DOCUMENT RESUME

ED 115 590 SP 009 659

AUTHOR	McKigney, John I.; Munro, Hamish N.
TITLE	Nutrient Requirements in Adolescence.
INSTITUTION	National Institutes of Health (DHEW), Bethesda, Md.
REPORT NO	DHEW-NIH-76-771
PUB DATE	75
NOTE	17p.
EDRS PRICE	MF-$0.76 HC-$1.58 Plus Postage
DESCRIPTORS	*Adolescence; Adolescents; Eating Habits; Health Education; *Nutrition; Nutrition Instruction
IDENTIFIERS	*Adolescent Nutritional Requirements

ABSTRACT

It is important to understand the nutrient requirements and the significance of nutrition both in pubescence and adolescence. The pubescent growth spurt is characterized by an increase in body size and a change in proportion of different tissues. Both of these factors are of great nutritional importance, since there is reason to believe that the growth spurt is sensitive to nutrient deprivation, although our knowledge of the requirements of adolescents for various nutrients is incomplete. The Food and Nutrition Board of the U.S. Academy of Sciences has published successive issues of its "Recommended Dietary Allowances (RDA). "The Ten-State Nutrition Survey (1968-70)," which measured food intake of lower income families in the United States, shows deficits among adolescents when compared with the RDA. The dietary inadequacies of adolescents may sometimes be accentuated by situations causing extra demands for nutrients, such as pregnancy, injuries, and involvement in sports. Excessive intake of nutrients also occurs during adolescence; one of the most common conditions due to an imbalance between food intake and expenditure is obesity. Excessive intake of dietary fat, notably saturated fat, has been associated with elevated blood cholesterol levels. Studies have indicated that the onset of both atherosclerosis and obesity may well occur during childhood, and that the most appropriate time to apply preventative measures and to provide nutritional education is during adolescence. (BD)

nutrient requirements in adolescence

John I. McKigney and Hamish N. Munro

(John I. McKigney is Health Scientist Administrator with the Growth and Development Branch of the National Institute of Child Health and Human Development, National Institutes of Health. Hamish N. Munro is Professor of Physiological Chemistry with the Department of Nutrition and Food Science at the Massachusetts Institute of Technology.)

DHEW Publication No. (NIH) 76-771

Considerable research effort in recent years has yielded solid rewards in the form of a much better understanding of nutrient needs during infancy and early childhood. In contrast, the significance of nutrition in development in later childhood and adolescence is not yet as clearly understood.

There are many clues to unanswered questions about how nutrition may be implicated in phenomena associated with adolescence. For example, the final mature height of American-born and -reared Japanese is greater than that of Japanese natives. Does this difference represent the benefits of a more abundant supply of nutrients during infancy or during the later growing period?

Autopsies on young American battle casualties during the Korean War revealed considerable deposition of fat in the wall of tne aorta. At what stage of growth and adolescence does such deposition take place, and is the adolescent diet a causal factor in this precursor of atherosclerosis? What are the implications of the changing dietary habits and fads to which the adolescent is inclined? Also, is it nutritionally more demanding to be an adolescent mother than to be an adult mother?

In order to answer some of these questions, and to assess our present state of knowledge of the optimum levels of nutrients for the adolescent, a conference* was held in June, 1973, at which some fifty scientists representing nutrition, anthropometry, clinical endocrinology, pediatrics and related biomedical fields pooled their experience. The following discussion of the nutrient needs of the adolescent is primarily based on the conclusions emerging from that meeting and the published proceedings (1).

Strictly speaking, *pubescence* is the correct term for the period of sexual development ending with the emergence of the capacity for sexual reproduction. On the average, this occurs at about 15 years for boys and 13 years for girls. The term *adolescence* is correctly applied to the period of growth after this time, that is, from a mean age of 15 to 21 years for boys and 13 to 17 years for girls (2).

When discussing nutrient requirements, both periods should be included in adolescence. The growth spurt associated with pubescence imposes important additional requirements about which we know too little. Furthermore the time of sexual maturity varies widely in individuals, so that some 10-year-old girls have already entered pubescence

* The conference was one of a series being sponsored by the Growth and Development Branch, National Institute of Child Health and Human Development, to focus attention on puberty and adolescence, and to define research areas which deserve priority attention in an expanded effort to broaden our knowledge of adolescent development. Those who contributed to the conference, in addition to the present authors, included: William R. Beisel, Mary Blackburn, Jo Anne Brasel, James P. Carter, C. Frank Consolazio, David B. Coursin, Mary C. Egan, Jordan W. Finkelstein, Gilbert B. Forbes, Hortense Gandy, Dale C. Garell, Peter V. Hamill, Felix P. Heald, D. Mark Hegsted, Ray Hepner, Robert Hodges, Malcolm A. Holliday, M. Isabel Irwin, Harry L. Jacobs, Herman L. Johnson, Francis E. Johnston, Jerome L. Knittle, James H. Leathem, Frank W. Lowenstein, Rijk Luyken, Robert Malina, Karl E. Mason, William J. McGanity, William M. Moore, John F. Mueller, Merrill S. Read, Sanford J. Ritchey, Alexander F. Roche, Harold H. Sandstead, Howerde Sauberlich, Arnold E. Schaefer, B. G. Shah, Angus M. Thomson, Frederick Trowbridge, Charlotte M. Young, Vernon R. Young.

while some 14-year-old boys are just beginning to show signs of sexual development. Consequently, this discussion deals with nutritional needs during the continuum from 10 years of age until growth ceases.

The pubescent growth spurt is characterized by an increase in body size which attains a rate matched or exceeded only by the developing fetus and infant in the first year of life. This growth spurt occurs earlier in girls and is less extensive than for boys, so that the relative heights and weights of boys and girls change more than once during the growing period. This has recently been documented for the United States in a unique series of publications of the National Center for Health Statistics, based on measurements made on large groups carefully chosen to be representative of the population. The Health Examination Survey was carried out between 1962 and 1970. These data show that girls are taller and heavier than boys from about 9 to 13½ years of age, after which the situation is reversed. The report also shows that black boys are taller than white boys until 9 years of age, whereas from age 14 on, white boys are taller than black boys. However, the weight of white boys is never less than that of black boys (3). Are these differences genetic or nutritional in origin?

Of even greater nutritional importance is the change in proportion of different tissues during the pubescent growth spurt. In the pre-pubescent years, the proportions of lean and fat tissue are about the same for boys and girls. During the growth spurt, however, girls gain proportionately more fat than lean tissue, and retain this ratio during the rest of growth. In contrast, boys acquire less fat and have a greater and more sustained gain in lean body mass (4). In fact, boys on an average gain about twice the amount of lean tissue gained in girls. Because this gain in bone and muscle is accompanied by increased tissue deposition of protein and such minerals as iron and zinc and calcium salts, one can predict that the puberty growth spurt of the male must make more dietary demands for protein, iron, zinc and calcium than does the growth spurt of the girl. It has been shown that the number of red blood cells of boys rises considerably during pubescence, whereas that of girls remains constant (5). The greater demand for iron for synthesis of red blood cells and formation of increased musculature can be correlated with the more frequent occurrence of anemia in pubescent males than females in lower income groups (6).

Is there any reason to believe that the growth spurt is sensitive to nutrient deprivation? Evidence of both a general and a specific character suggests that this may be so for populations on marginal food intakes. For example, preliminary examination of survey data being assembled in some developing countries with a high incidence of malnutrition in children suggests that little or no growth spurt occurs in adolescents (7). Similarly, records of the growth of Japanese schoolchildren extending over the past forty years or more show that the growth spurt was delayed and smaller during World War II; since then it has gradually returned to pre-war patterns and currently exceeds pre-war levels (8). It is not known whether malnutrition during infancy is responsible for the failure to have a normal growth spurt at pubescence, or whether the nutritional effect is a direct one at the time of the growth spurt.

Our knowledge of the requirements of adolescents for various nutrients is incomplete. One reason for this is that man seems to be the only animal showing a growth spurt, and experimentation on humans is both difficult and often unethical. The Food and Nutrition Board of the U.S. National Academy of Sciences has published successive issues of its *Recommended Dietary Allowances* (RDA), including those for adolescent boys and girls (9). Although these estimates of needs are based on many pieces of evidence, they can only be regarded as approximations. Boys 11-14 years old are allowed 2800 calories per day, rising to 3000 calories per day for the 15-18 age group. This latter allowance is greater than the energy intake allocated to the mature adult male. In contrast, girls aged 11-14 are allotted 2400 calories, declining to 2100 calories for ages 15-18. This difference in recommended allowances presumably reflects the later, larger and more prolonged growth spurt of males. However, the estimated protein requirements of the two sexes does not fully mirror this pattern for energy intake because the recommended intake of protein for the female tends to increase even when the energy allowance is decreasing. The Ten-State Nutrition Survey, 1968-1970, which measured food intake of lower income families in the U.S., shows deficits among adolescents compared with the RDA. The survey data (10) show that energy intake of white male adolescents was adequate, while that of white female adolescents was below the recommended level for their age. Energy intakes of black adolescents of both sexes were well below recommended levels. Data of the Health Examination Survey mentioned earlier show that white boys are taller and heavier than black boys from 14 years of age on. Thus, results of the two surveys are in agreement and suggest a nutritional basis for these differences in height and weight of adolescent males.

The Ten-State Survey also revealed deficits in the intakes of vitamin A, riboflavin, calcium and iron by adolescents, when compared with their recommended allowances. This can be correlated with clinical evidence of certain deficiency conditions among this group (11). Direct evidence of growth retardation associated with these suboptimal nutrient intakes emerges from a more detailed analysis of the Texas portion of the Ten-State Nutrition Survey (12). Failure to find evidence in the past of malnutrition as a factor in adolescent growth and development has probably been due to dilution of the data from low income groups with data from the wealthier majority of the population. Similarly, the benefits of better nutrition for fetal development has only recently become evident when attention was concentrated on specific poorer segments of the U.S. population (13). These various observations, though somewhat imprecise, as population

studies tend to be, clearly indicate that some segments of the adolescent population in the U.S. are receiving inadequate intakes of certain nutrients.

The inadequacies may sometimes be accentuated by situations causing extra demands for nutrients—for example, an adolescent pregnancy. Pregnancy in the adolescent appears usually not to be associated with competition between mother and child for nutrients (14). However, some investigators feel that marginal intakes of vitamin A, iron, calcium and trace minerals may make some adolescent mothers vulnerable to deficiency which, in the case of vitamin A, may be a contributory factor in producing birth defects in her unborn child (15). Studies on pregnant black teenagers in California (16) suggest that the recommended allowance of calories is substantially low, especially since it is now recognized (17) that the outcome of pregnancy may be improved by higher energy intakes than those previously considered adequate. The old notion that the unborn child is immune to malnutrition is being seriously questioned in light of recent studies which correlate birth weight with nutritional status of the mother. In future research in this area, special attention should be paid to the adolescent mother and the effects of nutrition on her own health as well as on that of her unborn child.

Other forms of stress also increase the demands of the adolescent for nutrients. In response to infection and to injury, the principal initial needs appear to be for adequate supplies of energy and amino acids in order to reduce wastage of tissues and to encourage rapid convalescence and replacement of tissue losses (18). The well-nourished adolescent is better able to meet such stresses.

Nutrition of the adolescent actively involved in sports is also beginning to receive serious consideration. Weight reduction of adolescents to meet requirements for certain sports by restricting food and fluid intakes is commonly practiced, the latter usually shortly before a contest (19). This can adversely affect the health and well-being of the growing adolescent. Water deprivation, particularly, may be responsible for collapse and even death of athletes during the stress of the game.

What has been said so far has dealt with recommended allowances of nutrients and evidence of groups in the U.S. population whose diets may not be meeting these recommended levels. However, excessive intakes of nutrients also occur in adolescence. One of the most common conditions due to an imbalance between food intake and expenditure is obesity, much of which stems from early childhood.

Studies on the number of fat cells in the body suggest that the normal person ceases to add fat cells to his or her body between the ages of 2 and 10 years, and then resumes production of new fat cells during puberty (20). Thus the normal child shows a pubertal increase in body fat as well as a general adolescent growth spurt. In contrast, the obese-prone child continues to add fat cells to his body during the whole of his first 10 years and thus enters adolescence with an abnormally large number of such cells which are also larger in size than those of non-obese children. Such fat cells demand to be fed and divert some of the energy intake to deposition of further body fat, reflecting an abnormal metabolic state which tends to persist through adulthood.

Excessive intakes of dietary fat, notably saturated fat, have been linked to atherosclerosis associated with elevated blood cholesterol levels. Young adults demonstrate fatty streaks in the lining of their blood vessels which are probably precursors of irreversible arterial damage. Studies on boys in a residential school showed a tendency to elevated levels of blood cholesterol which could be significantly reduced by lowering the total fat content of their diet and raising the unsaturated fat content (21). The blood cholesterol levels rose again when the boys returned to their home diets during the vacation. This implies that the onset of future atherosclerosis may well occur during childhood and, moreover, that the most appropriate time to apply preventive measures and to provide nutritional education is during adolescence. These two problems—atherosclerosis and obesity—raise the question of whether there should be a recommended dietary maximum as well as a recommended dietary allowance for some nutrients.

what does future promise in studies of adolescent nutrition?

Future studies of the nutrition of adolescents should be performed by more sophisticated and comprehensive procedures, including the use of bone growth measurements which indicate the developmental as well as the chronological age of the individual. Combined surveys involving biochemical and clinical measures of fitness and deficiency as well as bone age measurements should yield a clearer definition of the state of nutrition of this age group in the population.

More detailed study should be made of the pubertal growth spurt to refine estimates of nutrient requirements during this period of rapid change in body composition. Attention should be given to the potential development of individual dietary requirements for adolescents whose growth spurts vary considerably from the norm. Such studies should take into account not only the relationship of nutrient intakes to weight and height changes, but also correlation of body composition and sexual characteristics with plasma hormone levels.

The food habits of teen-agers need systematic exploration, including investigation of the effect of alcohol, drugs and steroid contraceptives on intake and utilization of nutrients. The immediate and long-term effects of "fad" diets, including those for rapid loss or gain in weight, need to be considered.

The identification of specific medical groups including adolescents with obesity, diabetes and elevated blood cholesterol levels should be followed by studies of the impact of nutrition on their future health and of means of changing their dietary habits for the better.

More basic information is needed about many aspects of adolescent development. There are indications that the maximum genetic capacity for adult stature has been reached in the U.S., whereas adult weight attained is still increasing. Research is needed to determine if this implies an increasing tendency towards adult obesity. The relationship between body composition of the adolescent and the incidence of illness and mortality in later life has yet to be explored. This information would be helpful in determining optimal objectives for adolescent nutrition. Finally, there is evidence from studies on rats (22) that the capacity to secrete growth hormone during the whole growing period can be affected by malnutrition of the fetus due to an inadequate maternal diet. It may be that the growth spurt of the human is also, to some extent, determined by nutrition in the uterus and in early post-natal life. All these research objectives are not only desirable but also urgent, considering the fact that foods in this country are increasingly engineered and processed for mass consumption. The productiveness, well-being and longevity of the future adult population may be enhanced by the answers to these questions regarding nutrition during the adolescent period of life.

references

1. McKigney, J. I. and Munro, H. N. (Eds.): *Nutrient Requirements in Adolescence*. Cambridge, Mass., MIT Press, 1975.
2. Roche, A., conference proceedings, pg. 33
3. National Center for Health Statistics: Height and Weight of Children. United States. *Vital and Health Statistics*. D.H.E.W. Pub. No. 1000—series 11—No. 104.
4. Cheek, D. B. *Human Growth*. Philadelphia, Pa., Lea and Febiger. pg. 247. 1968.
5. Daniel, W. A. Hematocrit: maturity relationship in adolescence. Pediatrics; *52:* 388-394. 1973.

6. Hepner, R., conference proceedings, pg. 171
7. Thomson, A. M., conference proceedings, pg. 349
8. Munro, H. N. Report of a conference on protein and amino acid needs for growth and development. Am. J. Clin. Nutr., 27: 55-58. 1974.
9. Food and Nutrition Board, National Academy of Sciences National Research Council. Recommended Dietary Allowances, Eighth Edition. 1974
10. Hegsted, D. M., conference proceedings, pg. 109
11. Hodges, R. E., conference proceedings, pg. 130
12. McGanity, W. J., conference proceedings, pg. 157

13. Winick, M., private communication.
14. Thomson, A. M., conference proceedings, pg. 249
15. Hodges, R. E., conference proceedings, pg. 131
16. Blackburn, M., conference proceedings, pg. 280
17. World Health Organization: Technical Report series No. 522. *Energy and Protein Requirements*. Report of a joint FAO/WHO *ad hoc* Expert Committee. Geneva. 1973.
18. Beisel, W. R., conference proceedings, pg. 259
19. Consolazio, C. F., conference proceedings, pg. 214
20. Knittle, J., conference proceedings, pg. 83

21. Hegsted, D. M., conference proceedings, pg. 113
22. Shrader, R. E. and Zeman, F. J. In vitro synthesis of anterior pituitary growth hormone as affected by maternal protein deprivation and post-natal food supply. J. Nutr., *103:* 1012-1017. 1973.

references

1. McKigney, J. I. and Munro, H. N. (Eds.): *Nutrient Requirements in Adolescence.* Cambridge, Mass., MIT Press, 1975.
2. Roche, A., conference proceedings, pg. 33
3. National Center for Health Statistics: Height and Weight of Children. United States. *Vital and Health Statistics.* D.H.E.W. Pub. No. 1000—series 11—No. 104.
4. Cheek, D. B. *Human Growth.* Philadelphia, Pa., Lea and Febiger. pg. 247. 1968.
5. Daniel, W. A. Hematocrit: maturity relationship in adolescence. Pediatrics; *52:* 388-394. 1973.

6. Hepner, R., conference proceedings, pg. 171
7. Thomson, A. M., conference proceedings, pg. 349
8. Munro, H. N. Report of a conference on protein and amino acid needs for growth and development. Am. J. Clin. Nutr., 27: 55-58. 1974.
9. Food and Nutrition Board, National Academy of Sciences National Research Council. Recommended Dietary Allowances, Eighth Edition. 1974
10. Hegsted, D. M., conference proceedings, pg. 109
11. Hodges, R. E., conference proceedings, pg. 130
12. McGanity, W. J., conference proceedings, pg. 157

13. Winick, M., private communication.
14. Thomson, A. M., conference proceedings, pg. 249
15. Hodges, R. E., conference proceedings, pg. 131
16. Blackburn, M., conference proceedings, pg. 280
17. World Health Organization: Technical Report series No. 522. *Energy and Protein Requirements*. Report of a joint FAO/WHO *ad hoc* Expert Committee. Geneva. 1973.
18. Beisel, W. R., conference proceedings, pg. 259
19. Consolazio, C. F., conference proceedings, pg. 214
20. Knittle, J., conference proceedings, pg. 83

21. Hegsted, D. M., conference proceedings, pg. 113
22. Shrader, R. E. and Zeman, F. J. In vitro synthesis of anterior pituitary growth hormone as affected by maternal protein deprivation and post-natal food supply. J. Nutr., *103:* 1012-1017. 1973.

DISCRIMINATION PROHIBITED — Title VI of the Civil Rights Act of 1964 states: "No person in the United States shall, on the ground of race, color, sex, age, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." Therefore, the National Institute of Child Health and Human Development, NIH, PHS, like every program or activity receiving financial assistance from the Department of Health, Education, and Welfare, must be operated in compliance with this law.