

CARPAL BONE SCALING IS ISOMETRIC AND NOT GENDER SPECIFIC

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INTRODUCTION

The contribution of the individual carpal bones to overall wrist motion is similar in males and females. For example, an early study of wrist flexion and extension revealed no gender-related differences in rotations at the midcarpal joint (Brumfield, '66). Similarly, more recent 3-D studies have found no differences in the magnitude of carpal bone rotation in men and women during flexion and extension (Wolfe, '00).

Although the magnitude of carpal bone motion appears to be similar in males and females, there *are* differences in the location of the rotation axes. In particular, the rotation axes of the carpal bones in females are located more proximally than in males (e.g. Neu, '01). This suggests that the differences in rotation axis location are primarily due to differences in bone size, as opposed to shape. However, this has never been studied systematically.

This study was performed to determine whether the gender-related differences in carpal bone size are simply due to scaling. To do so we tested the hypotheses that: 1) the volume of each carpal bone relative to wrist volume did not differ with gender, 2) the dimensions of the carpal bones in men and women scale on the same continuum, and 3) carpal bone dimensions scale isometrically (by an identical factor in all coordinate directions).

METHODS

After IRB approval and informed consent, both wrists of fourteen male and fourteen female volunteers with no wrist pathology were CT scanned (mean age 24.6

years, range 21-28). The individual carpal bones were segmented from the CT volume images, and the centroid locations, principal inertial axes, and volumes of each carpal bone were calculated (Crisco '98).

Carpal bone dimensions were defined by the dimensions of a rectangular parallelepiped bounding box whose sides were parallel to the principal inertia axes, with X, Y and Z dimensions corresponding to the smallest, middle and largest inertia values, respectively (Fig. 1).

The X, Y and Z dimensions of each bone were plotted as a function of carpal bone volume.

To determine whether the bones scaled isometrically an average-sized set of bones was selected and the X, Y and Z dimensions multiplied by a series of isometric scaling factors (the same for all three dimensions) to generate theoretical scaling curves, which included the smallest and largest carpal bone volumes. Comparisons of carpal bone dimensions, volume, and volume as a percentage of total wrist volume were made with unpaired Students' t-tests.

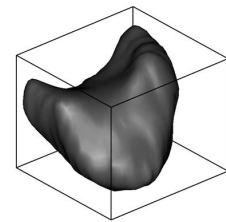


Fig. 1 Bounding box

RESULTS

As expected, the mean volume of each of the carpal bones was significantly smaller in females than in males (by an average of 30%). However, when the size of each carpal bone was calculated as a percentage of the total volume of the carpus,

there were no significant differences between genders (Fig. 2).

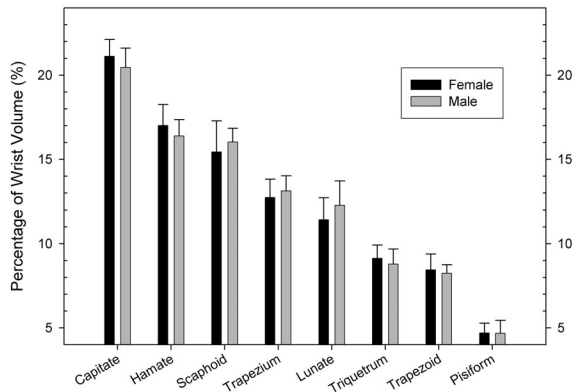


Fig. 2: Volume of each carpal bone as a percentage of the total wrist volume did not differ with gender.

Carpal bone dimensions increased as a function of volume, for each of the carpal bones (e.g. capitate, Fig. 3), and the relationship was similar in both men and women. The theoretical scaling curves had a slightly non-linear trend and closely followed the plots of the raw data from all subjects.

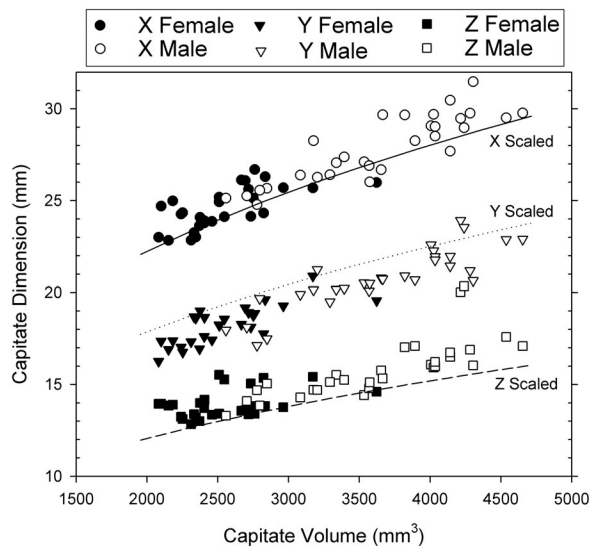


Fig. 3: The increase in each dimension of the capitate closely followed that predicted by the average capitate scaled isometrically, without any difference between male and females.

DISCUSSION

This study was performed to explore gender-related differences in carpal bone scaling. Our results suggest that the carpal bones in men and women scale similarly. While we found that the carpal bones in men are bigger than those in women, when comparisons were made of carpal bone volume as a percentage of overall wrist volume, we saw no significant differences. Our regressions revealed that the principal dimensions of the carpal bones (X, Y, and Z) in both men and women scaled on the same continuum and, most interestingly, despite their complex shapes, the three principal dimensions of the carpal bones scaled isometrically with volume (i.e. by the same factor in all three dimensions). There is little mention of this in the literature, though there are hints at such a trend in volume and inertial magnitude comparisons (Canovas, '00).

Our results provide important insight into the scaling of carpal bones. However, our dimensioning studies do not address issues of shape, nor do they describe differences in the curvature of the articular surfaces or in the locations of the bony prominences associated with ligament insertions. These will be the subject of future studies.

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