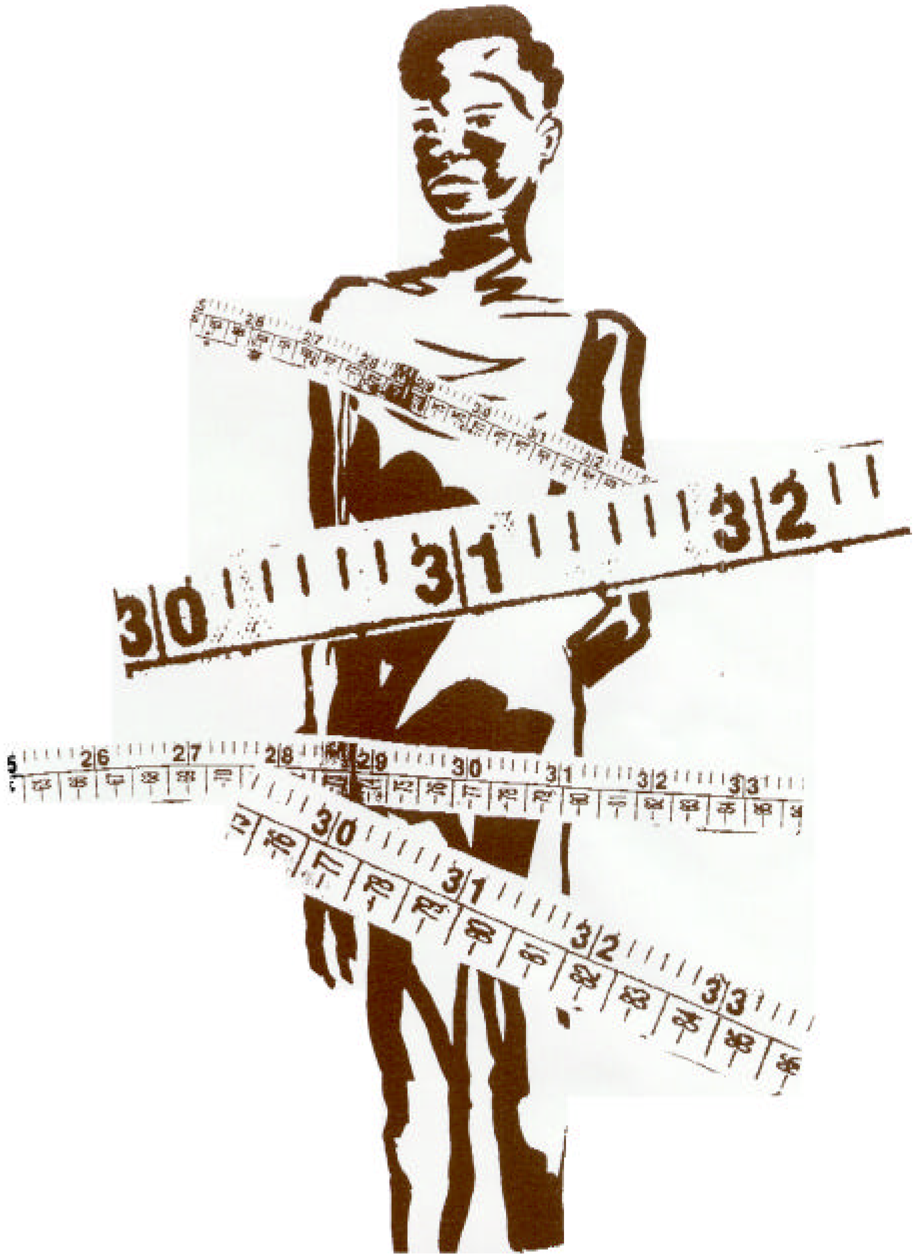
ADOLESCENTS



ASSESSMENT OF NUTRITIONAL STATUS IN EMERGENCY-AFFECTED POPULATIONS

July 2000

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We are grateful to the following reviewers for their comments:

Monika Blösnner (WHO), Tim Cole (Institute of Child Health), Mary Corbett (Concern), Mercedes de Onis (WHO), Mike Golden (University of Aberdeen), Saskia van der Kam (Médecins Sans Frontières), Carlos Navarro-Colorado (Action Contre La Faim), Nick Norgan (University of Loughborough), Claudine Prudhon (Action Contre La Faim), Simon Strickland (London School of Hygiene and Tropical Medicine), Stanley Ulijaszek (Oxford University).

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Funding support is gratefully acknowledged from CIDA, DFA (Ireland), NORAD, DFID (UK), UNHCR, UNICEF and WFP.
This report was made possible through the support provided by the Food and Nutrition Assistance (FANta) Project by the Office of Health and Nutrition Bureau for Global Programs, Field Support and Research at the U.S. Agency for International Development, under the terms of Cooperative Agreement No. HNE-A-00-98-00046-00 awarded to the Academy for Educational Development (AED). The opinions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Agency for International Development.

SUMMARY

The World Health Organization (WHO) currently recommends using the BMI (Body Mass Index) of individual adolescents compared to a reference population made up of adolescents in the United States and using the 5th centile of this reference as the cut-off point to define undernutrition. These recommendations may not be appropriate; surveys using these recommendations have found unrealistically high levels of adolescent undernutrition.

PROBLEMS WITH ANTHROPOMETRY IN ADOLESCENTS

Anthropometry may be more difficult in adolescents than other age groups because of many complicating factors.

- Body proportions, including indices using weight and height measurements, change with age, making it necessary to compare an individual to adolescents in a reference population who are of the same age. As a result, age must be collected on persons screened for admission to feeding programs or measured as survey subjects. Adolescents in many emergency affected populations do not accurately know their ages.
- Body proportions change with sexual development. The age at which sexual development occurs differs in different populations and complicates the comparison of subjects from one population to adolescents in a reference population.
- Body proportions may differ between the reference and survey populations. It may not be valid to expect all populations of adolescents, even if well nourished, to achieve the same body proportions as a single, universal reference.

POSSIBLE SOLUTIONS

These problems affect all anthropometric indices including weight-for-height, BMI, Rohrer Index (weight/height^3), and MUAC (mid-upper arm circumference). Regardless of the anthropometric index used, the following adjustments may allow better estimates:

- Better methods of assessing the age of attainment of key pubertal landmarks may allow adjustment for differences in maturation age between survey and reference populations.
- Cormic Index (sitting height/standing height ratio) may, to some extent, be used to adjust for ethnic differences in body proportions; however, this technique has not been studied in adolescents.
- A new international reference consisting of adolescents from 6 countries and a new method of determining cut-off points may alleviate some of the biases from using a reference population from a single country.

CURRENT RECOMMENDATIONS

Additional research is necessary before a single, valid methodology can be widely recommended for anthropometric assessment of adolescents. Only tentative and preliminary recommendations can be given at this time.

- *Screening for severe undernutrition*
  Until better methods can be developed and validated, screening for severe undernutrition in order to determine the need for therapeutic feeding should use clinical criteria.

- *Corrections for different ages of sexual maturation*
  In surveys, some correction for different ages of sexual maturation should be carried out if the age of sexual maturation differs substantially between the survey and reference population:
  For *pre-pubertal* adolescents, weight-for-height could be used as the anthropometric index and compared to revised weight-for-height tables currently in use.
  For *post-pubertal* adolescents, BMI could be used as the anthropometric index and compared to a new international reference population. Appropriate cut-off points could be used to identify malnourished individuals.

- *Corrections for effect of age on anthropmetric measurements*
  Regardless of which index is used, cut-off points are age-specifc; as a result, age should be collected as accurately as possible on all adolescents measured during screening or survey activities.

- *Reference populations*
  The reference population of American adolescents, currently recommended by WHO for use with BMI, should not be used.

- *Additional data*
  Adolescents should not undergo nutritional assessment in isolation. Young children, women of child-bearing age, adults, elderly, or other population subgroups should also be assessed. A large discrepancy between the estimated level of undernutrition in adolescents and other population subgroups should stimulate investigation of the validity of the methods and results of the adolescent assessment. Estimates of the levels of morbidity and mortality, and information on diet, food security, and food sources should also be collected

- *Comparison of surveys*
  In order to assess the methods and comparability of surveys, all survey reports should describe in detail the anthropometric index used, how measurements were taken, which reference population was used, how individuals were compared to this reference, the cut-off points used to define various degrees of undernutrition, and any other ancillary data collected on the population of interest.

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Signalling the need for norms and standards.

The SCN will identify for the attention of technical agencies or other bodies critical areas where norms and standards are missing or out-of-date and holding programmes back. This includes (especially) identifying knowledge gaps and significant areas in dispute or controversy; as well as identifying areas requiring operational research, and facilitating this work.

Extract from the ACC/SCN's Strategic Plan, April 2000

UNITED NATIONS   Administrative Committee on Coordination

SUB-COMMITTEE ON NUTRITION

THE UN SYSTEM'S FORUM FOR NUTRITION

VISION AND MANDATE

Our long-run vision is of a world in which malnutrition is no longer a human development constraint. This is possible, but to achieve it will require decisive action at country level, supported by a coherent and co-ordinated international strategy, founded on human rights and providing a framework for action throughout the UN and international development finance system, implemented in close partnership with NGOs, bilaterals and governments. Nutrition needs to be made a key development priority, recognized as vital to the achievement of other social and economic goals. Good nutrition under normal conditions contributes to the prevention and mitigation of death and malnutrition in emergency situations. Good nutrition facilitates the prompt return to conditions favouring development following disasters.

The mandate of the ACC/SCN is to raise awareness of nutrition problems and mobilize commitment to solve them -- at global, regional and national levels; to refine the direction, increase the scale and strengthen the coherence and impact of actions against malnutrition world wide; and to promote co-operation amongst UN agencies and partner organizations in support of national efforts to end malnutrition in this generation.

Three main areas for action have been identified: (i) Promote of harmonized approaches among the UN agencies, and between the UN agencies and governmental and non-governmental partners, for greater overall impact on malnutrition. (ii) Review the UN system response to malnutrition overall, monitor resource allocation and collate information on trends and achievements reported to specific UN bodies. (iii) Advocate and mobilize to raise awareness of nutrition issues at global, regional and country levels and mobilize accelerated action against malnutrition. These three functions are all vital and of equal importance and can be seen as a triangle, one dependent on the other.

The UN members of the ACC/SCN are the FAO, IAEA, IFAD, ILO, UN, UNAIDS, UNDP, UNEP, UNESCO, UNFPA, UNHCHR, UNHCR, UNICEF, UNRISD, UNU, WFP, WHO and the World Bank. The ADB and IFPRI are also part of this group. From the outset, representatives of bilateral donor agencies and NGOs have participated actively in SCN activities. The Secretariat is hosted by WHO in Geneva.

The SCN undertakes a range of activities to meet its mandate. Annual meetings have representation from those mentioned above as well as academia -- a one-day Symposium is held during the annual meeting, focussing on a subject of current importance for policy. The SCN convenes working groups on specialized areas of nutrition; currently there are nine working groups in areas ranging from foetal and infant malnutrition, nutrition of the school aged child, and household food security to capacity building .

The SCN's reports on the world nutrition situation, published every two to three years, are authoritative sources of information to guide the international community in its nutrition work. Nutrition Policy Papers and the SCN News summarise current knowledge on selected topics. Quarterly bulletins on the nutritional status of refugees and displaced persons are also published in collaboration with a large network of NGOs.

INTRODUCTION

This RNIS supplement discusses the assessment of undernutrition in adolescents in emergency situations. The World Health Organization (WHO) defines adolescents as persons aged 10-19 years old. Because of the focus on humanitarian emergencies, the discussion will include only an evaluation of acute undernutrition. This paper will not address many other important nutritional problems in adolescents, such as anaemia and other micronutrient deficiencies, poor nutritional habits, eating disorders, and obesity [1].

The report will also not directly address chronic undernutrition. In children and young adolescents, chronic undernutrition leads to stunting (low height-for-age). In adolescents, chronic undernutrition also delays normal maturation [2-8]. Although chronic undernutrition is an important and widespread problem [9] with multiple adverse health outcomes, it is not usually the highest nutritional priority in emergency situations. In such situations, acute undernutrition is often common and, at least in young children, may account for a substantial proportion of overall mortality [10]. Moreover, the distinction between acute and chronic undernutrition among adolescents and adults is not nearly as clear as it is among young children. Since adults and older adolescents no longer increase their height, they cannot become stunted, and thinness may result from either a sudden or long-standing food deficit.

This discussion emphasizes practical issues of anthropometric assessment of nutritional status rather than general knowledge of adolescent growth and development. Nonetheless, this supplement does include some information on these topics so that the reader can understand the difficulties associated with anthropometric assessment in this age group.

This paper also points out some of the deficiencies of the current recommendations regarding the nutritional assessment of adolescents, including those published by WHO. Examples of assessments that have used the recommended procedures are included. Many of these assessments have produced misleading results, and at least one has resulted in the implementation of potentially unneeded interventions.

In displaced and emergency-affected populations, the most common method of assessing the overall nutritional status in a population is to weigh and measure children 6-59 months of age [11-14]. However, emergencies in Europe, Central Asia, and Africa have highlighted the nutritional vulnerability of other population subgroups, such as elderly adults [1, 15-19]. Adolescents have not traditionally been considered at disproportionately elevated nutritional risk in emergency situations. Nonetheless, because of rapid growth in stature, muscle mass, and fat mass during the peak of the adolescent growth spurt, the requirements for some nutrients is as high or higher in adolescents than in other age groups [13]. Between 10 and 19 years of age, the requirement for many micronutrients, including vitamin A, thiamine, riboflavin, niacin, folic acid, vitamin B12, vitamin C, and iodine, reaches levels required by non-pregnant adults. Moreover, rapid growth produces a higher requirement among adolescents 10-14 years of age for calcium than any other population age group except pregnant women. The 2,420 kcal required per day by adolescents 15-19 years of age is the highest energy requirement of any age group. The recommended general ration of 2100 kcal per person per day for populations wholly dependent on relief food is based on a distribution of age and sex which assumes that 20% of the population are adolescents 10-19 years of age and 56% are adults. In populations with a higher proportion of adolescents or adults, this ration may provide insufficient energy [13].

Adolescence may also present a nutritional opportunity, although little is known about the short and long-term effects of acute undernutrition during adolescence. In many cultures, a large proportion of girls have their first pregnancy during adolescence. Improvement in nutritional status can improve pregnancy outcomes, including maternal death, foetal death, and preterm delivery, experienced by pregnant adolescents [9].

BACKGROUND ON ANTHROPOMETRY

Anthropometry is the measurement of certain parameters of the human body. It is frequently used to assess nutritional status in young children and adults [12, 20, 21]. Anthropometry has also been used to study the growth and development of school-aged children and adolescents. Only recently has an attempt been made to use anthropometric methods to assess acute undernutrition in adolescents [12].

Use of anthropometry requires two essential items: an anthropometric indicator and a cut-off point. The indicator, often called an anthropometric index, is a measurement or a combination of measurements made in the field, such as weight and height, or the combination of measurements with additional data, such as age. Different indices reflect different components of nutritional status. The index weight-for-height indicates thinness, and because acutely undernourished persons generally lose body weight but not height, weight-for-height decreases with acute undernutrition. On the other hand, young children with chronic undernutrition may not be thinner than normal children, but may have retarded growth in height. Chronic undernutrition may not be severe enough to cause weight loss, but does interfere with normal linear growth. As a result, height-for-age is decreased, and children become stunted. Weight-for-age reflects both acute and chronic undernutrition because both thin children and stunted children are underweight. In many emergency-affected populations, acute undernutrition may be superimposed over a high level of background chronic undernutrition. As a result, both thinness and stunting may be common.

Mid-upper arm circumference (MUAC) is an indicator of the amount of fat and muscle in the upper arm. Skinfold thickness measurements, taken at various places on the body, provide an estimate of the thickness of subcutaneous fat. Acutely undernourished persons metabolise fat and muscle to compensate for decreased nutrient intake, resulting in a decline in skinfold thickness and MUAC.

Anthropometry can be used to evaluate either individuals or populations. To identify those in need of nutritional rehabilitation, a cut-off point is established below which persons are offered nutritional therapy. Young children 6-59 months of age with severe acute undernutrition are usually treated in inpatient therapeutic feeding centres. The recommended admission criteria are weight-for-height <-3 z-scores or <70% of median (see Box 1 for explanation of cut-off points) or the presence of oedema [14, 22]. Anthropometric measurements are taken frequently during nutritional therapy and, in combination with clinical observations, are used to determine when children can be discharged. The application of universal cut-off points has the dual advantage of allowing comparisons of the level of undernutrition between populations and also helping to prevent bias on the part of feeding-centre staff when performing initial assessment or follow-up of patients.

Anthropometry is also used to determine the prevalence of undernutrition in a population. Anthropometric measurements for each child selected as part of a representative sample are compared to a reference population to determine each child's nutritional status. The proportion of sampled children who are undernourished provides an estimate of the prevalence of undernutrition in the entire population of children. Such surveys are most commonly performed in children 6-59 months of age, but can be undertaken in any population subgroup, such as older adults, adolescents, or pregnant women. Estimates of the prevalence of undernutrition, along with other data on food and health, are used to plan programmes of food aid and nutritional therapy, or to evaluate the effect of such programs.

Anthropometry, however, cannot provide the complete picture of the nutrition and food situation needed for problem solving and programme planning. Anthropometry can provide an estimate of the prevalence of undernutrition, but evaluations of food security, food distribution, nutrient content, morbidity and mortality, and other elements are needed to understand the causal factors resulting in undernutrition [23]. Nonetheless, anthropometric measurements are relatively easy to obtain in the field and anthropometric surveys can often be carried out in displaced populations, even during the acute phase of a humanitarian emergency.

Box 1. An explanation of cut-off points for anthropometric indices in children and adults

For each anthropometric index, a specific level must be determined as the cut-off point which distinguishes the normal nutritional state from undernourished. Cut-off points are also used to distinguish different levels of undernutrition. Cut-off points for anthropometric indices can be determined statistically. For example, the most commonly used index of acute undernutrition in young children is weight-for-height. Each measured child is compared to the reference population to determine how far that child is from the average child in the reference population. This discrepancy between an individual child and the reference can be expressed in a number of ways. One frequently used method when assessing individual children is the percent of median. A weight of a measured child is compared to the median weight of all children in the reference population of the same sex and height. We will use as an example a 17 month-old girl who weighs 8 kg and is 80 cm long. The median weight of girls in the reference population who are 80 cm long is 10.6 kg (note that age is not necessary). Therefore, the measured child has a weight-for-height which is 75% of median.

An alternate method, now somewhat outdated, is to express weight-for-height in centiles. That is, upon looking up in a centile table, we find that our 8 kg, 80 cm girl weighs less than 84% of girls in the reference population who are 80 cm long. Therefore, this child falls on the 16th centile of weight-for-height. In population surveys, the preferred method for expressing the comparison between a specific child and the reference is by using z-scores. The distribution of weights for all reference children of the same sex and height is described by the median and standard deviation, given in kg. One standard deviation is one z-score. Using the example girl referred to above, the standard deviation of the weight for reference girls who are 80 cm long is approximately 0.88 kg. The median weight of these reference girls is 10.6 kg. Because the weight of our example child is 2.6 kg lower, she falls 2.95 standard deviations below the median. Therefore, her weight-for-height z-score is -2.95. The z-score cut-offs for moderate and severe undernutrition (<-2 and <-3, respectively) were determined from the distribution of weight-for-height values in a sample of American children.

It must be remembered that reference populations are used only to develop statistical cut-off points and may not necessarily represent targets for, or examples of, optimum nutritional status. Indeed, by definition, 2.3% of the children in the American reference population will fall below -2 z-score weight-for-height and be defined as acutely undernourished. Regardless of whether percent of median, centile, or z-score is used, if anthropometry is being used to determine who needs nutritional intervention, children falling below the selected cut-off point will be included in such an intervention and those falling above this cut-off point will not be included. In a population survey, the prevalence of undernutrition is calculated by dividing the number of children falling below the selected cut-off point by the total number of children measured.

The cut-off point defining undernutrition is sometimes determined using health outcome data. For example, adult undernutrition is frequently assessed using the body mass index (BMI), which is also called the Quetelet Index. It is calculated as the weight in kilograms divided by the square of the height in meters (Wt/Ht^2). Although very little data are available relating a specific cut-off point to the consequences of acute undernutrition, there are many studies of the health outcomes of chronic undernutrition. These studies have shown that adults with a BMI less than 18 or 18.5 have more frequent illness, less capacity for physical labour, and, in women, poorer birth outcomes [21].

CURRENT WHO RECOMMENDATIONS FOR ADOLESCENT ANTHROPOMETRY

DESCRIPTION OF WHO RECOMMENDATIONS (SUMMARISED FROM: PHYSICAL STATUS: THE USE AND INTERPRETATION OF ANTHROPOMETRY, REPORT OF A WHO EXPERT COMMITTEE [12])

(1) To screen adolescents for severe undernutrition to determine the need for admission to therapeutic feeding:
- Use clinical criteria. Visual evidence of extreme emaciation can identify those requiring immediate feeding. The ability to walk or work may also be important in identifying those in greatest need. Pregnant and lactating adolescents may need additional nutritional support.

(2) To screen adolescents in less extreme need of nutritional interventions:
- Use BMI-for-age to assess acute undernutrition. Each measured adolescent's BMI is compared to members of the same age and sex in the National Center for Health Statistics (NCHS) reference population consisting of

adolescents in the United States who were measured as a part of the first National Health and Nutrition Examination Survey (NHANES I) in 1971-1974 [24, 25]. [Note that CDC has recently published new growth charts based on children from the US, see www.cdc.gov/nchs.]

- Adolescents falling below the 5th centile of the NCHS reference population may need intervention, although local cut-offs can also be developed which take into account the availability of resources to manage the patient load.
- Because of major differences between boys and girls in the timing of maturational events (including the growth spurt) separate references must be used for each sex.

(3) To estimate the prevalence of acute undernutrition in a population of adolescents:

- Use BMI-for-age as described above. Calculate the proportion of adolescents falling below the 5th centile or a locally-defined cut-off point.

(4) To estimate the prevalence of chronic undernutrition in a population of adolescents:

- Compare the height of each adolescent to the height of adolescents of the same sex and age in the NCHS reference population. Adolescents falling below the 3rd centile of the NCHS reference population are defined as stunted[26].

(5) In addition, WHO recommendations describe a method to adjust, at least in part, for potential differences in the ages of maturation between survey populations and the reference population. This adjustment can be undertaken when assessing either acute or chronic undernutrition.

- Along with weight, height, and age, survey workers should collect data on specific landmarks of sexual maturation. For each female adolescent, the Tanner breast stage and the age of menarche (if postmenarcheal) should be collected. For male adolescents, the Tanner genitalia stage and the age of attainment of adult voice should be collected. For female adolescents, investigators then calculate the median age of reaching the Tanner breast stage 2 and the median age of menarche. For male adolescents investigators calculate the median age of attaining the Tanner genitalia stage 3 and median age of attaining adult voice.
- The difference is calculated between the survey population and the reference population in the median ages of attaining these landmarks. For each sex, the differences for the two landmarks are averaged.
- For each sex separately, the average difference between the survey and reference populations in these median ages is then used to adjust the age of each survey subject. (See Box 2 for example of adjustment for maturational age in females.)

Box 2. Example of adjustment of BMI for maturational age for girls

The median ages of attaining breast stage 2 and menarche is calculated by plotting the cumulative percentage of girls who have attained these landmarks by age. The age at which 50% of girls have attained these landmarks is the median age. In a hypothetical survey population, if the median ages for girls of attainment of breast stage 2 and menarche is 12.2 years and 14.2 years, respectively; these are subtracted from the median ages in the NCHS reference population (10.6 and 12.8 years, respectively). The average of these two differences is approximately 1.5 years, which is then subtracted from the age of each of the girls in the survey population. This adjustment allows survey girls to be compared to girls in the reference population who are at the same

APPLICATION OF THE WHO RECOMMENDATIONS

Since their publication, the WHO recommendations have been used to analyse the results of several surveys undertaken in both stable and displaced populations in developing countries. The survey population characteristics and the estimated prevalence rates of thinness and stunting are summarised in Table 1.

Table 1 Summary of the results of surveys which used WHO recommendations to assess adolescent nutritional status

Reference	Camp or population	Date or survey	Age of survey subjects (years)	Number of survey subjects	Socioeconomic level of subjects	Prevalence of low BMI (thinness) <5th centile	Prevalence of low height-for-age (stunting) <5th centile
Stable populations							
	School irls in ha a an ladesh	ay u 1	1 1	females	iteracy fathers mothers	1	1
	Schoolboys in alcutta ndia	1	1 1	males	_1 years school fathers mothers		1
	School students in ombay ndia	1	1 1	males females	esidents of urban slums		
	esidents of rural villa es in e al	1	1 1	1 males 1 females	lower income areas		
	esidents of rural villa es in enin	1	1 1	1 males 1 1 females	lower income areas		1
Displaced populations							
	School attendees a uma cam enya	ril 1	ales emales 1	1 11 males females	efu ees de endent on food aid	oys irls	
	o ulation based sam le a uma cam enya	ovember 1	1 1	males 1 females	efu ees de endent on food aid		
1	o ulation based sam le cam s in adaab istrict enya	ovember 1	1 1	males 1 females	efu ees de endent on food aid	1	
	o ulation based sam le cam s in e al	October 1	1 1	males females	efu ees de endent on food aid	rude d usted	rude d usted

d usted for differences in a e of se ual maturation between survey and reference o ulations

Based on the data contained in Table 1 and in reports from these surveys, certain considerations cast doubt on the validity of some of these estimates of thinness and the methods employed to produce the estimates.

- Although no data were specifically collected on health outcomes, four of the surveys chose samples from among children who were well enough to attend school during survey activities. Nonetheless, three of these surveys estimated that the prevalence of thinness (indicating undernutrition) was greater than 50%. In the three refugee camp surveys that collected additional health data, there was no evidence of elevated morbidity or mortality in these populations [30-32].
- Two of the surveys included adolescents from families with relatively high socioeconomic status and yet still found substantial acute undernutrition among adolescents.
- In three surveys undertaken in refugee camps, monitoring showed that the amount of food contained in the general distribution was generally adequate [30-32]. One would have to hypothesize extraordinarily inequitable intra-household food distribution to explain the high prevalence of acute undernutrition among adolescents if the survey results are valid.
- In the refugee camp surveys there were no indications, other than the results of the adolescent surveys, that substantial undernutrition existed in any segment of the population. In all these populations, recent surveys of children less than 5 years of age had estimated a low prevalence of acute undernutrition [29-32].
- Eight surveys estimate the prevalence of both thinness and stunting. In five of these surveys, the estimated prevalence of thinness exceeded that of stunting by a factor of 1.6 - 6.3. Although little is known about the usual ratio of the prevalence rates of thinness and stunting among nutritionally compromised adolescents, these results would be highly unusual in children up to 5 years of age. An analysis of the results of 175 nutrition surveys throughout the world demonstrated that among children 12-23 months of age, stunting was 2.5-12.5 times more common that thinness, depending on the region where the survey was done [33]. In addition, in the WHO Global Database on Child Growth and Malnutrition, only Fiji has a higher prevalence of thinness than of stunting [34]. Although the applicability of these data to adolescents is not precisely known, one might expect that in adolescents - as for young children - the prevalence of stunting would exceed the prevalence of thinness because stunting is cumulative, while thinness is due to relatively recent undernutrition.

Uncritical use of the WHO recommendations may yield misleading results, which may, in turn, lead to inappropriate interventions. For example, as a consequence of one survey of adolescents, relief food was diverted from the general ration distribution to a supplementary feeding programme targeted to school attendees. Given the questions about the validity of the procedures recommended by WHO, this intervention may have been unnecessary and may have diverted food from population subgroups which needed this food more than adolescents who were sufficiently healthy to attend school.

COMPLICATIONS OF ADOLESCENT ANTHROPOMETRY

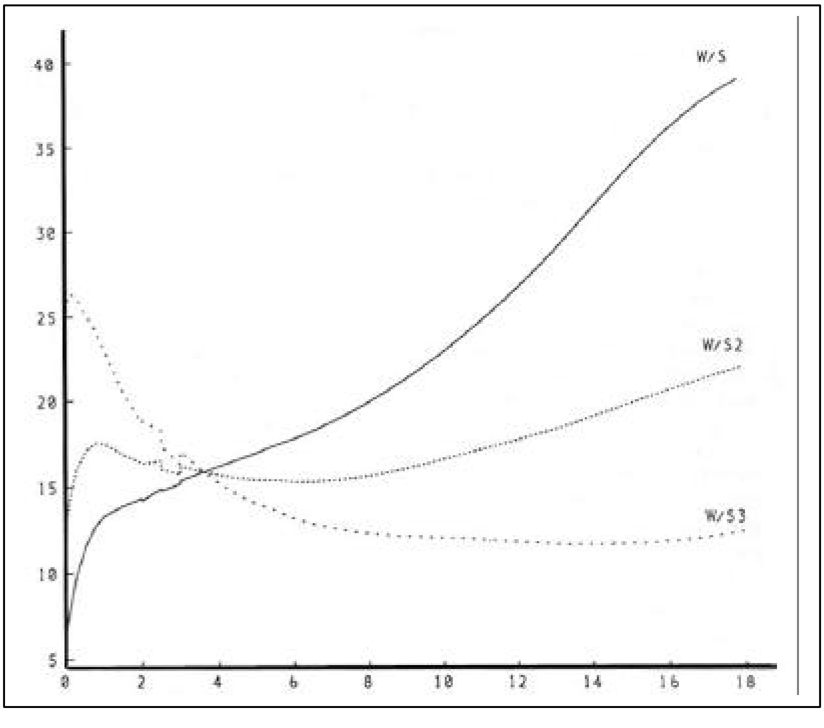
The anthropometric assessment of undernutrition among adolescents presents several problems that are not relevant to the assessment of young children. This section will outline some of these complications, including:

- *Changes in body proportions with age*
- *Pubertal development*
- *Inter-ethnic differences in genetic growth potential*

CHANGES IN BODY PROPORTIONS WITH AGE

Thinness, as measured by weight-for-height and BMI, changes with age in healthy, well-nourished children, adolescents, and adults. In populations in industrialised countries, BMI reaches a nadir at about 6 years of age, then rises steadily until middle-age [35-37]. (see figure 1) The Cormic Index (sitting height divided by standing height) measures the ratio of leg-length to trunk length, and is sometimes called the sitting height to standing height ratio. The Cormic Index declines throughout childhood because leg length increases faster than trunk length during prepubertal growth [38]. However, the adolescent growth spurt is made up disproportionately of growth in the trunk, leading to a rise in Cormic Index in later adolescence [38-40]. At least one study shows a sharp change in the index with onset of adolescent growth [40]. Other anthropometric measurements also change with age in adolescence. MUAC rises progressively throughout adolescence at a rate greater than that in early childhood [41].

Figure 1 Weight-for-height (W/S), BMI (W/S2), and Rohrer Index (W/S3) as a function of age during childhood and adolescence, constructed from medians of NCHS reference population ***(from Cole, 1991*** [37]***)***



Populations of many developing countries do not know their own ages. In young children age can be approximated by asking a mother about significant events on a local calendar which coincided with the child's birth. Such a technique may be much more difficult when asking about local events which occurred 10-19 years before. In any case, using such techniques to ascertain age takes substantial time, both in preparation of a local calendar and in posing extra questions during data collection.

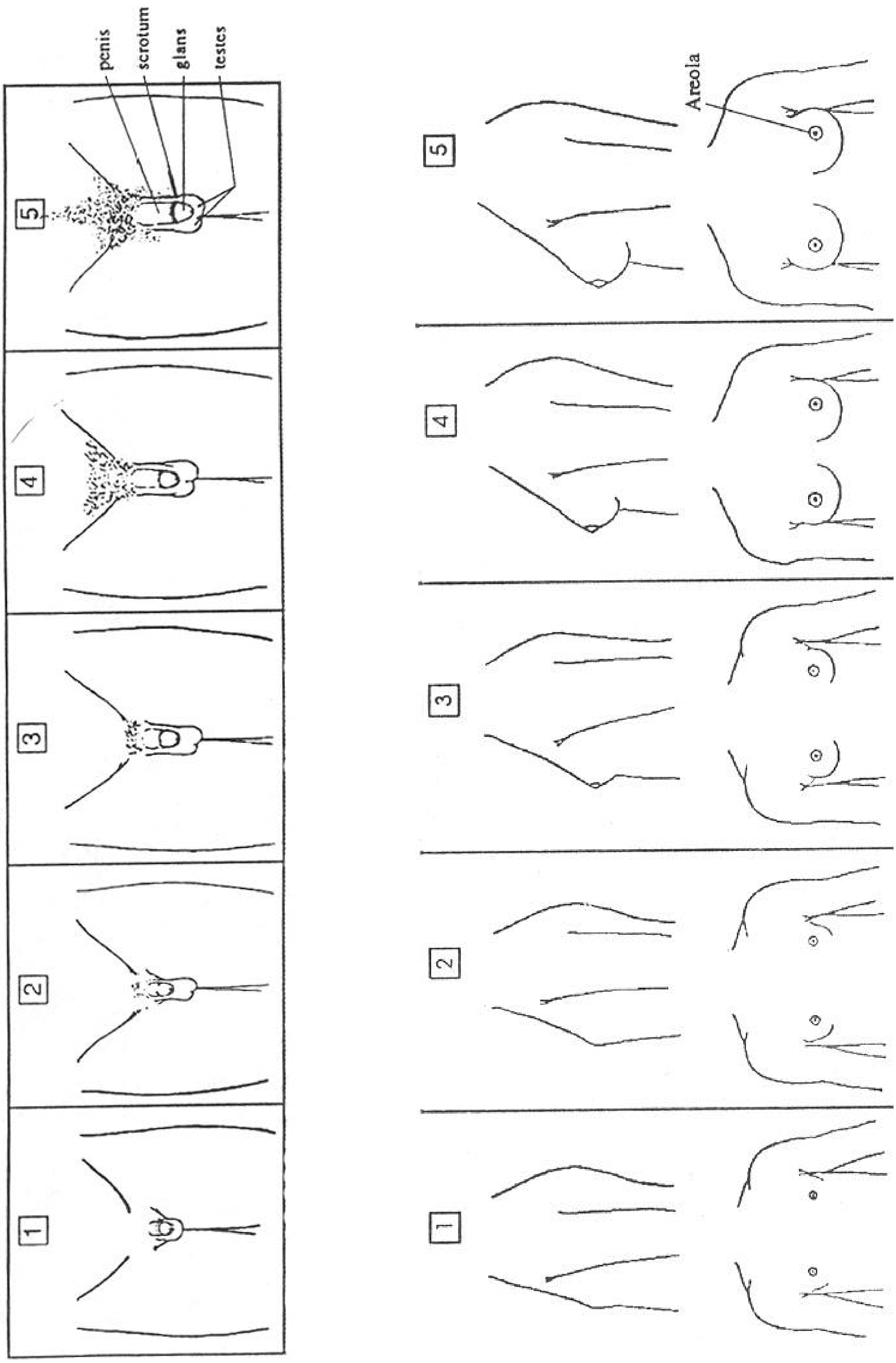
PUBERTAL DEVELOPMENT

Superimposed on the more gradual age-related changes, more rapid changes in anthropometric measurements occur during sexual development. For example, during the adolescent growth spurt, the highest rate of weight gain follows the highest rate of height gain [42]. This leads to an acceleration in the rise of BMI shortly after reaching the peak height velocity, and this rise is more related to pubertal development than chronologic age [42, 43]. Moreover, sexual development occurs at different ages in different populations [44]. As a result, differences between study populations and reference populations in sexual maturation can confound comparisons. Therefore, the comparison of a pre-pubertal child in a study population to post-pubertal individuals of the same age in a reference population would be invalid because the normal BMI for these two persons would be quite different. Chronic undernutrition can also delay sexual maturity and the adolescent growth spurt [4, 5, 44]. This delay can exaggerate differences in age of sexual maturation and the growth spurt between undernourished survey populations and well-nourished reference populations [45].

Associations are also found between sexual development and skinfold thicknesses and MUAC. The onset of puberty changes the rate of subcutaneous fat deposition and fat distribution, as measured by skinfold thickness,[46-49] and these changes occur independently of chronologic age [50]. Similarly, MUAC changes with onset of puberty [47, 49].

Adjustment for differences between the survey and reference populations, as recommended by WHO, requires the collection of data on the age at which certain landmarks of sexual maturation occur in the survey population. Each subject must be assessed

Figure 2 Examples of line drawings of various Tanner stages of sexual development

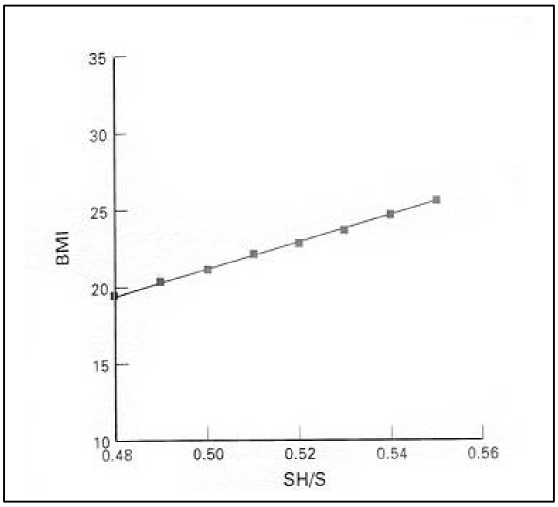


for pubertal changes; however, in practice, judging Tanner breast or genital stages during field surveys is very difficult. Health workers require extensive training and, in most field situations, exposing breasts and genitals of adolescents is not culturally acceptable. The single maturational landmark which might easily be collected in the field is age of menarche. In all populations where adolescents know their ages, age at menarche can be recalled by girls and women, and has been measured successfully in many surveys [2, 4, 43, 49, 51-53]. However, the situation is very different for boys, for whom no such easily obtained landmark exists. Self-assessment of genital and breast stage, using photographs or line drawings, has been validated in some countries, but has not been evaluated in developing countries or in a variety of cultures [54-56]. (See figure 2 for an example of drawings used in self-assessment.)

INTER-ETHNIC DIFFERENCES IN BODY SIZE AND SHAPE

Although well-nourished, healthy children younger than 5 years of age are of similar size and shape worldwide,[57] school-age children and adolescents may not be similar. Older adolescents who have completed their growth spurt and have essentially become adults may reflect adult differences in body shape. Adults display differences in Cormic Index, which is one measure of body shape [58]. Figure 3 demonstrates the substantial effect which differences in Cormic Index have on BMI. As a result, it may be inappropriate to compare older adolescents, who may manifest ethnic differences in anthropometric indices, to a single universal reference population. (See accompanying report on assessment of adult nutritional status for further details [59].)

Figure 3 BMI as a function of Cormic Index in a hypothetical 70 kg, 175 cm man. *(from Norgan, 1994 [58])*



WHICH ANTHROPOMETRIC INDEX?

There are several body measurements and combinations of body measurements that may be useful in assessing the nutritional status of adolescents. Measurements for use in humanitarian emergencies must use inexpensive equipment, be simple to teach to health workers, and be easy to interpret in the field. In addition, the ideal index used to assess adolescent nutritional status in emergencies would allow compensation for differences between the survey and reference populations in age, sexual development, and ethnicity. The measurements most commonly considered for use in emergencies include weight, height and MUAC. Skinfold thickness may also be a useful measure of body protein and fat stores, but is not considered useful in emergencies as it is difficult to obtain accurate measurements, particularly in emergencies.

WEIGHT-FOR-HEIGHT MEASURES

Indices which use weight and height are currently the most frequently used tools to assess adolescent undernutrition. As described above, WHO recommends the use of BMI. To screen adolescents for admission to nutrition programs, other organizations, including Médecins Sans Frontières (MSF) and Action Contre la Faim (ACF), use weight-for-height reference tables extended to older children and adolescents (Michael Golden, personal communication). This method uses existing reference tables of weight-for-age and height-for-age to calculate the median weight and 70% of median weight for adolescents of each sex and height category. These height-specific cut-off points are shown in Annex 1. Although demonstrated to be effective in screening adolescents for admission to therapeutic feeding programs, this table has not been evaluated for use in defining less severe degrees of undernutrition in order to estimate the prevalence of undernutrition in a population of adolescents. Moreover, many of the same drawbacks listed below apply to this use of weight-for-height.

Theoretical problems with indices using weight and height

Lack of data directly correlating measurements to health outcomes - there are no data directly correlating weight-for-height, BMI, or the Rohrer Index with functional or health outcomes in adolescents. Hence, as yet there are no validated cut-offs for these indices to define undernutrition in adolescents.

Age - indices using weight and height are correlated with age. In young children, it is assumed that the index weight-for-height is constant regardless of a child's age. That is, a well-nourished three year-old child is assumed to have the same "ideal" weight as a stunted five year-old child of the same height. Although this assumption may not be entirely true, it does not grossly interfere with the use of weight-for-height in children less than five years of age. In contrast, because adolescents add substantial muscle and fat, especially during sexual development, the normal weight for adolescents of a given height changes substantially depending on their age and pubertal development (figure 1). As a result, when using weight-for-height, it is necessary to collect and record accurate ages. Moreover, use of weight-for-height may also require adjustment for the difference in the age of sexual maturation between the survey population and reference population.

As with weight-for-height, BMI also changes with age [37] (figure 1). Although this association with age is not so strong as with weight-for-height, the use of BMI still requires the collection of accurate ages, and also ages of maturational landmarks from individual subjects.

The Rohrer Index is calculated as the weight in kilograms divided by the height in meters cubed (wt/ht^3). As seen in figure 1, the Rohrer Index may be less age-dependent during adolescence than other indices combining weight and height.

Correlations with height - some studies have found that the Rohrer Index is correlated with height, especially among older adolescents [60-62]. Moreover, there has been very little research on the correlation of the Rohrer Index with other measurements of body protein and fat stores, such as percent body fat. And finally, there is no widely available reference population or established cut-off points for this index.

Practical problems with indices using weight and height

Difficulties in obtaining the component measures during famine - the height and weight measurements required to assess weight-for-height, BMI, and Rohrer Index may be difficult to obtain during an emergency. During severe famines where adolescents are affected, many of the most severely undernourished requiring admission to therapeutic feeding centres cannot stand, making measurement of height impossible. Many studies have reported that gross weakness and flexor contractions prevented measurements of weight or height in a substantial proportion of severely undernourished adults. (See accompanying report on assessment of adult nutritional status for further details [59].) Moreover, the necessary equipment, including scales and height boards, may not be available.

Difficulties in the calculation of the indices - the calculation of BMI and Rohrer Index may be unfamiliar to field workers and therefore more difficult to use than other anthropometric indices.

Famine oedema - regardless of the specific index used, evaluation of nutritional status must take into account the presence or absence of oedema. Many adolescents and adults develop oedema when severely undernourished [1, 63]. This leakage of fluid into tissues artificially increases an individual's weight, which may result in a weight-for-height, BMI, or Rohrer Index which appears more normal than would be expected given the degree of emaciation. In addition, because adolescents and adults with oedema have a poorer prognosis than those who are equally undernourished but do not have oedema, adolescents with oedema should be identified and admitted to appropriate therapy. Although oedema in both feet or legs may be due to other causes, in a situation with a high prevalence of undernutrition, adolescents with bilateral oedema may be severely undernourished and should be referred to a clinician for further diagnosis. They should then be admitted for therapeutic feeding if famine oedema is diagnosed [59, 63].

Pregnancy - indices comparing weight and height cannot be used to assess pregnant adolescents. Because of the extra weight of the foetus, other products of conception, and added maternal tissue, indices using weight and height may not accurately indicate the nutritional status of pregnant adolescents. During pregnancy, other measures, such as weight gain during pregnancy or MUAC, must be used to judge nutritional status.

MUAC

MUAC is relatively simple and easy to measure and has recently been recommended for use in rapid screening of adults for undernutrition to determine the need for admission to a feeding programme[19, 59, 64, 65]. In many well-nourished populations, a reasonable correlation exists between MUAC and BMI in adults. A scheme using a combination of MUAC and BMI has been proposed to categorise the degree of undernutrition in adults [65]. No MUAC cut-offs have been established for the diagnosis of adolescent undernutrition yet. The published results of several nutrition assessment surveys of adolescents in developing countries include MUAC data; however, because of the lack of a reference population and cut-off points, no estimate of the prevalence of undernutrition could be made [4, 7, 51, 53, 66-71].

Theoretical problems with the use of MUAC

Lack of data directly correlating measurements to measurements of body fat and protein stores - there are no data directly correlating MUAC with other measures of body fat and undernutrition, such as BMI, in adolescents. In addition, there are no data relating MUAC cut-off points with functional or health outcomes in adolescents. Hence, as yet there are no validated cut-off points to define undernutrition with MUAC measurements in adolescents.

Age - MUAC changes substantially with age during adolescence, as shown in several reference populations from industrialised countries [41, 72]. As a result, a different cut-off point must be used for adolescents of different ages. This requires an accurate age for each survey subject in order to judge whether they fall above or below an age-specific cut-off point.

Sexual development - MUAC changes with sexual development. The rapid addition of soft tissue, predominantly muscle tissue in males and subcutaneous fat in females, which occurs with puberty results in a more rapid rise in MUAC at this time than prior to or following puberty. One study clearly demonstrates a greater MUAC in postmenarcheal female adolescents than premenarcheal female adolescents of the same age [53].

Ethnicity - ethnic differences in MUAC have not been sufficiently studied to determine if a single cut-off point for MUAC could be used for adolescents in all ethnic groups.

Practical problems with the use of MUAC

Measurement error - in spite of the convenience and ease of measurement, MUAC measurement requires careful training and supervision in order to prevent wrapping the measuring tape too tightly or too loosely, which results in an erroneous estimate. One study estimated that the smallest change over time detectable in MUAC was 8-10%, when measurements were taken by different observers[73]. A second study demonstrated that MUAC measurements show more inter-observer variability than weight and height measurements [74].

MUAC should be measured at the mid-point of the upper arm between the shoulder (lateral end of the clavicle) and elbow (inferior tip of the olecranon). Although this not critical in young children who often have little muscle contour in the upper arm, it becomes increasingly important in post-pubertal adolescents who have developed adult musculature. Therefore workers will have to be carefully trained to measure adolescent MUACs.

POSSIBLE SOLUTIONS FOR THE FUTURE

No single method has proved adequate for assessment of undernutrition in adolescents in emergency situations. Below are listed some possible strategies for overcoming the major difficulties.

CHANGES IN BODY PROPORTIONS WITH AGE

An anthropometric index that is unrelated to age is required if adolescents do not know their ages. The Rohrer Index may offer such advantages over weight-for-height, BMI, or MUAC. Further research is required in this area.

PUBERTAL DEVELOPMENT

Simpler methods of determining pubertal stage may, in the future, allow adjustment for this complicating factor. Such methods could include appropriate line drawings or photographs of different Tanner stages. In contrast, it may be easier and more accurate when assessing adolescents to consider pre-pubertal and post-pubertal adolescents separately. Ideally, this would require the assessment of the presence or absence of only one landmark of sexual development, rather than the determination of different levels of a development indicator, such as Tanner breast or genital stages. Such separation may make it possible to include pre-pubertal adolescents with school age children and post-pubertal adolescents with adults when choosing which anthropometric indicator or cut-off point to use.

INTER-ETHNIC DIFFERENCES IN GENETIC GROWTH POTENTIAL

A method has been proposed to account for at least part of the difference in body shape in adults by calculating a BMI which is adjusted for the Cormic Index [75-77]. However, this procedure remains untested in adolescents (Nicholas Norgan, personal communication). Theoretically, such an adjustment could also be applied to other anthropometric indices calculated from weight and height, such as weight-for-height or the Rohrer Index. The application of this technique to adolescents may be complicated by the normal changes in Cormic Index throughout adolescence. Moreover, some data indicate that chronic undernutrition changes the Cormic Index [78]. Stunted children may have a greater Cormic Index than comparable children without stunting.

An additional method of compensating for ethnic differences would be to choose different, more appropriate cut-off points (either % of median or z-scores) to define undernutrition when using a reference population whose ethnicity differs from that of the survey population. Some populations may be genetically thinner than the reference population, requiring a lower cut-off to define undernutrition. WHO recommends such a procedure when using anthropometry to screen persons for admission to nutritional rehabilitation [12]. Nonetheless, the procedure of determining appropriate cut-off points is not simple. Such a process would require either data on health outcomes in order to estimate a functional cut-off or data on a well-nourished population of similar ethnicity in order to derive a statistically-defined cut-off point. Collection of such data for multiple ethnic groups would be expensive and time-consuming.

Using a local reference would permit comparison of a survey population to well-nourished adolescents of the same ethnicity. Although this has been used in published surveys [79], creation of a reference population is a difficult task requiring substantial resources. Separate reference populations cannot be created for each nationality or ethnicity. An alternate possibility would be to create a few reference populations for use with major ethnic categories. Investigators could then choose a reference which most closely matches the survey population. For example, if a survey population is known to have an average Cormic Index of 0.50, the investigators would use a reference population with a similar average Cormic Index. Of course, such a strategy would make comparison of the results of different surveys very difficult if they used different reference populations to calculate the prevalence of undernutrition. In addition, it would require measuring sitting height as well as standing height in all surveys of adolescents.

A single, international reference population consisting of adolescents from multiple countries could be used, similar to that currently under development for children less than 5 years of age. A reference population described in recently published work includes children and adolescents from national surveys done in six countries [80]. In this proposal, cut-off points for BMI to define overweight and obesity were identified by determining the centile among 18 year-old adolescents in each national survey population which matched the adult BMI cut-off points of 25 and 30. That centile was then applied separately for males and females to each one-half year age group from 2-17.5 years to determine the cut-off BMI value at for each age and sex group. The cut-off points for each national population were then averaged to produce age- and sex-specific cut-off points for the combined international reference. The same procedure could be used to determine cut-off points which correspond to the adult cut-off points for various degrees of undernutrition, i.e., BMI of 16, 17, and 18.5 kg m^{-2}. This proposed reference and the method of determining cut-off points for BMI eliminates the bias which may result from using as a reference a sample from a relatively obese population, such as American adolescents. However, its use still requires accurate ages because the BMI cut-offs change substantially with age, and it does not correct for differing ages of sexual maturation. In addition, the reference proposed may not be appropriate for populations with different body shape, such as Nilotic Africans and Australian aborigines.

USE OF OTHER DATA

When assessing adolescents, additional data from the same population should be collected. Such data could include the prevalence of undernutrition in young children, the prevalence of undernutrition in adults, rates of morbidity and mortality, and information on food security, food distribution, and alternate sources of food. If a survey of adolescents indicates substantial undernutrition, but data on young children, adults, and other population groups do not demonstrate undernutrition or elevated morbidity or mortality, it is very important to look critically at the adolescent data. *It is unlikely that adolescents are the only population group with substantial undernutrition.*

Unless anthropometric measures are valid, i.e., they truly measure nutrition and health, they may not be useful at all. Other measures, such as strength or other functional outcomes, may better reflect an individual's risk of nutrition-related morbidity or mortality. Experience in screening adults for admission to therapeutic feeding programmes has demonstrated that three clinical signs (apparent dehydration, oedema, and inability to stand) predict mortality better than BMI [59, 63]. Such an approach, although as yet untested in adolescents, may be able to distinguish adolescents in need of therapeutic feeding from those who could benefit from a less intensive feeding program. However, clinical signs may not be useful for measuring the overall prevalence of lesser degrees of undernutrition in a population because persons with less severe undernutrition may not be so markedly impaired nor exhibit such a distinctive clinical picture.

Measures of muscle function, such as grip strength, shuttle run, or maximum jump height, may be able to detect moderate degrees of wasting. One author proposes that muscle performance may actually be affected earlier in the course of undernutrition than body composition [81]. In one study among surgical patients, hand grip was associated with MUAC, and those patients with hand grip less than 85% of normal did much poorer postoperatively [82]. In a second study, muscle strength, as measured by grip strength, endurance run, shuttle run, distance throw, and standing long jump, was greater in normally-nourished children 4-6.5 years of age than undernourished children [83]. However, in this study, muscle strength was correlated with stature, and after removing the effect of this variable, well-nourished and poorly-nourished children no longer differed in muscle strength. A third study that directly stimulated the ulnar nerve and measured isometric muscle contractions did not find a difference between undernourished and normally nourished adults [84]. Clearly, such measures are not ready to be used in the field. Much more work needs to be done to determine whether appropriate measures of muscle function exist, to describe a reference population and cut-off points, and to determine the sensitivity and specificity of proposed methods to detect moderate and severe undernutrition.

FUTURE RESEARCH NEEDS

Certain questions need to be answered before definite recommendations can be made regarding the best method of assessing nutritional status in adolescents.

Anthropometric index - the association of various indices, such as weight-for-height, BMI, and Rohrer Index, with age and height should be further explored in adolescents. Such exploration should include analysis of existing data from past surveys that measured weight, height, MUAC, and age of adolescents. Re-analyses using data from populations with a variety of health conditions and various degrees of undernutrition could be undertaken. In addition to investigating the association between anthropometric indices and age and height, future analyses of survey data could include estimates of the error induced in the estimated prevalence of undernutrition by various degrees of uncertainty about age. The index chosen should be the least dependent on age in order to minimize the effect of using inaccurate ages.

Defining functional cut-offs - longitudinal studies are required to determine whether adolescents falling below specific cut-off points for weight-for-height, BMI, and Rohrer Index have elevated morbidity or mortality, poor pregnancy outcome, suppressed growth, or decreased work ability or physical performance measures. These studies should be conducted in a variety of situations among adolescents with different levels of undernutrition.

Practicality of measurements and calculations - the practicality of obtaining various measures should be explored in field situations. Survey organizers should assess the ease of training survey workers in measuring MUAC, weight, and height, as well as assessing inter-observer variability when measuring adolescents.

Markers of pubertal development - the accuracy of self-reported Tanner stage for breast and genital development among female and male adolescents needs to be tested in a variety of populations. For example, adolescents' self-assessment upon viewing drawings or photographs of different Tanner stages could be compared to findings of physical examinations. Studies could also explore the use of other markers of sexual development, such as the extent of axillary hair. Moreover, the ages at which various landmarks of sexual development are achieved should be described in many different populations, both normally-nourished and undernourished, in order to determine which markers can be used for adjusting for different developmental ages between survey and reference populations.

Adjusting for differences in body shape - surveys should explore the utility of adjusting anthropometric indices for differences in body shape by using the Cormic Index or other indicators of body shape in distinct populations.

Vulnerability - more nutrition surveys should include assessments of the nutritional status of different age groups to determine the relative vulnerability of young children, adolescents, women of child-bearing age, elderly, and other population subgroups in different types of humanitarian emergencies.

Use of anthropometry at all - other measures, such as strength or other functional outcomes, may better reflect an individual's risk of nutrition-related morbidity or mortality and should be explored as indicators of adolescent nutritional status.

CONCLUSIONS AND RECOMMENDATIONS

A fundamental dilemma exists in trying to measure adolescent undernutrition: a system simple enough for a non-expert is required for use in emergencies, but the reality of adolescent undernutrition is very complex. Until better tools for nutritional assessment of adolescents are developed, current recommendations regarding the use of anthropometry in adolescents must be critically examined. Their use may yield misleading results that stimulate inappropriate interventions. Given the lack of validated anthropometric procedures, anthropometric measurement of adolescents should not currently be used as the sole technique for the nutritional assessment of adolescents. Such assessments should include evaluation of the nutritional status of other population subgroups, clinical evaluation of adolescents, evaluation of food uses and access, and measurement of the levels of morbidity and mortality among adolescents and adults.

No standard method of anthropometric assessment of the nutritional status of adolescents can be recommended at this time. However, recent developments have suggested potential methods that may be used until the results of the research described above are available and a method can be recommended. The following components should be included in any anthropometric assessment of adolescents:

- ***Screening for severe undernutrition*.** Until better methods can be developed and validated, screening for severe undernutrition in order to determine the need for therapeutic feeding should use clinical criteria as recommended for adults [59].
- ***Correction for differences in age of sexual maturation*.** Some measure of the age of specific pubertal landmarks should be measured during nutrition surveys of adolescents. Measures that may be useful include age of menarche in females. Unfortunately, validated markers that are practical for field use do not exist for males. Correction for differences between the survey population and the reference population should be undertaken if the necessary data are available for the reference population used.
- ***Prepubertal adolescents*.** Because young adolescents may be more similar to children, the most appropriate index for use in measuring undernutrition prevalence among prepubertal adolescents may be weight-for-height, at least until other indices are more fully investigated. Individuals can be compared to an existing reference using the preliminary weight-for-height tables in Annex 1. Data from this original reference population should be recalculated to provide direct weight-for-height cut-off points.
- ***Postpubertal adolescents.*** Because older adolescents may be more similar to adults, BMI should be used until other indices have been more fully investigated. Nonetheless, some linear growth continues and BMI continues to change with age after attaining sexual maturity. As a result, cut-off points should be age-specific. Although several reference populations exist for which BMI centiles and/or z-scores have been calculated, the international reference population described by Cole [80] may be the best reference currently available for use in the developing world. The method for creating age-specific cut-off points described by Cole should be used to determine cut-off points, in both percent of median and z-scores, corresponding to the adult BMI cut-off points of 16, 17, and 18.5 kg m^{-2}.
- ***Reference populations*.** The reference population of American adolescents, currently recommended by WHO for use with BMI, should not be used.
- ***Age*.** Both weight-for-height and BMI are age-dependent. Therefore, when these indices are used, age must be collected as accurately as possible for each survey subject or individual screened. It may be necessary to construct a local calendar to determine ages, although this may be difficult with adolescents because of the many years since birth. It may also be necessary to investigate the existence of systematically biased reporting of age which could lead to substantial under- or over- estimation of the prevalence of undernutrition when using weight-for-height or BMI.
- ***Additional data.*** Adolescents should not undergo nutritional assessment in isolation. Young children, women of child-bearing age, adults, elderly, or other population subgroups should also be assessed. A large discrepancy between the estimated level of undernutrition in adolescents and other population subgroups should stimulate investigation of the validity of the methods and results of the adolescent assessment.
- ***Comparison of surveys*.** In order to assess the methods and comparability of surveys, all survey reports should describe in detail the anthropometric index used, how measurements were taken, which reference population was used, how individuals were compared to this reference, the cut-off points used to define various degrees of undernutrition, and any other ancillary data collected on the population of interest.

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ANNEX 1

Median and 70% of median weights for various heights, for males and female adolescents. Data from Michael Golden.

	Weight (kgs)			
	Males		*Females*	
Height (cm)	*Median*	*70% of median*	*Median*	*70% of median*
100.0	15.916	11.141	15.565	10.896
100.5	16.046	11.232	15.686	10.980
101.0	16.177	11.324	15.807	11.065
101.5	16.308	11.416	15.928	11.150
102.0	16.440	11.508	16.050	11.235
102.5	16.574	11.601	16.172	11.320
103.0	16.707	11.695	16.294	11.406
103.5	16.842	11.789	16.418	11.492
104.0	16.978	11.884	16.541	11.579
104.5	17.114	11.980	16.666	11.666
105.0	17.252	12.076	16.791	11.754
105.5	17.391	12.173	16.917	11.842
106.0	17.530	12.271	17.044	11.931
106.5	17.671	12.370	17.172	12.021
107.0	17.813	12.469	17.301	12.111
107.5	17.957	12.570	17.432	12.202
108.0	18.101	12.671	17.564	12.295
108.5	18.247	12.773	17.697	12.388
109.0	18.395	12.876	17.833	12.483
109.5	18.544	12.981	17.970	12.579
110.0	18.694	13.086	18.109	12.676
110.5	18.846	13.192	18.250	12.775
111.0	19.000	13.300	18.394	12.876
111.5	19.156	13.409	18.540	12.978
112.0	19.313	13.519	18.689	13.083
112.5	19.473	13.631	18.841	13.189
113.0	19.634	13.744	18.996	13.297
113.5	19.797	13.858	19.154	13.408
114.0	19.963	13.974	19.316	13.521
114.5	20.131	14.092	19.481	13.637
115.0	20.301	14.211	19.650	13.755
115.5	20.474	14.331	19.823	13.876
116.0	20.649	14.454	20.000	14.000
116.5	20.826	14.578	20.181	14.127
117.0	21.006	14.705	20.367	14.257
117.5	21.189	14.833	20.558	14.390
118.0	21.375	14.963	20.753	14.527
118.5	21.564	15.095	20.954	14.668
119.0	21.756	15.229	21.160	14.812
119.5	21.951	15.366	21.371	14.960
120.0	22.149	15.504	21.588	15.112
120.5	22.350	15.645	21.811	15.267
121.0	22.555	15.789	22.036	15.425
121.5	22.763	15.934	22.270	15.589
122.0	22.975	16.083	22.510	15.757
122.5	23.190	16.233	22.756	15.929
123.0	23.409	16.387	23.008	16.105
123.5	23.632	16.542	23.265	16.285
124.0	23.859	16.701	23.527	16.469
124.5	24.089	16.862	23.794	16.656
125.0	24.323	17.026	24.066	16.846
125.5	24.561	17.193	24.344	17.040
126.0	24.803	17.362	24.625	17.238

	Weight (kgs)			
	Males		Females	
Height (cm)	Median	70% of median	Median	70% of median
126.5	25.050	17.535	24.912	17.438
127.0	25.308	17.716	25.202	17.642
127.5	25.563	17.894	25.497	17.848
128.0	25.822	18.075	25.796	18.057
128.5	26.084	18.259	26.098	18.269
129.0	26.351	18.446	26.404	18.483
129.5	26.622	18.635	26.714	18.700
130.0	26.896	18.828	27.027	18.919
130.5	27.175	19.022	27.343	19.140
131.0	27.457	19.220	27.662	19.363
131.5	27.743	19.420	27.984	19.589
132.0	28.032	19.622	28.308	19.816
132.5	28.325	19.827	28.635	20.044
133.0	28.621	20.035	28.963	20.274
133.5	28.921	20.244	29.294	20.506
134.0	29.223	20.456	29.627	20.739
134.5	29.529	20.670	29.961	20.973
135.0	29.838	20.887	30.297	21.208
135.5	30.150	21.105	30.634	21.444
136.0	30.464	21.325	30.973	21.681
136.5	30.782	21.547	31.312	21.918
137.0	31.101	21.771	31.652	22.156
137.5	31.424	21.997	31.993	22.395
138.0	31.748	22.224	32.334	22.634
138.5	32.075	22.453	32.676	22.873
139.0	32.404	22.683	33.018	23.113
139.5	32.735	22.915	33.360	23.352
140.0	33.068	23.148	33.703	23.592
140.5	33.403	23.382	34.044	23.831
141.0	33.739	23.618	34.386	24.070
141.5	34.078	23.854	34.727	24.309
142.0	34.417	24.092	35.068	24.548
142.5	34.758	24.331	35.408	24.786
143.0	35.101	24.571	35.748	25.023
143.5	35.445	24.811	36.086	25.260
144.0	35.790	25.053	36.424	25.497
144.5	36.136	25.295	36.760	25.732
145.0	36.483	25.538	37.093	25.965
145.5	36.831	25.781	37.428	26.199
146.0	37.179	26.026	37.762	26.433
146.5	37.546	26.282	38.095	26.667
147.0	37.897	26.528	38.429	26.900
147.5	38.249	26.774	38.763	27.134
148.0	38.602	27.021	39.099	27.369
148.5	38.957	27.270	39.436	27.605
149.0	39.313	27.519	39.774	27.842
149.5	39.671	27.770	40.115	28.080
150.0	40.031	28.021	40.458	28.321
150.5	40.393	28.275	40.805	28.564
151.0	40.757	28.530	41.155	28.809
151.5	41.124	28.787	41.510	29.057
152.0	41.494	29.046	41.878	29.315
152.5	41.867	29.307	42.244	29.571
153.0	42.243	29.570	42.616	29.831
153.5	42.622	29.835	42.995	30.096
154.0	43.004	30.103	43.382	30.367
154.5	43.391	30.373	43.779	30.645
155.0	43.781	30.647	44.186	30.930
155.5	44.175	30.923	44.606	31.224
156.0	44.574	31.202	45.041	31.528

	Weight (kgs)			
	Males		Females	
Height (cm)	**Median**	**70% of median**	**Median**	**70% of median**
156.5	44.976	31.483	45.494	31.845
157.0	45.384	31.769	45.969	32.178
157.5	45.797	32.058	46.473	32.531
158.0	46.214	32.350	47.011	32.907
158.5	46.637	32.646	47.588	33.312
159.0	47.064	32.945	48.215	33.750
159.5	47.496	33.247	48.901	34.231
160.0	47.932	33.553	49.665	34.765
160.5	48.374	33.862	50.533	35.373
161.0	48.820	34.174	51.550	36.085
161.5	49.271	34.490	52.803	36.962
162.0	49.728	34.809	54.449	38.114
162.5	50.189	35.132	56.089	39.262
163.0	50.655	35.459	56.662	39.664
163.5	51.128	35.790	56.694	39.686
164.0	51.605	36.124		
164.5	52.088	36.462		
165.0	52.576	36.803		
165.5	53.070	37.149		
166.0	53.570	37.499		
166.5	54.076	37.853		
167.0	54.588	38.212		
167.5	55.107	38.575		
168.0	55.633	38.943		
168.5	56.166	39.316		
169.0	56.706	39.694		
169.5	57.255	40.078		
170.0	57.812	40.468		
170.5	58.379	40.865		
171.0	58.955	41.269		
171.5	59.543	41.680		
172.0	60.144	42.101		
172.5	60.759	42.531		
173.0	61.390	42.973		
173.5	62.040	43.428		
174.0	62.713	43.899		
174.5	63.416	44.391		