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Original Article

Peak Bone Mass and Patterns of Change in Total Bone Mineral Density and Bone Mineral Contents From Childhood Into Young Adulthood

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Abstract

The literature has not reached a consensus on the age when peak bone mass is achieved. This study examines growth patterns of total bone mineral content (TBMC) and total bone mineral density (TBMD), peak bone mass, effect of concurrent anthropometry measures, and physical activity on growth patterns in a sample of 312 white males and 343 females aged 8−30 yr. We analyzed data from participants enrolled in Fels Longitudinal Study. Descriptive analysis was used to ascertain characteristics of participants and growth patterns of TBMC and TBMD. Mixed effects models were applied to predict ages at attainment of peak TBMC and TBMD and assess the effects of height, weight, body mass index (BMI), and habitual physical activity on the attainment. Significant differences between sexes were observed for measures of TBMC and TBMD, and differences varied with age. For females, predicted median ages at peak TBMC and TBMD attainments are 21.96 yr (interquartile range [IQR]: 21.81−22.21) and 22.31 yr (IQR: 21.95−22.59), respectively. For males, predicted median ages are 23.34 yr (IQR: 24.34−26.19) and 26.86 yr (IQR: 25.14−27.98) respectively. For females, height, weight, and BMI, but not physical activity, had significant influences on attainment of TBMC and TBMD ($p < 0.01$). For males, weight and BMI, but not height and physical activity, exerted significant influence on attainment of TBMC and TBMD ($p < 0.01$), and also modified correlations between age and peak TBMC and TBMD. Our results suggest that (1) for both sexes, trajectories of TBMC and TBMD follow a curvilinear pattern between ages 8 and 30 yr; (2) predicted ages at peak TBMC and TBMD are from early to late 20s for both white males and females, with females reaching their peaks significantly earlier than males; and (3) concurrent height, weight, and BMI, but not habitual physical activity, exert significant effects on trajectories of TBMC and TBMD.

Key Words: Body bone mineral content; body bone mineral density; dual-energy X-ray absorptiometry.

Introduction

Osteoporosis is a major problem of public health and the leading cause of bone fractures. In the United States, about 10 million individuals are estimated to have osteoporosis; 18 million more are at risk of developing the disease; and another 34 million are at risk of having low bone mass, which is conducive to fractures. About 1 in 2 women and 1 in 4 men in their sixth decade will have an osteoporosis-related fracture some time during their remaining lifetime *(1)*. The direct medical cost of osteoporosis reached $17 billion in 2005 *(2)*. As the age of the US population increases, the prevalence of osteoporosis and its associated costs will rise significantly.

Osteoporosis is a disease characterized by low bone mass and structural deterioration of bone tissue, leading to bone fragility and an increased risk of fractures *(3)*. Bone mass is

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Table 1
Characteristics of Anthropometry Measurements in Study Cohort

Characteristics	Mean (SD)	Percentile				
		10th	25th	50th	75th	90th
Birth weight (kg)						
Boys						
CDC growth chart, 2000	3.41 (0.55)	2.72	3.08	3.43	3.77	4.08
FLS participants	3.47 (0.54)	2.81	3.17	3.47	3.78	4.08
Girls						
CDC growth chart, 2000	3.29 (0.52)	2.64	2.98	3.29	3.63	3.92
FLS participants	3.26 (0.54)	2.61	2.95	3.26	3.60	3.88
Weight (kg)						
Boys						
8-yr-old CDC growth chart, 2000	26.01 (4.23)	21.61	23.25	25.46	28.01	31.13
8-yr-old FLS participants	26.87 (5.09)	23.80	23.70	25.50	28.20	31.60
12-yr-old CDC growth chart, 2000	41.23 (9.82)	31.41	34.93	38.90	45.76	54.27
12-yr-old FLS participants	42.57 (10.35)	32.35	35.10	39.30	50.00	59.10
16-yr-old CDC growth chart, 2000	63.64 (11.76)	51.71	55.97	62.03	68.55	77.11
16-yr-old FLS participants	66.00 (14.04)	53.00	56.20	62.69	71.90	93.60
Girls						
8-yr-old CDC growth chart, 2000	25.84 (4.68)	20.75	22.51	25.06	28.24	31.87
8-yr-old FLS participants	26.38 (2.22)	21.80	23.50	25.80	29.20	34.80
12-yr-old CDC growth chart, 2000	43.63 (10.27)	31.98	36.52	41.73	48.76	57.38
12-yr-old FLS participants	43.75 (9.91)	34.30	37.77	43.70	50.90	61.90
16-yr-old CDC growth chart, 2000	57.16 (10.76)	46.04	49.84	55.57	61.69	69.57
16-yr-old FLS participants	57.02 (9.17)	48.30	51.80	57.25	63.20	69.30
Height (cm)						
Boys						
8-yr-old CDC growth chart, 2000	127.62 (5.83)	121.00	124.05	127.75	131.40	134.80
8-yr-old FLS participants	128.85 (5.21)	122.85	125.10	128.54	132.00	135.60
12-yr-old CDC growth chart, 2000	149.67 (7.68)	140.45	145.05	149.05	154.55	160.15
12-yr-old FLS participants	151.37 (6.82)	143.25	146.65	150.93	155.30	161.40
16-yr-old CDC growth chart, 2000	172.85 (7.13)	163.45	168.40	173.20	177.60	181.65
16-yr-old FLS participants	175.47 (6.61)	167.10	171.31	175.35	179.98	183.80
Girls						
8-yr-old CDC growth chart, 2000	126.78 (6.10)	119.25	122.75	126.95	130.70	134.35
8-yr-old FLS participants	127.91 (5.45)	120.60	124.07	127.87	131.45	135.00
12-yr-old CDC growth chart, 2000	152.00 (7.69)	142.25	146.15	151.16	156.8	161.35
12-yr-old FLS participants	152.37 (7.03)	142.93	146.65	150.93	155.30	161.40
16-yr-old CDC growth chart, 2000	163.17 (6.24)	155.30	158.85	163.40	167.10	171.20
16-yr-old FLS participants	164.23 (6.01)	156.67	159.82	164.15	167.99	183.80
BMI (kg/m^2)						
Boys						
8-yr-old CDC growth chart, 2000	16.03 (2.07)	14.19	14.89	15.64	16.71	18.16
8-yr-old FLS participants	16.10 (2.22)	14.21	14.67	15.40	16.65	18.39
12-yr-old CDC growth chart, 2000	18.44 (3.36)	15.37	16.32	17.50	19.71	22.98
12-yr-old FLS participants	18.41 (3.39)	14.95	15.96	17.49	20.03	24.85
16-yr-old CDC growth chart, 2000	21.25 (3.25)	18.05	19.30	20.65	22.37	25.37
16-yr-old FLS participants	21.38 (4.10)	17.57	18.63	20.37	22.80	29.62
Girls						
8-yr-old CDC growth chart, 2000	16.04 (2.07)	13.95	14.69	15.55	17.02	18.71
8-yr-old FLS participants	16.02 (2.05)	14.09	14.88	15.72	17.42	19.52
12-yr-old CDC growth chart, 2000	18.90 (3.44)	15.40	16.42	18.39	20.55	22.91

(*Continued*)