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ORIGINAL ARTICLE

Age-related changes in cortical bone thickness of ancient Egyptians

Moushira Erfan Zaki *, **Ayman A. Azab**, **Walaa Yousef**

Biological Anthropology Department, Medical Research Division, National Research Centre, Egypt

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KEYWORDS

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Abstract *Background:* Cross-sectional properties are affected by intrinsic factors such as age and levels of sex hormones. The aim of the present study was to assess age related changes in long bone cortical bone measurements in ancient Egyptian males and females.

Material and methods: The material of the present study consisted of 245 skeletons. Measurements of cross-sectional properties from CT images were taken from humerus, femur, and tibia. Cross-sectional images were obtained in the transverse plane of each bone, perpendicular to both coronal and sagittal planes.

Results: The results of the present study revealed that the cortical area showed a consistent decrease after age 50 years in all bones for both sexes; this reduction was significant in the tibia of males and in the humerus and femur of females. The present study demonstrated an increase in endosteal diameter of long bones, with an associated decrease in thickness of compact cortical bone which is more obvious in ancient Egyptian females than in males.

Conclusions: The present results highlight important sex-specific differences in patterns of age-related bone loss. These findings are comparable to those from other human populations and represent a valid resource for clinical application and for comparisons with contemporary subjects.

1. Introduction

In general, bone is deposited at the periosteal envelope prior to mid-adolescence and at the endosteal envelope after that (1–5). Other age-related changes include expanded medullary cavities, thinner cortices and the net loss of trabecular bone (6,2,7–9,5).

Ruff and Hayes (10) concluded that, age progress resulted in notable changes in bone properties, through increased bone resorption by increasing the age, especially in females after the menopause. In the human females, after menopause, bone resorption increases due to estrogen reduction. On the other hand, in males bone loss is about 30% less than in females. Once the reduction in bone amount and/or density has become clinically significant, the individual is diagnosed as an osteoporotic patient. Therefore, after menopause, the females become more susceptible to osteoporosis (11).

Bone density increases by age till getting the greatest bone density (peak bone amount) at about the age of 30 years in

* Corresponding author.

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the majority of people, and then after this age, the amount of bone resorption exceeds the amount of bone deposition. Thus, bone mass starts to decrease at a rate of 0.5–1.0% per year (12,13). Feik et al. (14) studied the effect of age on bone remodeling of the femoral midshaft and the related-difference between the two sexes. They found distinctive sex differences in cortical bone remodeling along the duration of adulthood. In adults, till the seventh decade, males showed a quite consistent increase in subperiosteal area (total cross-sectional area), polar moment of inertia, and medullary area. In old age, sex differences decreased and both sexes showed a decrease in periosteal apposition and an increase in endosteal resorption. The aim of the present study was to assess age related changes in long bone cortical bone measurements in ancient Egyptian males and females.

2. Materials and methods

The study skeletons were kept in a storeroom at Giza and belong to the Old Kingdom period (2700–2190 B.C.), which is known as the period of pyramid builders (15). They were excavated from the Giza necropolis. The materials of the present study consisted of 245 adult skeletons of ancient Egyptians, with no gross pathological changes or fractures that may affect the bone's biomechanical properties. They were classified according to sex: 128 males and 117 females.

Determination of the sex of the skeletons was done using the descriptive methods of both pelvises (16) and skull (17) when available.

When both pelvis and skull were absent, sexing depended on the long bones. The maximum length and head diameter of humerus and femur and bone length of tibia were measured according to the definitions, landmarks and the techniques described by Buikestra and Ubelaker (18).

Age at death was estimated using the metamorphosis of the auricular surface (19) depending on the chronological changes in the auricular surface of the ilium.

Biomechanical length of humerus, femur and tibia was obtained according to Ruff and Hayes (10). The biomechanical bone lengths, and the maximum bone lengths, were measured and the bone midpoint was obtained. The biomechanical bone lengths were used to mark the bone points at which the cross-sectional images were obtained in the transverse plane of each bone, i.e., perpendicular to both coronal and sagittal planes, at the mid-shaft point of femur and tibia, and at the 40% from the distal end of the humerus (to avoid the deltoid tuberosity), using a Toshiba CT somatom scanner. Bone lengths were measured parallel to the longitudinal axis of each bone, defined by the intersection of the coronal and sagittal planes. Antero-posterior and mid-lateral breadths of both subperiosteal and endosteal areas were measured at the two planes from M–L axis counterclockwise to major axis. In addition, cortical bone thickness at anterior, posterior, medial, and lateral parts of the bone section was measured.

Body size standardization is a very important process to avoid the effect of the difference between individuals or samples in their body size on bone geometric properties. Body size standardization was done, using the following equations: For cross-sectional areas: (area/long bone length^3) * 10^8. The geometrical properties generated from the CT image included the following: Total subperiosteal are (TA); Medullary area (MA); cortical area (CA). Percent cortical area (%CA) was calculated as (CA/TA) * 100 (18).

3. Results

Table 1 shows the frequency distribution of the age at death for males and females. The material was classified into four age groups: 20–30y, 30–40y, 40–50y, and above 50 years.

Table 2 shows means and standard deviations of the standardized cross-sectional areas "total sub periosteal area (TA); medullary area (MA); cortical area (CA); and percent cortical area (CA %)" of humerus, femur, and tibia for males and females of the four age groups. These data indicate that the alterations of the total cross-sectional area (TA) with age, either by the increase or by the decrease, in all bones for males and females, are non-significant except for the significant decrease after age 50 years of female humerus. The medullary area (MA) of the femur and tibia was significantly increased at the fourth age group of the females, while in males this increase was significant in the femur. The cortical area (CA) shows consistent decrease after the age 50 years in all bones for both sexes. This decrease is significant in the tibia of males and the humerus and femur of females. The highest values of cortical area (CA) were in the first and third age groups ((20–30) and (40–50) years) for all bones of males and for humerus and tibia of females, while the lowest was in the fourth age group (50+ years), in all bones of both sexes. The cortical area percent (CA%) showed a significant decrease at age 50+ in the femur and tibia of both males and in the humerus, femur and tibia of females. CA% of male humerus shows an increase by age till 50 years and then decreases, while male femur shows an increase till age 40 years followed by a significant decrease. The cortical area percent (CA%) of both the femur and tibia in females shows a consistent decrease by age. In males, the highest significant differences between age groups were noticed in the anterior cortical thickness of the femur, medial and lateral of the tibia followed by the posterior and lateral thicknesses of the femur and then by the anterior and posterior thicknesses of the tibia. In females the significant differences between age groups were noticed in the medial thickness of the humerus and the medial and lateral thicknesses of the tibia followed by the posterior and lateral thicknesses of the humerus. The significant decrease in the cortical thicknesses of the humerus of the females was at the third age group (40–50 years) for the anterior, posterior and lateral thicknesses, and this decrease was earlier at the second age group (30–40 years). The medial (M) and lateral (L) cortical thicknesses of the tibia were more affected by the age as they showed a significant decrease at the old age when compared with the anterior and posterior thicknesses, particularly in females. In males, the humeral (A & P), femoral (A, P & L)

Table 1 Age distribution of workers and high officials males and females.

Age/years	Males %	Females %
20–30	25.5	38.3
30–40	81.1	53.1
40–50	60.7	52.2
50+	32.6	46.4
Mean age	39.35 years	40.24 years