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Prediction of bone mineral density and content from measures of physical activity and sedentary behavior in younger and older females

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ABSTRACT

Background. Little is known regarding the extent to which physical activity (PA) and sedentary behavior (SB) influence bone mineral content (BMC) and bone mineral density (BMD) in females across the lifespan.

Methods. Data from 2232 females aged 12 years and older collected as part of the 2007–2008 National Health and Nutrition Examination Survey were analyzed. Categories of PA and SB were used to predict femoral and spinal BMD and BMC in four age groups (G1: 12–17; G2: 18–39; G3: 40–64; G4: ≥65 years). Self-reported PA categories included sufficient moderate-to-vigorous recreational PA (S-MVRPA) and insufficient MVRPA (I-MVRPA).

Results. G1 females who accumulated S-MVRPA displayed greater femoral and spinal BMC and BMD compared to G1 females who displayed I-MVRPA. For G4 females, higher levels of SB were associated with lower femoral BMC and BMD.

Conclusions. These findings highlight the importance of engaging in sufficient moderate-to-vigorous physical activity during adolescence and reducing sedentary behavior in older adults to improve bone health in females.

Introduction

Osteoporosis, a bone disease characterized by low bone mass and structural deterioration of bone tissue, currently impacts more than 10 million people in the United States and is predicted to affect more than 14 million people by 2020 (Burge et al., 2007). A strong association has been observed between non-fatal fractures and reduced functional performance and loss of independence in the elderly (Stevens et al., 2006), and postmenopausal women with osteoporotic vertebral fractures report a diminished quality of life (Silverman et al., 2001).

Engaging in appropriate levels of physical activity can reduce the potential for developing osteoporosis later in life (Gunter et al., 2012; Karlsson et al., 2008; MacKelvie et al., 2002; Ondrak and Morgan, 2007; Rizzoli et al., 2010). Current bone health recommendations for children and adolescents include participation in resistance exercise and high-impact physical activities at least three days a week for a total of 10 to 20 min daily (Kohrt et al., 2004). To maintain bone health during adulthood, it is recommended that individuals engage in weight-bearing endurance activities three to five times a week and jumping and/or resistance exercise two to three times a week, resulting in 30 to 60 min of daily combined physical activity (Kohrt et al., 2004). While performing regular physical activity can reduce bone fractures and the risk of falling in the elderly (Gregg et al., 2000), relatively few older men and women in the United States achieve current minimal physical activity recommendations (Brawley et al., 2003) and 47% of adults 65 to 74 years of age and 61% of adults over 75 years of age are physically inactive (Agency for Healthcare Research and Quality, 2013).

Independent of physical activity, sedentary living has also been shown to influence a variety of health outcomes (Tremblay et al., 2010a). Recent findings have demonstrated a positive dose–response relationship between sedentary time and all-cause/cardiovascular disease mortality (Dunstan et al., 2010; Katzmarzyk et al., 2009; Warren et al., 2010) and metabolic dysfunction has been linked to physical inactivity (Tremblay et al., 2010b). With respect to bone health, evidence suggests that a reduction in sedentary time should accompany increases in moderate-to-vigorous-intensity weight-bearing activity to mitigate bone loss (Zerwekh et al., 1998).

Abbreviations: BMC, bone mineral content; BMD, bone mineral density; I-MVRPA, insufficient moderate-to-vigorous recreational physical activity; S-MVRPA, sufficient moderate-to-vigorous recreational physical activity; SB, sedentary behavior; VMHDS, vitamins minerals, herbals, or other dietary supplements.

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While separate causal associations have been reported among physical activity, sedentary behavior, and selected health indices (Boreham and Riccoch, 2001), surprisingly little is known concerning the relative contributions of both physical activity and sedentary behavior on health status across the lifespan, particularly with regard to skeletal health measures such as bone mineral content (BMC) and bone mineral density (BMD). Against this backdrop, the purpose of our study was to evaluate the ability of physical activity and sedentary behavior to predict bone mineral density and content in a large and ethnically-diverse sample of female adolescents and younger and older women.

Materials and methods

Subjects

Data from 2232 females aged 12 years and older, collected as part of the 2007–2008 National Health and Nutrition Examination Survey (NHANES), were included in this analysis. Study participants were grouped into four age categories; a) adolescents (12 to 17 years, n = 337, G1); b) young adults (18 to 39 years, n = 721, G2); c) middle-aged adults (40 to 64 years, n = 847, G3); and d) older adults (65 years and older, n = 327, G4). Descriptive characteristics of the sample are shown in Table 1.

Physical activity

Measures of physical activity were obtained from self-reported time spent in moderate-to-vigorous-intensity recreational physical activity (MVRPA) (excluding work and transportation). Calculation of MVRPA was based on written responses to a physical activity survey. Vigorous-intensity recreational physical activity (VRPA) was evaluated by asking the following question (Question 1); "Do you do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 min continuously?" Participants who answered 'yes' to Question 1 were requested to answer two additional questions: (a) "In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational activities?" (Question 2); and

Table 1
Descriptive statistics for study participants by age group in younger and older females.

	All[a] (N = 2232)	Adolescents (n = 337)	Young adults (n = 721)	Middle-aged Adults (n = 847)	Older adults (n = 327)
Age group (%)		11.26 (0.95)	35.29 (1.57)	42.86 (1.25)	10.59 (0.72)
Race/ethnicity (%)					
Non-Hispanic White	69.67 (3.28)	60.76 (4.28)	64.37 (4.01)	72.83 (3.34)	83.99 (3.55)
Non-Hispanic Black	11.85 (1.90)	16.59 (2.28)	13.29 (2.27)	10.46 (1.83)	7.63 (2.28)
Mexican	8.12 (1.55)	12.24 (2.83)	10.88 (2.28)	5.94 (1.07)	3.38 (1.04)
Hispanic & others	10.36 (1.54)	10.41 (2.95)	11.46 (1.60)	10.77 (1.70)	5.01 (1.62)
BMI (%)					
Normal	42.59 (1.63)	69.31 (2.59)	43.57 (3.07)	35.83 (1.79)	38.23 (3.34)
Overweight	29.04 (1.50)	19.20 (2.77)	26.64 (1.80)	31.68 (2.54)	36.77 (2.93)
Obese	28.38 (1.35)	11.49 (2.73)	29.79 (2.62)	32.48 (2.17)	25.00 (2.86)
MVRPA (%)					
I-MVRPA	62.38 (2.35)	42.50 (3.34)	57.56 (2.60)	67.95 (3.79)	77.00 (3.14)
S-MVRPA	37.62 (2.35)	57.50 (3.34)	42.44 (2.60)	32.05 (3.79)	23.00 (3.14)
Sedentary time (min·day^{-1})	338.04 (7.17)	463.97 (9.05)	325.51 (11.36)	320.66 (9.51)	316.33 (13.56)
BMC (g)					
Femur	29.56 (0.21)	28.54 (0.57)	30.54 (0.30)	29.61 (0.33)	27.20 (0.32)
Spine	57.87 (0.37)	52.57 (1.00)	61.01 (0.48)	58.12 (0.70)	52.06 (0.65)
BMD (g·cm^{-2})					
Femur	0.93 (0.01)	0.94 (0.01)	0.98 (0.01)	0.92 (0.01)	0.81 (0.01)
Spine	1.02 (0.01)	0.97 (0.01)	1.07 (0.01)	1.01 (0.01)	0.93 (0.01)
Supplement intake					
Vitamin D (μg)	3.70 (0.11)	3.42 (0.32)	3.42 (0.20)	3.96 (0.16)	3.85 (0.19)
Calcium (mg)	844.39 (23.97)	821.37 (53.41)	853.64 (25.88)	856.54 (31.40)	788.82 (25.38)
Magnesium (mg)	257.64 (7.30)	207.16 (11.98)	255.26 (9.38)	276.33 (8.50)	243.63 (7.08)
Sugar (g)	108.34 (2.38)	117.21 (5.61)	112.93 (3.71)	106.67 (3.53)	90.43 (2.48)
Protein (g)	67.60 (1.24)	61.28 (2.33)	68.90 (1.42)	70.17 (2.06)	59.58 (0.95)
Milk consumption					
No Milk	16.02 (0.70)	12.69 (2.28)	12.32 (1.31)	18.74 (1.25)	20.89 (3.25)
>1 glass/day	83.98 (0.70)	87.31 (2.28)	87.68 (1.31)	81.26 (1.25)	79.11 (3.25)
Smoking[b]					
Yes	17.86 (1.62)	–	22.72 (2.17)	20.55 (2.95)	9.78 (1.72)
No	82.14 (1.62)	100	77.28 (2.17)	79.45 (2.95)	90.22 (1.72)
Osteoporosis history[c]					
Yes	4.68 (0.66)	–	0.64 (0.55)	5.37 (1.25)	20.37 (2.36)
No	95.32 (0.66)	100	99.36 (0.55)	94.63 (1.25)	79.63 (2.36)
Prednisone or cortisone[d]					
Yes	4.90 (0.70)	–	97.11 (0.72)	93.30 (1.02)	90.48 (1.50)
No	95.10 (0.70)	100	2.89 (0.72)	6.70 (1.02)	9.52 (1.50)
Menopausal status[e]					
Menopause/hysterectomy	33.43 (1.32)	–	2.67 (0.85)	52.13 (2.26)	95.78 (1.23)
Others/No	66.57 (1.32)	100	93.33 (0.85)	47.87 (2.26)	4.22 (1.23)

Abbreviations: BMI = body mass index; MVRPA = self-reported moderate- to vigorous-intensity recreational physical activity (activities of at least 10 min continuously that cause small to a large increases in breathing or heart rates); I-MVRPA = insufficient MVRPA (0 to <150 min·week^{-1} for adults and <60 min·day^{-1} for adolescents); S-MVRPA = sufficient MVRPA (≥150 min·week^{-1} for adults and >60 min·day^{-1} for adolescents); BMC = bone mineral content; BMD = bone mineral density.
All values are presented as a percentage (%) and standard error (SE) for categorical variables, and mean and SE for continuous variables.
[a] Adolescents = ages 12 to 17, young adults = 18 to 39, middle-aged adults = 40 to 64, old adults = ages 65 and older.
[b] Smoking = smoking status at the time of survey.
[c] Osteoporosis history = ever treated for osteoporosis (yes vs. no/don't know/no response).
[d] Prednisone or cortisone = ever taken prednisone or cortisone daily (yes vs. no/no response).
[e] Menopausal status = not having regular periods due to menopause or hysterectomy (yes vs. no); not including adolescents.