Nutritional Influences on Bone Growth in Children

Frances A. Tylavsky

Department of Preventive Medicine, University of Tennessee Health Science Center, Memphis, TN 38105

This introduction and summary of the following reviews represent the proceedings of the Nutrition and Bone Health Working Group of the American Society for Bone and Mineral Research held in Minneapolis, MN, on September 19, 2003. The objective of this program was to provide a current review of the research efforts on dietary factors that affect bone health from infancy through adolescence by experts in this field.

Dr. Susan J. Whiting from the College of Pharmacy and Nutrition, University of Saskatchewan, introduced the speakers: Dr. Bonny Specker, from the Ethel Austin Martin Program in Human Nutrition, South Dakota State University, and Dr. Velimir Matkovice from the Departments of Physical Medicine and Rehabilitation, Medicine, and Nutrition, The Ohio State University. Dr. Frances A. Tylavsky from the Department of Preventive Medicine, University of Tennessee, introduced Dr. Susan Whiting. Discussion followed each presentation, with a panel discussion at the conclusion of all presentations. Dr. Frances A. Tylavsky moderated the discussion.

Several studies have focused on the effect of maternal diet, breastfeeding, vitamin D intake, and calcium, phosphorus, and palm olein content of formulas during early growth (1). Results of these studies suggest that early influences from both the mother and infant or toddler can affect bone mineral accretion, but long-term effects on bone health are unknown. Only recently have results from a prospective cohort study (2,3) and long-term randomized calcium supplementation trials been available to provide estimates of bone accretion during puberty with quantification on peak bone mass (4). Prior to this, the requirements for calcium have focused on the findings from cross-sectional studies and double-blind-randomized calcium supplementation trials (5).

Despite strides over the last 10 y in estimating accretion of total body bone mineral content (BMC) \(^3\) of children through prospective studies, there are still limitations that may affect the direct extrapolation of data. Members of the working group pointed out the dearth of information on boys and various ethnic groups. Research is now being completed to shed some light on requirement differences for boys (2,6) and African-American females (7). Drs. Whiting and Specker presented the importance of considering the interactions of calcium intake with genetic factors, physical activity, and dietary intake of vitamin D, carbonated soft drinks, and fruit and vegetables. Evidence suggests that factors negatively affecting bone health [BMC and BMD (bone mineral density)] in girls may not have the same effect in boys (8,9).

Bone accretion is best estimated from BMC obtained with whole body dual-energy X-ray absorptiometry (DXA). Longitudinal studies that cover the span of early puberty though 18 y of age are most instructive in estimating calcium requirements. As presented by Dr. Whiting, the timing of measurements and interpretation of data are critical for estimating the requirements and thus recommendations. In the Saskatchewan Bone Mineral Accrual Study, the accretion of total body BMC varies when estimated by chronological versus biological age. The accretion of whole body BMC and thus the requirement is greatest during the peak height velocity and varies with gender. Dr. Whiting's data suggest that lower calcium requirements for adolescent females are needed for most of the adolescent period (1000 mg/d) with greater recommendations needed during maximal height velocity (1500 mg/d). Dr. Matkovic presented evidence that the effectiveness of calcium supplementation is height dependent. Given the difficulties in predicting changes in height, Dr. Matkovic suggests that calcium recommendations be set at 1500 mg/d to meet the demand of all teenage females. Together, these data indicate that we should probably reconsider our basis for determining calcium requirements and thus recommendations. Currently, recommendations are specified for wide chronological age categories. If we express the requirement for calcium in relation to body height, i.e., mg of calcium per cm, this may better define the need for calcium during bone growth as well as during bone maintenance subsequent to attainment of peak bone mass. This would be analogous to energy and protein requirements, which are expressed per kilogram of body weight. Connecting calcium requirements to height would adjust the level depending on skeleton size. Thus, smaller individuals would have a lower requirement and would be more likely to meet their needs through the consumption of less food than would taller individuals who have greater metabolic areas. The challenge in providing recommendations that meet the needs of 95% of all children is quite different from estimating requirements for specific time periods without the full knowledge of genetic capability, physical activity

---

1 Presented at the Nutrition and Bone Health Working Group program at the "American Society of Bone Mineral Research, 25th Annual Meeting," held in Minneapolis, MN, September 19–23, 2003. The Nutrition and Bone Health Working Group program was organized by Susan J. Whiting and was sponsored by The National Dairy Council. Supplement contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Dairy Council. Guest editors for the supplement publication were Susan J. Whiting, College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, Saskatchewan, and Frances A. Tylavsky, University of Tennessee, The Health Science Center, Memphis, TN.

2 To whom correspondence should be addressed. E-mail: ftlyavsky@utmem.edu.

3 Abbreviations used: BMC, bone mineral content; BMD, bone mineral density; DXA, dual-energy X-ray absorptiometry; pQCT, peripheral quantitative computed tomography.

patterns, and hormonal milieu. While making recommendations based on height may eliminate the need to provide gender and ethnic specific requirements, the application to the lay public may present challenges that need to be considered.

Much of our knowledge of factors that affect bone accretion is based on instruments that may or may not be able to provide estimates of the whole body mineral content. This is particularly true of studies involving toddlers and those performed prior to the availability of whole body DXA. Thus our knowledge base will be expanded as studies with access to whole body DXA are published. National Health and Nutrition Examination Survey (NHANES) is scheduled to release whole body assessment of participants starting at age 8 in the summer of 2004. This resource will become invaluable for cross-sectional analyses as well as for determining gender and ethnic differences. NIH initiatives are underway that focus on longitudinal assessment in healthy children to establish growth charts for bone quality and accretion using DXA and pQCT (peripheral quantitative computed tomography). While DXA provides assessment of bone accretion, it is not able to provide sensitive measures of bone quality as obtained from pQCT. Through a combination of measurement tools, we can delineate factors that have differential effects on bone sites and bone type (trabecular vs. cortical), as well as bone quality (10–12).

Limitations inherent to bone assessment warrant discussion at this time for the interpretation of data presented at this workshop. To date, most of the research presented on whole body DXA results has used pencil beam technology. The current state of the art with respect to DXA is use of fan beam technology. The fan beam DXAs have been calibrated to pencil beam technology to yield the same bone mineral density values. However, bone area and BMC are dependent on body thickness (13,14) and magnification effects across a range of body weights have not been addressed. Nor has the pediatric software been evaluated to determine when a child who has grown can be transitioned to adult software without error in assessment of bone accretion. A current initiative is underway to address these questions, but it will take years before we have the answers to these questions. Until then, the following reviews present the state-of-art knowledge of nutritional influences on bone growth in children.

**LITERATURE CITED**