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**Symposium on
'Adolescent nutrition: are we doing enough?'**

**Symposium de
'La nutrition de l'adolescent: en faisons-nous assez pour elle?'**

Adolescent nutritional status in developing countries

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Statut nutritionnel des adolescents dans les pays en développement

RÉSUMÉ

L'intérêt porté par le monde pour l'adolescence s'est considérablement accentué dans la dernière décennie. Une grande partie de l'attention a porté sur la santé de l'adolescent, en particulier sur la grossesse de l'adolescente et sur les maladies sexuellement transmissibles, y compris l'infection à HIV, mais le statut nutritionnel de l'adolescent a suscité peu d'intérêt. Onze études sur le statut nutritionnel d'adolescents garçons et filles ont été menées récemment dans neuf pays en développement (une au Bénin, au Cameroun, en Equateur, en Inde, à la Jamaïque, au Mexique, au Népal, et deux au Guatemala et aux Philippines). Ces études étaient très différentes quant au protocole, à la taille de l'échantillon, et à la méthode de recueil des données. L'anémie était le problème nutritionnel le plus important, avec une prévalence élevée dans quatre des six études où elle a été mesurée (55% en Inde, 42% au Népal, 32% au Cameroun, et 48% dans l'étude métabolique du Guatemala) et une certaine prévalence dans deux autres (17% en Equateur et 16% à la Jamaïque). Le ralentissement de la croissance avait une prévalence élevée dans neuf des études (27–65%). La taille aussi bien chez les filles que chez les garçons de ces neuf études ne s'est pas améliorée au cours des huit années de l'adolescence: elle approchait le 5ème percentile à l'âge de 10 ans et à l'âge de 18 ans. Un BMI faible n'avait une prévalence élevée que dans trois de ces études (23–53%). De façon surprenante, il est apparu que les garçons avaient par rapport aux filles au moins deux fois la prévalence du faible BMI relatif à des données de référence spécifiques de sexe. A la différence de la croissance en taille, le BMI augmentait substantiellement au cours des huit années d'adolescence chez toutes les filles, que leur BMI ait été faible ou satisfaisant à l'âge de 10 ans, mais seulement chez les garçons dont le BMI était faible à l'âge de 10 ans. A l'âge de 18 ans, la médiane du BMI pour les filles et les garçons était bien au-dessus du 5ème percentile. Cependant dans les trois pays où était observé une médiane faible pour le BMI à l'âge de 10 ans, les garçons n'avaient pas atteint le 50ème percentile et continuaient à grandir, tandis que les filles avaient atteint le 50ème percentile et avaient arrêté de grandir. Ces résultats suggèrent que le statut en fer des adolescents a besoin d'être amélioré, mais qu'il faut être prudent lorsqu'il s'agit d'améliorer leur taille si le BMI est adéquat à l'âge de 18 ans.

World interest in adolescence has grown dramatically in the past decade. Adolescents, defined by World Health Organization (1986) as persons aged 10–19 years, comprise

20% of the global population. A remarkable 84% of adolescents are in developing countries (United Nations, 1990), and their percentage there relative to other age-groups is rising (Blum, 1991). Much of the interest has been on adolescent health, focusing largely on the increasing incidence of adolescent pregnancy and sexually-transmitted disease, including human immunodeficiency virus (HIV) infection. Little of the attention has been on nutrition.

From another disciplinary approach, there has long been interest in reducing undernutrition in developing countries. These efforts have essentially focused on children aged 0–5 years, because much growth retardation occurs during these early years, and because the benefits from healthy growth will be realized for so many years in the future. There is also a focus on pregnant women, and to some extent on lactating women, but primarily for the nutritional benefits that accrue to their young children. Within the nutrition efforts in developing countries, traditionally, attention has not been paid to adolescents.

The purpose of the present review is to begin to bridge the gap between these two disciplinary areas. It seeks to inform adolescent health promoters about the nutrition concerns that should be added to their portfolio, and to inform nutrition promoters in developing countries about the advantages of an additional focus on adolescents. The review is based predominantly on results from the Nutrition of Adolescent Girls Research Program, a set of eleven studies in developing countries coordinated at the International Center for Research on Women (ICRW) between 1990 and 1994 and supported by the US Agency for International Development, because little other information was available (Kurz *et al.* 1994).

METHODS

The Nutrition of Adolescent Girls Research Program included five studies in Latin America and the Caribbean (Ecuador, Mexico, two in Guatemala, and Jamaica), four in Asia (Nepal, India, and two in the Philippines), and two in sub-Saharan Africa (Benin and Cameroon). Nutritional status and other aspects of the lives of adolescent girls and boys were described, such as their health, educational factors, activities and self-perceptions (Kurz & Johnson-Welch, 1994). Described here are only the findings on anaemia, height and BMI.

The eleven studies had a variety of designs (Table 1). For example, the Ecuador study sample was nationally representative. Other samples were chosen from within certain villages or urban areas, usually lower-income areas. Sample sizes ranged from twenty-four to approximately 2000 adolescents. Two studies were extensions of longitudinal supplementation trials: one in Guatemala (based at the Institute of Nutrition of Central America and Panama) and one in Mexico (based at the National Institute of Nutrition). In both cases, the children who were adolescents in 1992 were born into the study, and received food supplementation from about 3 months to 7 or 10 years of age. Eight studies were cross-sectional in nature, that is, adolescents were studied only in 1992 and 1993. Finally, one study was an intervention during adolescence, evaluating whether food supplementation increased growth hormone levels. In the other ten studies, there were no interventions during adolescence.

Table 1. Design features of the eleven studies comprising the Nutrition of Adolescent Girls Research Program of the International Center for Research on Women

Study countries	Sample size	Age range (years)	Design	Location
India (Potdar, unpublished results)	69 Males 69 Females	10-19	School-based, girls and their brothers	Bombay urban slums
Nepal (Regmi & Adhikari, 1994)	179 Males 148 Females	10-18	Community-based	Three villages, western rural Nepal
Benin (Inoussa <i>et al.</i> 1994)	179 Males 171 Females	12-18	Community-based	Four villages, southern rural Benin
Philippines: Cebu (Roldan <i>et al.</i> 1994)	94 Males 96 Females	12-19	School-based	Cebu City, urban and Vigan, rural four schools
Ecuador (de Grijalva & Grijalva, 1994)	865 Males 1092 Females	10-19	Nationally representative	Coast and Highlands; urban and rural
Philippines: Mindanao (Bouis <i>et al.</i> 1994)	290 Males 208 Females	12-19	Community-based	Bukidnon rural
Cameroon (Kurz & Ngo Som, 1994)	163 Males 302 Females	12-19	School-based and fifty not in school	Forest and Sahel zones; urban and rural
Mexico (Chavez <i>et al.</i> 1994)	41 Males 41 Females	12-19	Longitudinal, food supplementation from birth to 10 years	One village, rural Puebla
Guatemala: Metabolic (Torún <i>et al.</i> 1995)	24 Females	10-12	Food supplementation (2510 kJ/d) at age 10-12 years, crossover design, stunted girls selected	Guatemala City urban secondary schools
Guatemala: Longitudinal (Martorell <i>et al.</i> 1994)	1061 Females	9-23	Longitudinal, food supplementation from birth to 7 years	Four villages; rural eastern highlands
Jamaica (Walker <i>et al.</i> 1994)	452 Females	13-14	School-based	Kingston; nine urban secondary schools

ANAEMIA

It is well known that women of reproductive age have poor Fe status (an estimated prevalence of 47% across developing countries), and that it worsens during pregnancy (59%; DeMaeyer & Adiels-Tegman, 1985). Among women who have one or more children, poor Fe status is considered largely due to pregnancy.

Adolescence is an ideal time to study pre-pregnancy Fe status because many girls around the world (at least 25%) will have had their first child by age 19 years, and a great many more shortly thereafter (Senderowitz, 1995). Furthermore, adolescent girls and boys may be developing Fe deficiency anaemia because of rapid growth and the start of menstruation (Brabin & Brabin, 1992). Despite strong reasons for focusing on anaemia during adolescence, little research has been done on it. Of 523 studies on anaemia reviewed for World Health Organization, only thirty-nine included adolescents. The estimated prevalence of anaemia in adolescents among the thirty-two studies from developing countries was 27%, compared with 6% in developed countries (DeMaeyer & Adiels-Tegman, 1985).

In the studies in the ICRW program, anaemia was the greatest nutritional problem the adolescents in the studies experienced. It was highly prevalent according to haemoglobin levels and cut-off values from the International Nutritional Anemia Consultative Group (1985) in four of the six studies in which it was assessed: India 55% (R. D. Potdar, I. Parikh and S. M. Rege, unpublished results), Nepal 42% (Regmi & Adhikari, 1994), Cameroon 32% (Kurz & Ngo Som, 1994), the Guatemala metabolic study 48% (Torún *et al.* 1995). In the Guatemala metabolic study with a sample size of twenty-four girls, prevalence was assessed as percentage of participants who experienced >5 g/l increase in haemoglobin after 3 months of Fe supplementation. There was a moderate prevalence in two other studies: Ecuador, according to packed cell volume levels adjusted for altitude, 17% (de Grijalva & Grijalva, 1994); Jamaica, according to haemoglobin levels, 16% (Walker *et al.* 1994).

Boys experienced as much anaemia as girls in two of the three studies which had enrolled both girls and boys (India, Cameroon and the Guatemala longitudinal study), and in Ecuador more boys were anaemic than girls (20% of boys and 15% of girls, $P < 0.05$). Girls are often expected to have higher rates of anaemia than boys because of Fe lost during menstruation, but because they are developing muscle mass, boys also have high Fe requirements. It is not known whether there are functional consequences of transient anaemia among boys during adolescence.

To explore the response of Fe status to intervention, a food supplement that contained 100% of the recommended daily allowance for Fe was given in the Guatemala metabolic study. Haemoglobin levels increased on intake of the Fe supplement, but then fell when only the placebo was taken. This suggests that while Fe status can improve rapidly with supplementation, additional interventions are needed to maintain the improved status.

STUNTING

Stunting among adolescents is of interest for several reasons, both of which reflect future risks. First, a short woman tends to have a small pelvis and, therefore, is more likely to have obstructed labour during childbirth. Second, 25% of a person's attained height is achieved during adolescence, which marks the end of growth in height and the

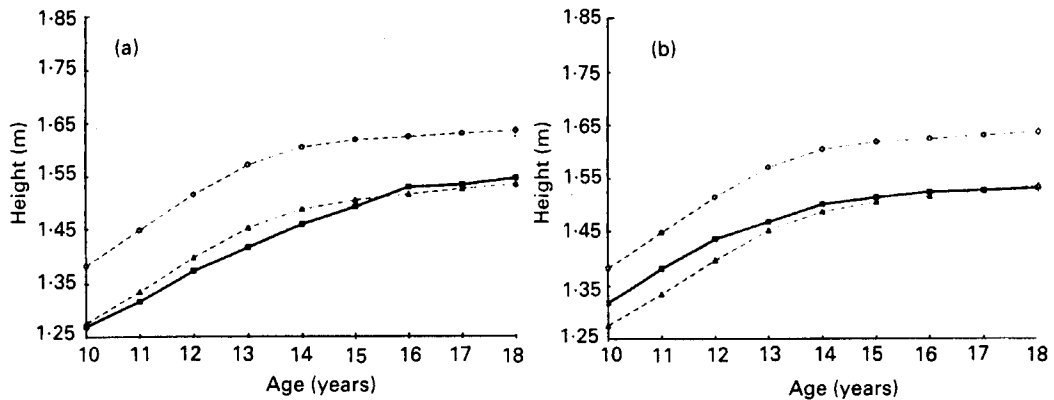


Fig. 1. Height of adolescent girls by age in the (a) Nepal and (b) Ecuador studies within the Nutrition of Adolescent Girls Research Program of the International Center for Research on Women. (●), 50th Percentile of the National Center for Health Statistics (NCHS) reference data (Hammill *et al.* 1979); (■), adolescent data from Nepal or Ecuador; (▲), 5th percentile of the NCHS reference data.

attainment of adult height. Stunting is defined as height-for-age less than the 5th percentile of the National Center for Health Statistics (NCHS; Hammill *et al.* 1979) and World Health Organization (1995) reference data.

Stunting among adolescents was highly prevalent in nine of the ICRW studies: Philippines (Midanao) 65% (Bouis *et al.* 1994), Mexico 62% (Chávez *et al.* 1994), Guatemala (longitudinal) 57% (Martorell *et al.* 1994), Ecuador 50% (de Grijalva & Grijalva, 1994), Nepal 47% (Regmi & Adhikari, 1994), Philippines (Cebu) 43% (Roldan *et al.* 1994), Benin 41% (Inoussa *et al.* 1994), India 32% (R. D. Potdar, I. Parikh and S. M. Rege, unpublished results), Guatemala (metabolic) 27% (Torún *et al.* 1995). Short stature among adolescents is caused in large part by infection and inadequate dietary intake during the first 3 years of life. Height is difficult to make up during the later childhood years and so these children are still short when they reach adolescence. Only in Jamaica and Cameroon, where nutritional status is known to be relatively good, was there little stunting (2% (Walker *et al.* 1994) and 12% (Kurz & Ngo Som, 1994) respectively).

The pattern of girls' growth in height during adolescence was remarkably similar across the nine studies in which stunting was highly prevalent, and is shown here for the Nepal and Ecuador studies (Fig. 1). The pattern is that the mean height of girls did not improve across the 8 years of adolescence for which data were collected. Mean height was near the 5th percentile at the ages of 10 and 18 years. Only small regional variations occurred. Girls' height in Nepal actually dipped slightly at the middle of the age-range. In Ecuador, it started above the 5th percentile, but then lost momentum relative to the reference data, decreasing steadily to the 5th percentile by the age of 18 years.

The pattern of boys' growth in height during adolescence was also remarkably similar across the nine studies in which stunting was highly prevalent, and was almost similar to that of the girls. Values are shown here also only for Nepal and Ecuador (Fig. 2). Boys' height, like that of the girls, did not improve across the 8 years of adolescence. In both studies, boys' height was slightly above the 5th percentile at the age of 10 years and was slightly below the 5th percentile by the age of 18 years.

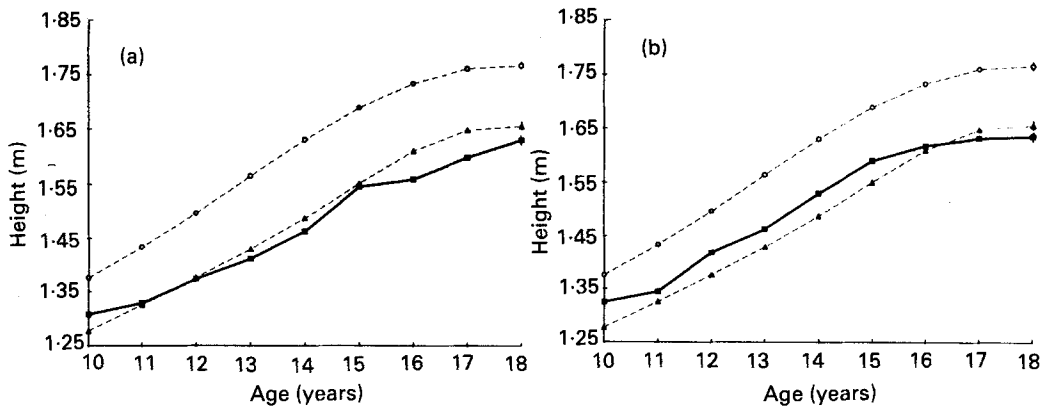


Fig. 2. Height of adolescent boys by age in the (a) Nepal and (b) Ecuador studies within the Nutrition of Adolescent Girls Research Program of the International Center for Research on Women. (●), 50th Percentile of the National Center for Health Statistics (NCHS) reference data (Hammill *et al.* 1979); (■), adolescent data from Nepal or Ecuador; (▲), 5th percentile of the NCHS reference data.

UNDERNUTRITION

Adolescence is an important time for gains in weight as well as height. Both muscle and fat increase, with girls gaining relatively more fat, and boys gaining relatively more muscle. Undernutrition (low weight) is of particular interest because it results in poor pregnancy outcomes, in particular low birth weight (Kramer, 1987). Undernutrition may also limit school achievement and work productivity, but this has not been investigated among adolescents. Undernutrition is defined as BMI (weight/height²) less than the 5th percentile of the NCHS (Must *et al.* 1991a,b) and World Health Organization (1995) reference data.

Undernutrition among adolescents was highly prevalent in only three of the studies: India 53% (R. D. Potdar, I. Parikh and S. M. Rege, unpublished results), Nepal 36% (Regmi & Adhikari, 1994), Benin 23% (Inoussa *et al.* 1994). It was of relatively low prevalence in the other eight countries (3–13%).

In seven of the eight studies with both boys and girls, at least twice as many boys as girls were undernourished. Only in the Mexico study, where the sample size may have been too small to detect a difference that was statistically significant, was this not the case. The disproportionate number of boys experiencing undernutrition was a surprise, and warrants further investigation.

The pattern of girls' growth, in terms of BMI, during adolescence was remarkably similar across studies in the ICRW programme, but was typified by two different starting points, as shown in the comparison between the Nepal and Ecuador studies (Fig. 3). In both studies, mean BMI increased substantially relative to the reference data across the 8 years of adolescence for which data were collected. This is in striking contrast to the lack of increase observed in height relative to the reference data. In the Nepal study, girls started at the age of 10 years near the 5th percentile for BMI and by the age of 18 years were near the 50th percentile, whereas in the Ecuador study, girls started at the 50th percentile and by age of 18 years were well above it.

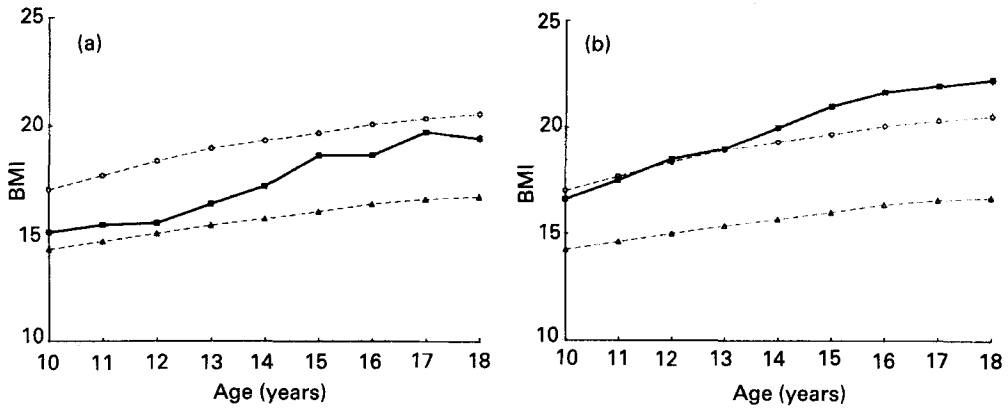


Fig. 3. BMI of adolescent girls by age in the (a) Nepal and (b) Ecuador studies within the Nutrition of Adolescent Girls Research Program of the International Center for Research on Women. (●), 50th Percentile of the National Center for Health Statistics (NCHS) reference data (Hammill *et al.* 1979); (■), adolescent data from Nepal or Ecuador; (▲), 5th percentile of the NCHS reference data.

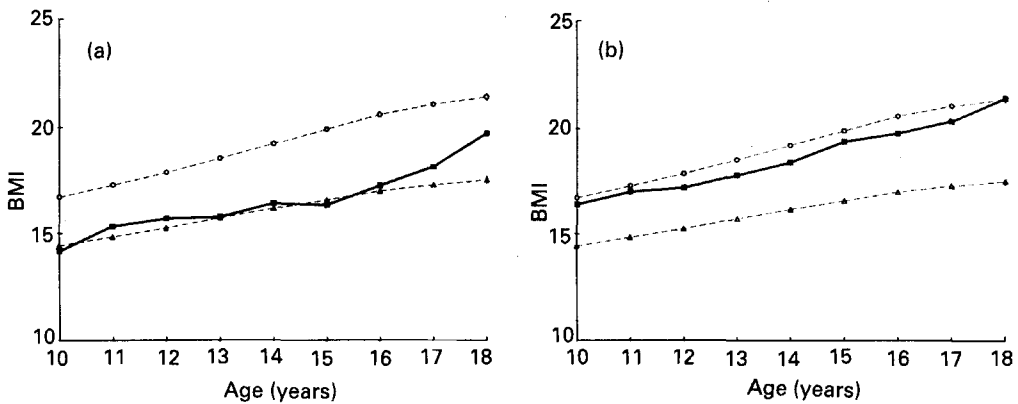


Fig. 4. BMI of adolescent boys by age in the (a) Nepal and (b) Ecuador studies within the Nutrition of Adolescent Girls Research Program of the International Center for Research on Women. (●), 50th Percentile of the National Center for Health Statistics (NCHS) reference data (Hammill *et al.* 1979); (■), adolescent data from Nepal or Ecuador; (▲), 5th percentile of the NCHS reference data.

The Nepal study was one of the three in which the prevalence of undernutrition appeared to be high, when all ages (10–18 years) were combined. Fig. 3(a), however, suggests a different interpretation whereby the girls begin to mature later than their counterparts in the US-based reference population, but then grow at a greater rate throughout adolescence, moving from the 5th percentile at 12 years of age to nearly the 50th by 17 years of age. Their apparent undernutrition is characterized by late maturation in the early years of adolescence, and seems to be corrected by the later years.

For boys, the pattern of growth in BMI during adolescence, not just the starting points as for girls, appeared to follow two different paths, as shown in the comparison between the Nepal and Ecuador studies (Fig. 4). Nepali boys started at 10 years of age at the 5th

percentile for BMI, and increased substantially, although they did not reach as near to the 50th percentile at 18 years of age as the Nepali girls, consistent with the higher undernutrition prevalence among boys than girls. Ecuadorean boys, in contrast, started at 10 years of age near the 50th percentile, and did not increase above it throughout the adolescent years.

DISCUSSION

Anaemia was the largest nutritional problem among adolescents in the studies under the ICRW programme. It is also the nutritional problem for which treatment strategies and subsequent improvement are relatively well established, especially for adult women, and also among adolescents (Torún *et al.* 1995). The presence of anaemia in adolescents is not well known, although reliable data with prevalence rates similar to those reported here have been available for at least a decade (DeMaeyer & Adiels-Tegman, 1985). This is consistent with adolescents not receiving a high priority within nutrition efforts. Improving Fe status in a sustainable fashion is an investment in the future productive and reproductive lives of adolescents. It would also be expected to promote growth during the adolescent years.

The results on adolescent height and BMI were not as straightforward to interpret, and do not immediately suggest an intervention expected to reduce stunting or undernutrition. Before the sets of studies described here, there was a small and mixed literature that discussed the possibility of the degree of stunting from early childhood being reduced during the growth spurt of adolescence (Satyanarayana *et al.* 1981; Martorell *et al.* 1990), that is, in the absence of an intervention. The possibility of achieving some 'catch-up growth' during adolescence without an intervention also raised the question about additional gains in height that might be achieved with an intervention; for example, supplemental food. Results from studies without an intervention, and one study with an intervention, contribute to attempting to answer these questions.

Growth in height of girls and boys in the studies in Nepal and Ecuador without interventions do not indicate catch-up growth during adolescence relative to the reference standards. Adolescents were at about the 5th percentile from the ages of 10 to 18 years. The one study known to have given food supplementation to see if growth could be accelerated assessed growth through hormone levels. Although levels of plasma insulin-like growth factor were somewhat higher after the supplement, this result was observed only during the second half of the intervention period (Torún *et al.* 1995). Although the interpretation is not clear, because the translation of changes in growth hormone levels in the short term to changes in stature is not known, these results may suggest that only small gains in height may be possible. Thus, while these studies are not optimistic about the extent of catch-up growth in height that can be expected during adolescence, they are also not definitive.

Another way to approach the question of whether to promote gains in height through food supplementation during adolescence is by simultaneously considering the size of gains in BMI or weight. A food intervention during adolescence aimed at increasing final stature will also cause an increase in weight, partly as fat stores. Whether this is advantageous depends on existing weight and fat stores. If underweight among adolescents is prevalent, then a food intervention could contribute to reducing the prevalence of both underweight and stunting. However, if underweight is not prevalent, as in these

studies by the age of 18 or 19 years, despite a high prevalence of stunting, then any benefits of greater stature must be balanced against the potential for promoting overweight. Thus, the BMI data from the studies presented here suggest caution, indicating that adolescents gain more weight relative to the BMI reference data than they do height relative to the height reference data. This occurs without an intervention, and may suggest that a food intervention would favour a gain in weight, rather than height. In the absence of studies showing that much height could be gained, and weight gain balanced, food supplementation during adolescence should be approached with caution unless low BMI is prevalent at age 18 or 19 years.

RECOMMENDATIONS

In general, the results from the set of studies described here on adolescents in developing countries clearly suggest that the Fe status of adolescents requires improvement, but suggest caution about attempting to improve their height in view of adequate BMI by age 18 or 19 years.

Inasmuch as anaemia was the greatest nutritional problem (among those monitored) that adolescents in these studies experienced, it is strongly recommended that adolescents be included in programmes that address anaemia. This includes programmes that promote the production and consumption of Fe-rich foods and foods enhancing Fe absorption, and that prevent or treat infections causing Fe loss, such as hookworm and schistosomiasis. A focus on anaemia in programmes that address adolescent health is also strongly recommended. Adolescents can be reached through schools in countries where a high proportion attend school. Otherwise, community-based health workers could seek out non-school-going adolescents in addition to other target groups, and other options can be considered where health workers are not community based. It is not known whether boys would benefit as much as girls from interventions to reduce the prevalence of anaemia. Although boys and girls had a similarly high prevalence of anaemia during adolescence, Fe status improves among adult men once they have finished growing.

It should be recalled that girls in these studies were not pregnant. The healthy improvements in BMI that occurred during adolescence would have perhaps been curtailed had pregnancy occurred before the end of the growth spurt. Thus, a related recommendation is to postpone the first pregnancy until after adolescence to maintain or improve the nutritional status of girls and women. The programmatic experience on postponing adolescent pregnancy is much more extensive than on adolescent anaemia, although success of these programmes has not been widespread.

Finally, although the topic here is adolescents, it should not go unstated that a very good time to promote growth in height is in early childhood, especially 0–3 years of age, and so this is also strongly recommended.

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