Original Article

Age and Anthropometric Determinants of Radial Bone Mass in Premenopausal Caucasian Women: A Cross-Sectional Study

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Abstract. A sample of 181 healthy premenopausal Caucasian women, 20 to 50 years of age, was part of a cross-sectional study on the determinants of radial bone mineral content (BMC), bone width (BW) and areal bone mineral density (BMD) at two sites, the distal (Dis) or 5 mm-site (about 50% cancellous tissue) and the mid-radial (Mid) site (over 90% cortical tissue), as measured by single photon-absorptiometry. Women in their 20s (n=45) had significantly lower DisBMC and DisBW values than women in their 30s (n=65) or 40s (n=71). No such trends were noted for any of the mid-radial measurements with increasing age. With age, height and weight included in the same regression equation, age remained the only significant positive predictor of all three distal variables, while height was the only significant positive predictor of the mid-radial variables. Body weight was not associated with any of the bone variables in this model. A low lean body mass (LBM) or low body mass index (BMI) was consistently correlated with significantly lower bone values at both radial sites. These data suggest that peak bone mass (PBM), for the distal and largely cancellous portion of the radius, was achieved later in adulthood (30s) than the mid-radial or mostly cortical portion of the radius in which PBM was achieved much earlier, probably in late adolescence.

Keywords: Distal radius; Mid-radius; Age; Anthropometry; Peak bone mass; Bone density; Lean body mass; Body mass index

Introduction

Age-related bone loss is a universal phenomenon occurring in both males and females and in both types of bone tissue, cancellous and cortical. Significant variations in bone mineral loss exist, however, with respect to age of onset (pre- or postmenopausal) and the specific bones involved, e.g., lumbar spine, forearm, femoral neck and femoral shaft. These variations are considered to result from many factors, including gender, heredity, hormonal status, body size, body composition and lifestyle factors, e.g., diet, physical activity, smoking, and excessive alcohol or coffee consumption. Bone mass, as a whole, increases rapidly in childhood and adolescence, reaches a peak (peak bone mass or PBM) at the latest by the fourth decade of life and remains relatively stable, especially the compact bone of the appendicular skeleton, until the age of 40 [1] or 50 [2–5]. However, it has been reported by several investigators that trabecular bone loss can be initiated long before menopause, even as early as the late adolescent years [2, 6–9]. This loss remains linear throughout life except for a transient acceleration phase around the time of menopause.

The aims of this cross-sectional study of 181 healthy, premenopausal Caucasian women between the ages of 20 and 50 were the following:

1. To estimate time-frames when peak bone mass (PBM) of the two types of bone tissue are attained
2. To test the hypothesis that neither the cancellous nor the cortical bone components of the radius undergo any significant loss of mineral/density prior to the onset of menopause; and
3. To determine, through linear regression analyses, the nature of the associations, if any, between each of the bone variables at each site and the following
factors: age, height, weight, lean body mass (LBM) and body mass index (BMI).

Methods

Subjects

Over 200 Caucasian premenopausal women between the ages of 20 and 50 years were recruited via notices in various university and community buildings. Excluded were women with established endocrine disorders such as hyper- or hypothyroidism, thyroidectomy, parathyroidectomy, kidney disease, hypertension, diabetes, gastrointestinal disorders known to affect digestion and/or nutrient absorption, steroid therapy (not including oral contraceptives), and pregnancy or lactation. Also excluded from this study were women (a) who had started the process of menopause, i.e., they had not had any menstrual cycles for at least 6 consecutive months, (b) who had undergone oophorectomy, or (c) who had reported a history of amenorrhea for at least 6 consecutive months. As a result of these stringent exclusion criteria, only 181 of the recruited subjects were studied. Informed consent was obtained for all subjects in compliance with guidelines of the Committee on the Protection of Human Subjects at the University of North Carolina.

Personal Health Questionnaire. Each participant was asked several personal health-related questions in order to satisfy inclusion/exclusion criteria.

Anthropometric Measurements

Age (years), height (cm), and weight (kg) information was obtained from each study participant and values of lean body mass (LBM in kg) and body mass index (BMI) were calculated. The formula used for the computation of LBM is that by Boddy et al. [10] and is specific for women: 18.23 + (1.014 × 0.01) × [(14.76 × Weight) + (22.07 × Height) - (0.95 × Age) - 1669].

BMI was calculated as the ratio of weight (kg) over height (cm) to the one and a half power [11] rather than the more traditionally used ratio of weight over height to the second power. The reason for this choice is that the former ratio is more appropriate for women while the latter is more suited to men, due to their different body composition.

Bone Measurements

The bone mineral content (BMC) in g/cm, bone width (BW) in cm and areal bone mineral (BMD) in g/cm² were determined at the 5 mm site (5 mm radius-ulna gap) or distal site (Dis) and at the 2/3 site (67% distal from the olecranon process) or mid-radial site (Mid) of the non-dominant arm with a Norland Model 278A single-photon absorptiometer (Norland Instruments, Ft. Atkinson, WI). The 5 mm measurement site, introduced by Awbrey et al. [4] was chosen because of the greater consistency in the composition of the radius between individuals and of its relatively greater percentage of cancellous (trabecular) bone tissue. Percentage of trabecular bone content varies from approximately 38% as determined from cadavers by Eastell et al. [12] to about 55% by Schlenker and Von Seggen [13]. The 2/3 site of mid-radius is essentially cortical bone (90% or more) [14]. DisBMC, DisBW, MidBMC, and MidBW measurements were made for each subject using a special forearm positioning device and from these values areas (DisBMD and MidBMD) were calculated. Analysis of BMC by this method in our hands gives a coefficient of variation (precision) of within ± 3%.

Statistical Analyses

A statistical Analysis System (SAS) package was used for the analyses of the data [15]. Simple descriptive statistics (mean, median and range) were obtained on each of the dependent (bone values) and independent variables. Multiple regression (model) analyses were carried out between each bone variable and the chosen independent variables, age, height, weight, LBM and BMI. The different regression models used for the analyses presented in this paper, and their appropriate tables (see Results), are as follows:

Bone variables=Age-decades (20s, 30s, 40s) (Table 2)
Bone variables=Age+Height+Weight (Table 3)
Bone variables=Age+LBM tertiles (Table 4)
Bone variables=Age+BMI tertiles (Table 5)

Results

1. Descriptive data for the whole sample (n=181): anthropometric and bone variables for women 20 to 50 years old (mean±SD). From the distribution of values for LBM and BMI, tertiles (low, intermediate and high) were formed for each of these anthropometric variables. Table 1 shows the cut-off values used for the formation of tertiles of LBM and BMI.

<table>
<thead>
<tr>
<th>LBM tertile</th>
<th>Low (n=60)</th>
<th>Intermediate (n=60)</th>
<th>High (n=61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=42.934 kg</td>
<td>&gt;42.934 kg and &lt;=44.570 kg</td>
<td>&gt;44.570 kg</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BMI tertiles</th>
<th>Low (n=61)</th>
<th>Intermediate (n=60)</th>
<th>High (n=60)</th>
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</table>

Table 1. Cut-off values for the definition of tertiles of LBM and BMI for the whole sample (n=181)