Adiposity and TV Viewing Are Related to Less Bone Accrual in Young Children

Karen S. Wosje, PhD, Philip R. Khoury, MS, Randal P. Claytor, PhD, Kristen A. Copeland, MD, Heidi J. Kalkwarf, PhD, and Stephen R. Daniels, MD, PhD

Objective To examine the relation between baseline fat mass and gain in bone area and bone mass in preschoolers studied prospectively for 4 years, with a focus on the role of physical activity and TV viewing.

Study design Children were part of a longitudinal study in which measures of fat, lean and bone mass, height, weight, activity, and diet were taken every 4 months from ages 3 to 7 years. Activity was measured by accelerometer and TV viewing by parent checklist. We included 214 children with total body dual energy x-ray absorptiometry (Hologic 4500A) scans at ages 3.5 and 7 years.

Results Higher baseline fat mass was associated with smaller increases in bone area and bone mass over the next 3.5 years ($P < .001$). More TV viewing was related to smaller gains in bone area and bone mass accounting for race, sex, and height. Activity by accelerometer was not associated with bone gains.

Conclusions Adiposity and TV viewing are related to less bone accrual in preschoolers. *(J Pediatr 2009;154:79-85)*

The strength of bone is its resistance to fracture, and this largely reflects skeletal adaptation to muscle forces.[1] However, the impact of obesity on bone strength in children is unclear.[1] Obesity might promote increases in bone strength to support the locomotion of a heavy body mass; higher adiposity in children may be related to greater bone area and bone mineral content/bone mass (BMC).[2-4] If overweight children have a bone strength advantage, it might be due to the greater muscle force needed to move a larger body mass. On the other hand, in adults of similar weight, those with more fat mass have lower bone mass[5] and higher fracture risk.[6] In studies of children, some have reported that forearm fracture risk is greater in children with more fat mass,[7,8] whereas others have not reported this.[9] Part of the increased fracture risk with greater fat mass may be due to poorer balance[10] and higher impact force with falling in heavier children.[11] Children with greater relative fat mass may be more prone to fracture because they have lower BMC.[12,13] Muscle mass is more strongly correlated with BMC than is fat mass in children,[14] so overweight children with low muscle mass may still have low BMC. Different characterization of adiposity as absolute fat mass[2-4] or fat mass relative to total mass[12,13] may also contribute to the inconsistent findings.

Physical activity must be considered as a possible confounder or mediator of the relation of bone mass with fat mass, as either low activity or high sedentary time may plausibly lead to low muscle and high fat mass or vice versa. The inconsistent findings on the relation between adiposity and BMC, and possibly fracture risk, in children reflect our limited understanding of the relations among activity, fat mass, and bone during growth.

A limitation of prior pediatric studies on bone health in relation to body fat is that they have included children spanning multiple stages of maturation.[2,7,8,12,13,15-18] At puberty, the levels of bone- and adiposity-promoting hormones such as estradiol and leptin[19] are changing and thus complicating the evaluation of the relation between body fat and bone. Studies on bone health in relation to body fat were conducted in solely pre pubertal or early pubertal children (Tanner stage 1 or 2), ranging in age from 7 to 10 years. A study in 10-year-old girls showed that higher baseline fat mass was associated with greater subsequent 2-year increases in total body bone area and BMC.[3] Similarly, fat mass was associated with greater bone area and BMC in 7- to 8-year-olds.[4] A third study

BMC	Bone mineral content/bone mass	IGF	Insulin-like growth factor
BMI	Body mass index	pQCT	Peripheral quantitative computed tomography
DXA	Dual energy x-ray absorptiometry		
GH	Growth hormone		

From the Division of General and Community Pediatrics (K.W., K.C., H.K.) and the Division of Cardiology (P.K., R.C.), Cincinnati Children's Hospital Medical Center, Cincinnati, OH; and L. Joseph Butterfield Chair in Pediatrics, The Children's Hospital, Denver, CO (S.D.).

Supported by grant R01HL064022 (PI: Dr. Daniels) from the National Heart, Lung, and Blood Institute. The authors declare no conflicts of interest.

Submitted for publication Mar 4, 2008; last revision received May 7, 2008; accepted Jun 19, 2008.

Reprint requests: Dr. Karen S. Wosje, Cincinnati Children's Hospital Medical Center, Division of General and Community Pediatrics, ML 7035, 3333 Burnet Ave, Cincinnati, OH 45229-3039. E-mail: karen.wosje@cchmc.org.

0022-3476/$ - see front matter

10.1016/j.jpeds.2008.06.031

showed no difference in bone density between children with body mass index (BMI) above the 95th and below the 85th percentiles for age and sex.[20] None considered the potential confounding or mediating effects of physical activity, which may partly explain the lack of agreement of findings. Our objective was to examine the relation of adiposity with bone accrual in preschoolers, with a focus on the role of physical activity and TV viewing.

METHODS

Study Population

The data for the current analyses were collected as part of a longitudinal study of children in which serial measures of fat, lean and bone mass, height, weight, physical activity, and dietary intake were taken every 4 months from ages 3 to 7 years (13 visits). The main aim of this study was to determine the age at BMI rebound (the point in early childhood when body fatness reaches a nadir before increasing again). Children recruited from pediatric practices in a midwestern metropolitan region were eligible if they were born at term (38 to 42 weeks' gestation), had a birth weight that was appropriate for gestational age, were free from known chronic disease, and had at least 1 biological parent available to provide information. The parent(s) provided written informed consent. The study was approved by the institutional review board.

Of the 372 children enrolled in the larger study, 348 (93%) had a total body dual energy x-ray absorptiometry (DXA QDR4500, Hologic Inc; Waltham, Massachusetts) scan at baseline, and 308 completed the study. To maximize the time interval between baseline and follow-up scans, while maintaining a narrow age range at each scan, we only included, in this analysis, the 215 children with 2 acceptable scans, one between ages 3.25 and 3.75 years, and the other between 6.75 and 7.25 years (Figure 1; available at www.jpeds.com).

Anthropometrics, Body Composition, and Bone

Height and weight were measured using a wall-mounted stadiometer and digital scale. BMI z scores were determined using the 2000 Centers for Disease Control and Prevention growth reference.[21] Total body fat mass, lean mass, bone area, and BMC were measured by DXA. We previously reported measurement error of <1.9% for fat, lean, and bone mass by DXA QDR4500 at our institution.[22] The skull was excluded from the bone area and BMC data to avoid the complication of the decline in head size relative to body size over time in young children. All scans were analyzed with low-density bone edge detection algorithms (Hologic software v12.4). Trained personnel visually inspected all printed scans, and those with major limb or trunk movement were excluded (n = 24, Figure 1).

Physical Activity and TV Viewing

Parents were asked to have the child wear for 2 weekdays and 1 weekend day per visit a triaxial accelerometer (RT3, Stay Healthy Inc; Monrovia, California) on the right hip except when sleeping, swimming, or bathing. The triaxial data were downloaded as vector magnitude units (ie, "counts" based on all 3 axes). Sometimes the accelerometer was worn for more than 3 days, as the RT3 collects data for 7 days once switched on. For each day, accelerometer counts per minute were calculated following the algorithm in Table I (available at www.jpeds.com). After this process, 6348 days from our 214 children qualified for analyses. We used the average of the average counts per minute over all of the child's visits (80% with at least 10 visits) for analyses. The overall mean counts per minute for years 1 (3 visits), 2 (3 visits), 3 (3 visits), and 4 (4 visits) did not differ by a large degree (<8%), suggesting that information was not lost by averaging over all 13 visits. All usable days were included (93% of children with ≥20 usable days).

For 2 weekdays and 1 weekend day at each visit, TV viewing was estimated from the parent(s) check-box responses to the question: "How much time did your child spend watching TV or videotapes?" (0; 1 to 30; 31 to 60; or >60 minutes) from "wake-up time until noon," "noon until 6 pm," and "6 pm until midnight." The check-box responses were assigned categorical values of 0, 1, 2, and 3. The sum of the categorical values for the 3 time increments was calculated (range, 0 to 9), and the average sum across the 3 days determined. An increase of 1 was assumed to represent an additional 30 minutes of TV viewing (1 = 30 minutes; 2 = 60 minutes; . . . ; 9 = 270 minutes). These estimates were averaged to obtain the hours per day spent viewing TV using all 3-day records (95% with at least 12 records). The overall mean TV viewing for years 1 (3 visits), 2 (3 visits), 3 (3 visits), and 4 (4 visits) had a narrow range (2.0 to 2.3 hours), suggesting that, as with counts per minute, information was not lost by averaging over all 13 visits. Outdoor playtime was measured on the same questionnaire with the same check-box method as previously described,[23] giving the average hours per day spent in outdoor play over 13 visits.

Calcium Intake

Parent(s) were asked to provide a 3-day diet record (2 weekdays and 1 weekend day) for the same days as the accelerometer recordings. Nutrient Data System for Research (NDS) software (v2005, Nutrition Coordinating Center; University of Minnesota, Minneapolis, Minnesota) was used to determine average daily calcium intake for each 3-day record. Only 10 of the 4258 records collected for the whole cohort were <3 days. The average of the 3-day averages over 13 records (97% with at least 12 records) was used to control for the potential confounding effect of calcium intake, which may be related to both bone[24] and fat[25] accrual in children.

Statistical Methods

The percentage change in bone area (Δbone area) and ΔBMC from age 3.5 to 7 years were calculated, and linear regression was used to examine the bivariate relation of these