Exploring Age-related Changes in Cortical Bone in Individuals Over 50 Using Radiographs

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Introduction:

Changes in bone morphology occur throughout the aging process. These changes include the thinning of cortical bone and an overall change in bone shape.

Using AP & ML digital radiographs of left femora from the Texas State Donated Skeletal Collection, we examined the reduction of cortical bone area and changes in bone morphology along the midshaft with age.

Research Questions:

- Is there a patterned reduction in cortical bone area compared to total bone volume with age?
- Are there traceable changes in midshaft and cortical shape with age?
- Is there a difference in cortical bone area changes or morphology between males and females?
- Is this method comparable to other established aging methods?

Materials and Methods:

- Digital radiographs of left femora from 164 individuals (106 males, 58 females) from the Texas State Donated Skeletal Collection.
- The amount cortical bone relative to the medullary cavity at three areas of the midshaft was measured (Figure 1).
- Digitized exterior margins of the midshafts to analyze changes in bone shape (Figure 1).
- Linear regression tests were used to measure the amount of correlation between cortical area and age.
- LOESS regression was used to measure the rate of correlation with age (Figure 2).
- A Generalized Procrustes Analysis was used to assess the changes in bone morphology by 10-year age cohorts.
- Statistics were run using using JMP® PRO (Version 14) statistical software and R (3.5.2).

Results:

- There is a weak to moderate correlation between age and MV:BV. The correlation is strongest at midshaft and weaker at the proximal and distal ends of the metaphysis (Table 1).
- This correlation is stronger in females than males.
- There are distinct changes is bone shape throughout the aging process. There are greater amounts of endosteal bone loss in the posterior and medial sides of the femur, particularly at midshaft (See GIF via QR code).

Summary:

There is a weak to moderate correlation between age and the bone volume ratio (MV:BV) in individuals over 50 years. The midshaft shows the highest levels of correlation and females have a higher level of correlation than males.

The results of this study show that this method is not more accurate or reliable than other aging methods. However, this method can be used in combination with other methods or as a stand-alone if only the midshaft is present.

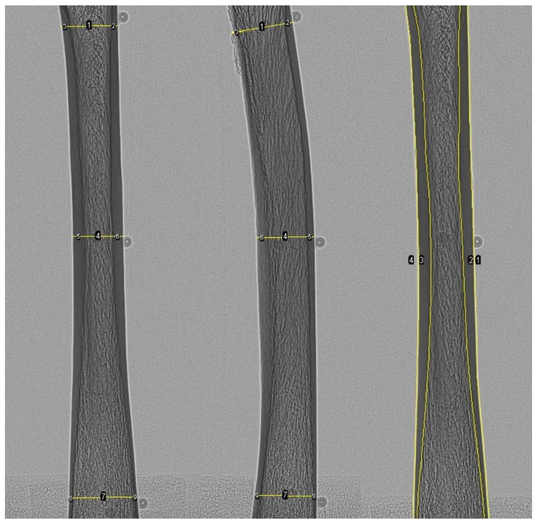

Figure 1: Cortical bone area measurements in the AP (Left) and ML planes (Middle) at 20%, 50%, & 75% length from the distal end. Digitized margins of cortical bone in the AP Plane (Right). This was also done in the ML plane.

Sample	Measure	Correlation	Covariance	P-value	R^2
Combined	Avg Ratio 20%	0.210	0.078	0.0069	0.044
	Avg Ratio Mid	**0.394**	0.356	<0.0001	0.155
	Avg Ratio 75%	0.320	0.229	<0.0001	0.103
	Avg Ratio All	**0.384**	0.221	<0.0001	0.147
N=164					
Females	Avg Ratio 20%	0.333	0.144	0.013	0.111
	Avg Ratio Mid	**0.505**	0.604	<0.0001	0.256
	Avg Ratio 75%	**0.427**	0.383	0.0011	0.183
	Avg Ratio All	**0.496**	0.377	0.0001	0.246
N=55					
Males	Avg Ratio 20%	0.124	0.043	0.1973	0.015
	Avg Ratio Mid	0.304	0.204	0.0013	0.093
	Avg Ratio 75%	0.233	0.144	0.0146	0.054
	Avg Ratio All	0.288	0.130	0.0024	0.083
N=109					

Table 1: Linear regression results for averaged measures for females and males. Correlations over 0.35 are in bold.

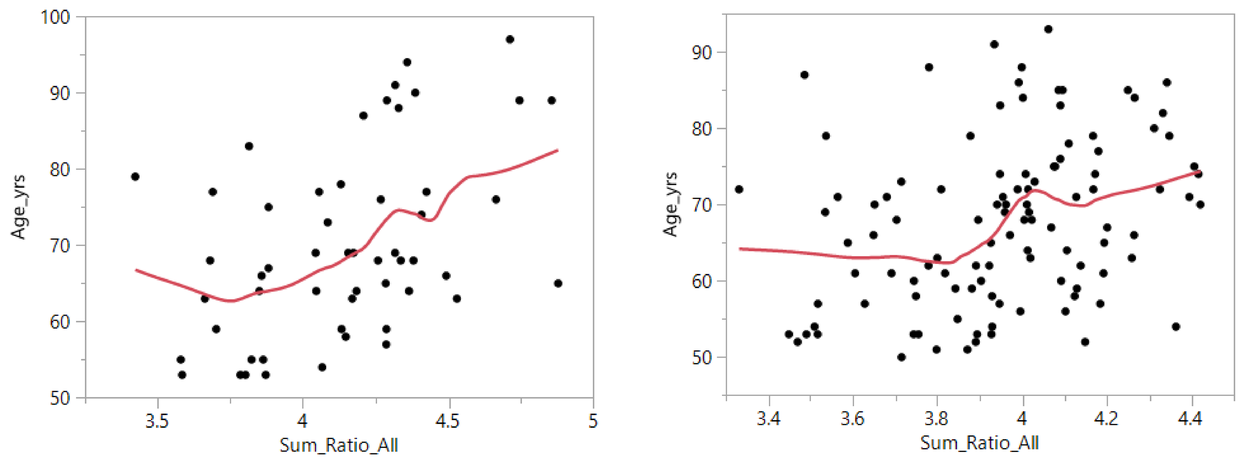

Figure 2: LOESS regression plots for all measures of cortical bone area along the midshaft. Left: Female. Right: Male.

Discussion:

The weak to moderate correlation is consistent with what other researchers have found (Smith, Walker 1964; Carlson, Armelagos, Van Gerven 1976; Russo et al. 2005).

These results indicate that it may be possible to accurately estimate age in individuals over 50 using morphological characteristics.

The differences in correlation between males and females can be tied to sexual dimorphism and is potentially related to menopause.

The remainder of the variation in MV:BV is likely attributable to body mass and physical activity level.

Higher rates of cortical bone thinning and greater variation in diaphyseal shape is evident in the 70+ age cohorts suggesting show that there is an increase in bone remodeling activity.

This is perhaps due to changes in activity level and/or a response to reduced bone strength that are part of the aging process.

Further analysis may include volumetric measures of the entire cortical bone area and inclusion of more demographic groups.

A GIF of the changes in diaphyseal morphology can be seen by accessing the QR code below.

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References:

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