height and 90% of the reference median height-for-age. Studies of this kind show, for example, marked differences between Asia and Latin America, wasting being much commoner in Asian populations.

It seems clear, therefore, on biological, epidemiological and statistical grounds, that wasting and stunting represent different processes of malnutrition. More information is needed on the determinants of the two processes and the relative effectiveness of given interventions for their prevention and treatment. Particularly important questions deal with the functional implications of stunting and its eventual reversibility. A detailed examination of stunted growth by velocity data may provide a better understanding of the process.

Experience will show how far the distinction between wasting and stunting is of practical importance. For the evaluation of nutritional and health interventions it is clearly essential, because of differences in the responsiveness of the two indicators. For long-range planning, the distinction may not be so important (20).

It has been shown that weight-for-height and height-for-age together account for more than 95% of the variance in weight-for-age (16). This means that weight-for-age represents the sum of the information given by the other two indices. For this very reason it may remain an appropriate index only for certain applications (see below, pp. 936-937).

#### USE OF THE NCHS POPULATION AS A STANDARD

Discussion has continued in recent years on whether or not it is necessary and appropriate to utilize an international reference (5-7). In analysing this question, it is important to distinguish between a *reference* and a *standard*.

A *reference* is a device for grouping and analysing data. Thus the average weight of a group of children has no meaning unless they happen to be exactly the same age, whereas the average value of the index "weight-for-age" does have meaning. For the construction of such an index a reference population is necessary. In principle, it does not matter what set of reference data is used, provided that it is large enough to contain adequate statistical information and the population is reasonably healthy and well-nourished to avoid major distortions. It is also clearly desirable, for comparative purposes, that there should be a common reference. These principles underlay the recommendation, which was made in 1977 (2) and subsequently endorsed by WHO (8), to adopt the NCHS population as a reference for international use.

A *standard* embodies the concept of a norm or target—that is, a value judgement. It is this concept that has led to difficulty, since the international reference is widely used also as a standard. The justification for this usage is the evidence collected by Habicht and others (5, 7) that in populations the effect of ethnic differences on the growth of young children is small compared with the effects of the environment. It is accepted that there may be some ethnic differences between groups, just as there are genetic differences between individuals, but for practical purposes they are not considered large enough to invalidate the general use of the NCHS population both as reference and as a standard. This judgement has been endorsed in the report of a recent FAO/WHO/UNU Expert Consultation (9).

There are, however, circumstances in which this usage is felt to be inappropriate and in which local standards are preferred. As a matter of principle, those who are concerned with planning in a particular country may find it unacceptable to base their targets on the characteristics of an alien population. In

countries where growth failure in children is widespread and severe, such targets would be unrealistic and unattainable and therefore serve as a hindrance to practical planning.

A realistic target or local "norm" could be set by shifting the international reference downwards. This approach is acceptable if it means simply altering the target, so that, for example, the stated aim would be for the mean height of children to be within 95% rather than 100% of the international reference. It is not acceptable if it means that in the calculation of height-for-age the expected height is taken as 95% of the reference median rather than 100%. When that is done, it is not possible to use the centiles and standard deviations of the reference population, so that the statistical value of the reference is lost.

It is necessary to distinguish between two types of local standards: that derived from an elite, presumably well-nourished group and that which represents the average of the population. A disadvantage of the former is that often an elite group may not be ethnically representative of the population as a whole. Where elite standards have been established in some cases (e.g., Colombia, Mexico, Brazil), they differ little from the NCHS reference. Local standards which represent an average of the population rather than an elite are only useful for identifying groups or individuals who differ from the rest of the population and who may therefore constitute priority targets for intervention. However, many developing countries are experiencing secular trends of increasing weight and height (10), making it necessary to update local population-average references after several years. The development of statistically valid national reference values is costly and often beset with logistic problems, particularly in a very large country such as India. There appear to be no major advantages to offset these drawbacks, and therefore the establishment of local or national reference values is not an urgent priority.

#### ANALYSIS AND PRESENTATION OF DATA

There are two approaches to the analysis and presentation of data. The first describes the whole distribution; the second provides an estimate of the number or proportion outside the reference distribution. The approaches are complementary and the purpose will determine which is preferred, as discussed in more detail below (pp. 936-937). This type of choice exists in many fields of public health nutrition, and is succinctly described as the choice between shifting the distribution and truncating it.

Whichever approach is to be used, there is then, as discussed in the 1977 report (2), a choice of three ways in which each observed measurement can be

related to the reference: by its position within the centile distribution of the reference; as a standard deviation score (Z-score); or as a percentage of the reference median.

*Descriptions of the whole distribution*

Fig. 1 is an example of how the distribution of the total population may be represented in centiles. The figure is drawn from an actual study and illustrates how a change in the distribution, as the result of an intervention, can be visualized very easily. Statistical methods, such as the chi-square test, can be used for comparing these distributions. However, problems in using centiles for cut-off points are discussed later.

The presentation and statistical treatment of the numbers is the same, whether they represent Z-scores or percentages of the reference median. The simplest descriptor of the whole distribution is the mean Z-score with the SD, or the mean percentage of the reference median with the SD. Standard statistical tests can be applied to these numbers.<sup>a</sup>

A method of representing the whole distribution, which has been useful in population studies, is to construct a cumulative distribution curve and calculate its slope (Fig. 2). The slopes found for different populations and the position of the curve can then be compared, along with the median Z-scores. However, it is unclear just how much of the cumulative distribution slope can be explained by measurement variability.

It appears that the best way of giving a complete picture of the whole distribution which can be compared with that of the reference population is a frequency curve or histogram of Z-scores (Fig. 3). The first step in constructing such a distribution curve would be tabulation of the data in the form shown in Table 1, which can be done for any age group, with any index. The size of the interval used for grouping the data, e.g., 0.5 or 1.0 Z-score unit, will depend on the number of measurements available, the facilities for analysing them, and the extent to which fine grouping is likely to be of practical value. For percentage of the median, the distribution curve is not practical because the data for the reference population are

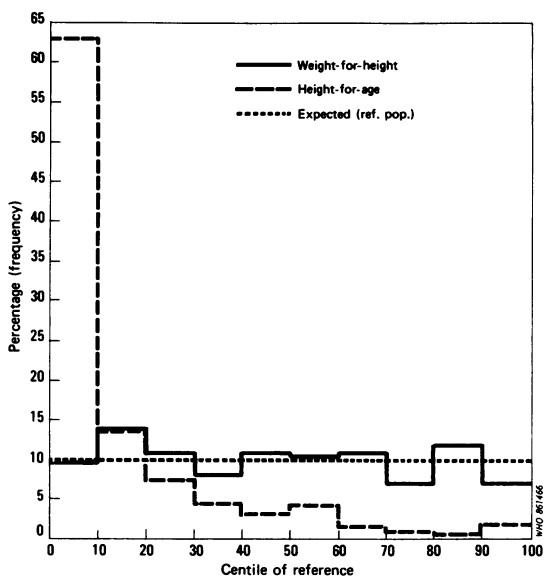


Fig. 1. Centile distribution of weight-for-height and height-for-age.

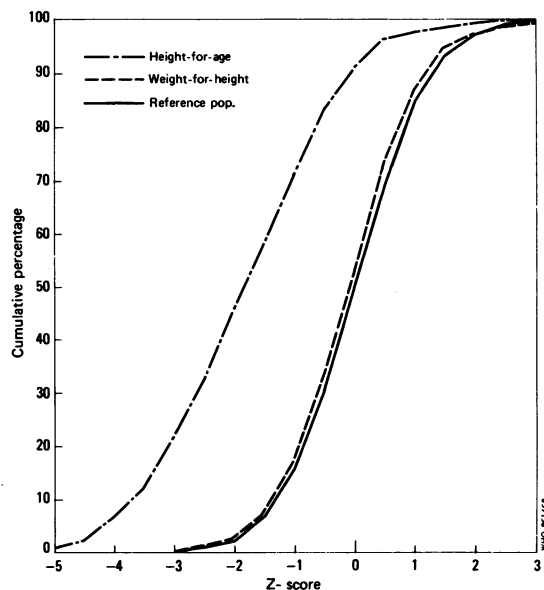


Fig. 2. Cumulative distribution curves of Z-scores, the weight-for-height and height-for-age values are for a population that is stunted but not wasted.

<sup>a</sup> Concern has been expressed about the application of statistical tests when the distribution is skewed. In most populations the distribution of height-for-age is approximately normal (Gaussian), whereas the distributions of weight-for-age and weight-for-height are skewed. In most groups from developing countries the distribution is less skewed than that of the reference population, because the latter contains more overweight children. Therefore, in constructing the NCHS reference tables (3) the population was divided into two halves at the median, and standard deviations calculated separately for each half. Since both observed and reference populations are skewed, relating one to the other will reduce the effect of skewness. Standard statistical tests based on the assumption of a normal distribution can then be applied to the values so derived.

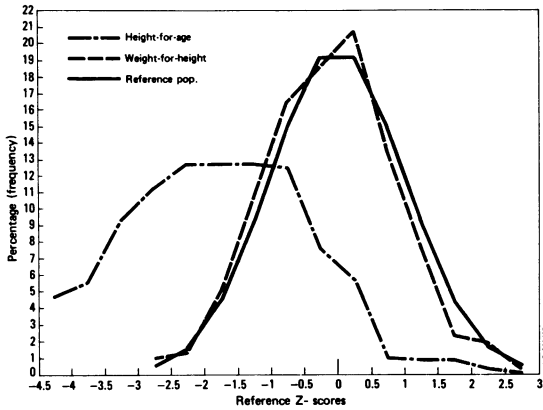


Fig. 3. Distribution curves of weight-for-height and height-for-age in relation to reference Z-scores.

age-dependent when expressed in these terms and are not readily available.

*Definition of the number at risk and choice of cut-off points*

For many purposes the most useful way of describing the nutritional situation is to present an estimate of the number or proportion who might be con-

sidered at risk. In principle such an estimate is given by the number outside the reference population. In practice it is conventional to use cut-off points, which are *indicators*, in the sense defined above; for example, the number below the 3rd centile; the number with Z-scores less than -2SD; or the number with weight-for-height less than 80% of the median. With centiles and Z-scores it is an advantage that the same cut-off can be used for both weight and height, whereas with percentage of the median the cut-offs are necessarily different.

The disadvantage of using centiles for cut-offs is that the number at extreme degrees of risk cannot be quantified, since centiles below the 3rd or above the 97th cannot be defined from the reference population except by back-calculation from the standard deviations.

It is in the choice of cut-offs that the difference between Z-scores and percentage of the median becomes particularly important. For example, in one survey of weight-for-height of children between 1 and 2 years old, 27% had Z-scores of -2 or below, whereas only 15% were below 80% of the reference median (17). This discrepancy cannot be eliminated simply by adjusting one or the other cut-off, because the coefficient of measurement variation varies with age. By definition, Z-score cut-offs take this into account, percentage of the median cut-offs do not.

Two objections have been made to the use of fixed cut-off points such as those cited above. The first is that at best they represent a purely statistical separ-

Table 1. Anthropometric data on the distribution of Z-scores in a sample population, used for constructing the distributions in Fig. 1 and 3; the reference distribution in column 4 is a normal distribution, by definition

Z-score range	Sample population distribution		Reference distribution (all indices and age groups) (%)
	Weight-for-height of 2-year-olds (%)	Height-for-age of 2-year-olds (%)	
-5.49 to -5.0		0.8	
-4.99 to -4.5		1.3	
-4.49 to -4.0		4.7	
-3.99 to -3.5		5.5	
-3.49 to -3.0	0.0	9.4	0.1
-2.99 to -2.5	1.0	11.2	0.5
-2.49 to -2.0	1.3	12.8	1.7
-1.99 to -1.5	5.0	12.8	4.4
-1.49 to -1.0	10.7	12.8	9.2
-0.99 to -0.5	16.4	12.5	15.0
-0.49 to 0	18.6	7.6	19.1
0.01 to 0.5	20.8	5.7	19.1
0.51 to 1.0	13.5	1.0	15.0
1.01 to 1.5	7.6	0.8	9.2
1.51 to 2.0	2.3	0.8	4.4
2.01 to 2.5	1.8	0.3	1.7
2.51 to 3.0	0.3	0.0	0.5
3.01 to 3.5	0.0	0.0	0.1

ation of "malnourished" from "normal". Ideally, cut-off points should be based on biological considerations, such as increased risk of mortality or of functional impairment. The cut-off should distinguish a deficit that matters from one that is of no real significance. This is a valid objection, but the practical problems of establishing a relation to risk are very great. Prospective studies of mortality, such as those of Chen and co-workers in Bangladesh (29), make it possible to determine the predictive value of different indices and to define the cut-off points which produce the optimum combination of sensitivity and specificity (30-32). However, death is not the only outcome which needs to be considered, and even for this particular outcome the results almost certainly cannot be generalized from one region to another. The quantitative relation between mortality risk and anthropometric deficit will vary, among other things, with infectious load. It also varies with age, a given deficit carrying greater risk in younger children (33).

The second objection is that the conventional cut-off of  $-2SD$  or its equivalent may be unrealistic and of limited use in practice. Thus, in an emergency situation where resources are restricted a lower cut-off point might have to be used to identify the children most in need, i.e., an increase in specificity at the expense of sensitivity (20, 30, 31). Again, if 60% of children in a particular country are described as significantly stunted, because they are below  $-2SD$  in height-for-age, this cut-off would defeat one of the aims of concentrating on the tails of the distribution, which is to identify those particularly and exceptionally at risk. In this case, if one wants to determine which children are most severely stunted, a lower cut-off point could be used.

Cut-offs should be chosen at the point most appropriate for the particular purpose in view, the reasons for choice being clearly stated. For most group or population comparisons, where uniformity is important, the standard statistical cut-off points of  $\pm 2SD$  from the mean should be maintained (17). In order to utilize a single method of relating measurements to the reference, it would also be necessary to use Z-scores in the presentation of whole distributions (Fig. 3). This is in accordance with the 1977 report (2), which recommended the use of Z-scores to express both distributions and cut-off points because they have a statistical meaning. Since then, WHO has also recommended to Member countries (8) the use of Z-scores for monitoring nutrition and health progress.

#### SEQUENTIAL OR LONGITUDINAL MEASUREMENTS

When serial measurements are made, the *velocity* of weight or height gain can be calculated. The sig-

nificance of a change in weight or height clearly depends on the time over which that change is observed. Failure to gain weight over 3 days has a different significance from failure to gain weight over 3 months. Therefore when velocities are reported, it is important to indicate the time over which they are measured. Different time intervals will be appropriate in different situations; it will depend on the age of the children, whether weight or height gain is the main object of interest, and whether the process being studied is of short or long duration. The smaller time intervals will have the greatest error. These points must be taken into account at the time when a sequential or longitudinal study is being planned.

Accurate estimates of velocity require that the same children should be examined at defined intervals. Longitudinal studies of this kind will usually not be feasible as a general survey method, but for particular purposes they can give very important information. For example, data on the velocity of weight gain in children and adults have been used to demonstrate seasonal variations (21), the effects of infections (22), and the effects of interventions and impacts of programmes on population groups (P. Rao, personal communication, 1983). Studies of the rate of increase in length have revealed that the widespread stunting seen in many less developed countries in children aged between 3 and 5 years is the result of a process of slowed skeletal growth that starts in infancy (23). A reduction in velocity is an earlier and more sensitive index of growth failure than a deficit in *attained* weight or height. Yet it is uncertain when the degree or duration of this growth failure has importance to the child's wellbeing.

Because of their sensitivity, measurements of velocity can show significant differences in quite a small sample. In a study of seasonal growth changes in Nepal, average weight gains over two-month intervals were calculated for 28 children (21). The standard errors of the differences between values for successive two-monthly weight gains were small enough for a difference of 250 g to be statistically significant (D. Nabarro, personal communication, 1984). The same applies to the results of studies examining relationships between illness and growth. If velocity data are to be used to compare the effects of interventions on different groups of children, the subjects in each group should be examined at the same time of year because of possible seasonal differences in growth and comparisons should be made only between children of similar ages. If these precautions are not observed, the differences detected may be wrongly attributed to the effects of the intervention.

At present there is no completely satisfactory reference for measurements of growth velocity in young children. Since the NCHS reference is cross-sectional, the difference between weights or heights at

two ages in any centile column provides an estimate of the expected gain in a child who starts in that centile, but there is no estimate of the variability of gain, so that no statistical significance can be attached to any deviation from the expected rate. Tanner's velocity standards (24) were obtained from a longitudinal sample, but the intervals of 3 months are too long for them to be useful for young children or for detecting short-term, e.g., seasonal changes. Fomon (25) has published data for weight and height gain over periods of 2-4 weeks from birth to 6 months, but the sample was small. Even in this group of healthy infants the coefficients of variation were very large (up to 37%). There is, therefore, an urgent need for an international reference for growth velocity.

Difficulties are encountered in the analysis and presentation of velocity data when a number of sequential measurements have been made on the same child, often at irregular intervals. Pomerance & Krahl (26) showed that gains in weight and height are linear when plotted against a logarithmic function of time. Slopes were obtained and centiles established for weight and height gain from 1 to 36 months in a sample of 3500 children. It remains to be seen whether this somewhat complex method would be satisfactory for quantifying deviations from the expected growth over a relatively short period. Dugdale (27) has proposed a method of summarizing the gains over any chosen period in a single statistic, even though the intervals between measurements are not regular, but this method has not so far been widely used.

Seasons have been found to have distinct effects on weight and height gains in developed nations (28), but it is unclear which seasons will have these effects in various developing countries and if the degree of seasonal effect on growth velocity is comparable to that which can be expected among well-nourished populations in the developing countries. For health workers who are concerned with identifying children at risk it may be useful to know the expected rates of weight and height gain of healthy children in their own communities, at different ages and different seasons. For this purpose averages based on locally constructed data may be more realistic targets than those derived from an international reference. However, the logistics in obtaining statistically significant local reference data by season would be even more difficult than those of cross-sectional local references.

Changes in weight over time, recorded on growth charts, are widely used in health centres for assessing the growth of individual children. These records potentially provide a source of information on the growth of those children who attend health centres, considered as a group (clearly a biased group) and not

simply as individuals. In fact, very little use has been made of this information, for the purpose of *community* assessment.

#### PURPOSES OF ANTHROPOMETRIC ASSESSMENT

In this paper we are mainly concerned with the use of anthropometric indices and indicators for the assessment of populations or groups. Their application for the diagnosis and follow-up of individuals, e.g., in health centres or obesity clinics, is also important but will only be briefly considered.

The basic objective of anthropometric assessment at the community level is to provide an estimate of the prevalence and severity of malnutrition. This information is of obvious importance for the formulation of health and development policies. Within this general objective there are a number of specific purposes which will determine the type of population to be studied, the type of information to be collected, the indices to be used, and the most useful method of presentation.

#### *Choice of appropriate indices and indicators*

The choice of indices and indicators is subject to constraints. There are practical limits to the feasibility, accuracy, and precision of all measurements, including that of age. The size of the sample and the number of measurements that can be made are constrained by the resources available.

For children, the use of two indices, weight-for-height and height-for-age, is to be recommended for most purposes but not necessarily for all. In certain instances the combined index, weight-for-age, may be practical for giving an overview of the distribution of nutritional problems in a country, or the direction of change.

Weight-for-height is an index that is particularly important for the description of current health status (see above, p. 932). This index alone, or its equivalent — arm-circumference-for-height — may be a sufficient tool for screening in emergencies, that is, for counting the undernourished.

Deficits in height-for-age seem to reflect overall social conditions. Therefore an indicator based on height-for-age, such as the proportion of stunted children, has been suggested as a measure of overall social deprivation.

It will generally be desirable to use more than one method for presenting and analysing the data: both to describe the distribution as a whole by one of the techniques discussed above (p. 933), and to give information about the extremes of the distribution by the use of cut-off points (pp. 934-935). For some purposes, it may be enough to present the proportion



below a particular cut-off, e.g., for screening or for overall international comparisons (17).

Some examples of different situations in which anthropometric assessment may be used are given below.

(1) *Overall assessment of a population* requires a widely representative sample. It is generally accepted that such a study should concentrate on children up to 5 years of age, because their condition constitutes a sensitive indicator of that of the population as a whole. When comparisons are being made, an appropriate method of presentation is the population below  $-2SD$  as a cut-off point (e.g., see ref. 17).

(2) For *identification of target groups or areas for priority action* a combination of indices of weight-for-height and height-for-age is needed in order to assess the nature of the problem as well as its magnitude (see above, p. 932).

(3) *Nutritional surveillance* is a tool for planning and involves the continuous or periodic collection of agricultural and economic information as well as of anthropometric data. The basic problems here relate to the choice of the sampling frame and the coordination, analysis and interpretation of the information.

(4) As a specialized aspect of surveillance, the *monitoring of nutritional status* to determine trends is of particular importance to national health authorities. Here it is desirable to use, wherever possible, a combination of health indices including weight-for-height and height-for-age. The most useful method of analysis will be by examining the total distribution, rather than only the extremes.

(5) In *evaluating the impact of programmes*, anthropometric assessment has a dual function: it provides information about the nutritional status of children, which is important in its own right, but it also constitutes a sensitive indicator of impact on the population as a whole. In the special case of evaluating supplementary feeding programmes, it is important to take account of the period of time over which the evaluation is made, as different indices may be more appropriate for shorter or longer times. For example, even with a successful programme it will be some time before significant changes in height can be observed.

(6) In *emergency situations*, where the needs are urgent but resources limited, anthropometric indicators, based on a cut-off point of a particular index such as weight-for-height, are used for screening, to select those who need priority attention. For this use the cut-off point has to be chosen to provide optimum sensitivity and specificity, according to the particular circumstances. This question has been dis-

cussed in detail by Habicht (30) and will not be further considered here.

(7) *Sequential measurements* are particularly valuable for studying the effects of seasonal changes in food supply or disease prevalence, and for identifying alterations in growth at an early stage (see pp. 935-936). Large samples are not required. On the other hand, the information obtained should be as detailed as possible.

(8) *Anthropometric assessment of individuals* is regularly carried out in clinics with the help of growth charts. This method of assessment depends on consecutive measurements, which make it possible to determine whether growth is proceeding satisfactorily. Assessment of an individual from a single measurement is inevitably insensitive because of the wide range of intra-individual variation. The records from such clinics are of potential value for assessing the status of the population, but they have seldom been used for this purpose, partly because of the difficulty of analysing sequential data (see pp. 932-935).

#### ANTHROPOMETRIC INDICES AND INDICATORS IN OTHER AGE GROUPS

It is not the intention of this paper to discuss in great detail the anthropometric assessment of nutritional status in subjects other than children. More work needs to be done before practical recommendations can be made. The remarks below, however, indicate some of the problems to which attention should be given.

##### *Adolescents*

Because of the variable timing of the pubertal growth spurt the indices of weight and height in relation to age are of little value for the assessment of nutritional status in this age group. Weight-for-height is useful, but the NCHS reference does not include this information for children over 10 years of age. A recent FAO/WHO/UNU Expert Consultation (9) used the data of Baldwin (34) for children and adolescents aged from 10 to 18 years.

The interpretation of weight-for-height data in adolescents is complicated by the fact that body composition is more variable at this age than in healthy young children and differences in fatness and muscle mass between the two sexes increase with age.

##### *Adults*

There are very large variations worldwide in the average heights of different groups (10). The FAO/WHO/UNU Expert Consultation (9) accepted that

no judgement can be made about a desirable range of heights for adults. Therefore anthropometric assessment of nutritional status in adults must be based on weight-for-height or proxies for weight, such as arm circumference.

The body mass index defined above is being increasingly used in place of the percentage of "ideal" weight. The BMI is a numerical index which does not in itself relate to any reference. It would be possible to compare the thinness or fatness of different populations by comparing the distribution of BMI, but this has seldom been done. There is, in fact, not very much information about the distribution of BMI in representative age and sex groups of different populations. A representative average value in an industrialized country is  $25 \pm 2.5 \text{ kg/m}^2$  (36).

In order to interpret values of the body mass index for individuals or groups it is necessary to establish cut-off points or levels of risk. The "ideal" weights of the American Life Assurance Association (37) attempted to do this by relating the weight at each height to mortality experience. This population, however, is a highly selected one. From this and other evidence (36) it is suggested that, at the upper end of the range, a BMI of  $30 \text{ kg/m}^2$  (corresponding roughly to the average + 2SD) can be taken as a cut-off point, above which there is a significantly increased mortality risk. There is little information or consensus about risks attached to low levels of BMI.

### *Birth weight*

The prevalence of low birth weight, defined by WHO as a weight less than 2500 g, is much greater in developing than in industrialized countries (38). Since low birth weight is the single most important determinant of infant mortality, it may, like the infant mortality rate, be regarded as an indicator of the general social development of the population. Moreover, to the extent that retarded fetal growth is caused by malnutrition of the mother before and during pregnancy (39-41), low birth weight can be regarded as an indicator of the health and nutritional status of the pregnant mother. The value of this indicator depends on establishing the causal relationship more firmly and for this more work is needed. Supplementary feeding trials of pregnant women have provided useful evidence on this point (40, 42).

It is probably only smallness for gestational age, rather than prematurity, that is influenced by maternal nutrition. In developing countries about 80% of low-birth-weight infants are small for gestational age rather than premature. Ideally, therefore, premature infants should be excluded when birth weight is being used as a nutritional indicator, but in practice this may be difficult.

The presentation of data on birth weight for the

purposes of assessment and comparison follows the same principles as those discussed above (see pp. 932-935). For some purposes the most useful statistic may be the mean and standard deviation, for others the proportion of birth weights below the internationally accepted cut-off point (2500 g). The relation between birth weight and mortality risk is not necessarily the same in developed and less developed countries (43) and therefore the same cut-off point may not be appropriate. This is a subject on which more work is needed in order to establish realistic cut-off points for risk.

The weight-for-height of the mother at the beginning of pregnancy is an index of her nutritional status which might be more widely used for identifying those at risk of an unfavourable outcome. In mild to moderately malnourished populations maternal weight gain during pregnancy is positively associated with the nutrient intake of the mother and also with birth weight (44). For these reasons increasing attention is now being given to the development of reference values of weight gain in pregnancy (35), although the available evidence suggests that there is a very wide scatter (44). It remains to be seen how far pregnancy weight gain could develop into a useful method of nutritional assessment. The practical difficulties are clearly great, since the mother has to be identified and weighed at the beginning of her pregnancy.

### CONCLUSIONS

An attempt has been made to clarify various questions which have appeared during the last few years on the use of anthropometric indicators. Several terms causing confusion have also been identified and defined. The main conclusions are:

— The terms "wasted" and "stunted" or "thin" and "short" are preferable to "acute" and "chronic" malnutrition, which can sometimes be misleading.

— Since wasting and stunting refer to different biological processes of malnutrition, their indicators, weight-for-height (wasting) and height-for-age (stunting), should be used whenever possible in anthropometric surveys.

— Because of logistical problems in creating local reference values, creation of such values is not considered a high priority. The continued use of the NCHS population as a reference is supported; if necessary, realistic goals can be set by lowering the cut-off points.

— It is generally desirable to use more than one method of presenting and analysing anthropometric data: both to describe the distribution as a whole and to utilize cut-off points to give information about the extremes of distribution.

—For most group or population comparisons, where uniformity is important, the standard statistical cut-off points of mean  $\pm 2SD$  and presentation of the whole distribution utilizing Z-scores should be maintained.

—A reduction in growth velocity, as determined by sequential measurements, can be used as an earlier, more sensitive index of growth failure than can a deficit in attained weight or height. This is especially relevant to growth monitoring in primary health care.

—Anthropometric nutritional assessment has several public health and development uses, such as overall population assessment, identification of target groups or areas for intervention, continuous nutritional surveillance as a tool for development planning, monitoring nutritional status to determine trends of particular health importance, evaluating the impact of programmes, selecting persons in need of immediate attention in emergency situations, studying the effects of seasonal changes in food supply or disease prevalence, and individual nutritional assessment, including use of sequential measurements to determine if growth is proceeding properly.

Many areas requiring further research have been pinpointed, three of which have been discussed in some detail:

(1) *Wasting and stunting.* More information is necessary on the natural history of the processes which lead to wasting and stunting. There is also a gap in information on the effectiveness of interventions for prevention and treatment of these two conditions. Very little is known on the functional implications of stunting and its reversibility.

(2) *Sequential measurements.* There is an urgent need for an international reference for growth velocity which will give an idea of the expected coefficient of variation on which to base criteria to assess longitudinal growth. There is at present limited knowledge on the differences between countries in seasonal changes in growth velocity. The most appropriate analysis and presentation of velocity and sequential data have yet to be determined.

(3) *Anthropometry of non-child populations.* Since the majority of anthropometric research has been done on children, knowledge about other age groups presents many more gaps; only a few of these gaps have been touched upon in this paper. More information is necessary on the distribution of body mass index by age and sex in different populations, and whether or not this is the best indicator for adult anthropometry needs to be determined. It is unclear

how well pregnancy weight gain can be used for nutritional assessment and prediction of pregnancy outcome or whether another indicator could be developed. The interpretation of weight-for-height in adolescents is still unclear.

Although there are many other questions regarding the use and interpretation of anthropometric indicators of nutritional status, the importance of anthropometry as a public health indicator has been firmly established.

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## RÉSUMÉ

## UTILISATION ET INTERPRÉTATION D'INDICATEURS ANTHROPOMÉTRIQUES DE L'ÉTAT NUTRITIONNEL

L'anthropométrie est considérée comme la méthode la plus commode d'évaluation de l'état nutritionnel de groupes d'enfants bien que les variations des courbes de croissance tiennent à diverses raisons et pas seulement à la nutrition. A mesure que l'on acquiert une plus grande expérience de l'anthropométrie, il devient nécessaire d'en revoir de temps à autre la présentation et l'interprétation. Cet article fait suite à un rapport publié en 1977 par un groupe de travail semblable (J. C. Waterlow et al., *Bull. Org. mond. Santé*, 55: 489-498 (1977)) dont les propositions sur l'utilisation des données relatives à la taille et au poids ont été largement acceptées. La signification biologique de l'émaciation (maigreur) et du retard de croissance (petite taille) est maintenant mieux comprise et l'on connaît mieux l'épidémiologie de cas états pathologiques. De même, on sait davantage de choses sur les utilisations et les applications des populations et des normes de référence. Des références internationales sont utiles pour des comparaisons entre pays ou groupes de population et la surveillance d'éventuelles modifications.

Pour la planification de services il est possible que l'on préfère des références locales assorties de cibles ou de normes temporaires adaptées aux conditions locales. Pour la présentation des données, on accorde maintenant davantage d'importance aux valeurs de l'écart-type. Le recours à des séquences ou à des séries de mesures et le calcul de la vitesse de croissance plutôt que l'enregistrement de valeurs isolées présentent de nombreux avantages mais pâtissent encore de l'absence de valeurs de référence bien établies.

Les indicateurs anthropométriques doivent être choisis en fonction d'objectifs précis et cet article en offre quelques exemples. Il donne aussi une liste des secteurs qui devraient faire l'objet de recherches, par exemple les processus conduisant à l'émaciation et au retard de croissance, les implications fonctionnelles du retard de croissance, les influences saisonnières et autres sur la vitesse de croissance et l'anthropométrie nutritionnelle des adolescents et des adultes.

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