INTRASKELETAL HETEROGENEITY OF BONE MINERAL DENSITY

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1 INTRODUCTION

Dual X-ray bone absorptiometry (DXA) is the most widely used bone density measurement technology, and the gold-standard test to diagnose osteoporosis. Densitometric analyses in skeletal samples from archaeological contexts have mostly utilized the proximal femur[1] but the radius can be a reliable alternative to evaluate bone loss in past populations[2]. In this study we aimed to assess the heterogeneity of bone mineral density (BMD) in the femur and the radius in a pooled Portuguese sample and to consider the value of the radius in the study of bone mineral density (BMD) in archaeological skeletal samples.

2 MATERIALS & METHODS

Fifty-one individuals (♀: 24 / ♂: 27) from four medieval / early modern Portuguese sites compose the pooled study base (Table 1). One femur and one radius from each individual were scanned with a Hologic QDR-4500C Elite densitometer. All bones displayed a very good index of preservation, with no visible soil ingress. For the purposes of this study, three regions of interest (ROI) of the proximal femur («neck», «trochanter» and «Ward's area») and three ROI of the radius («1/3 radius», «mid distal radius» and «ultradistal radius») were evaluated.

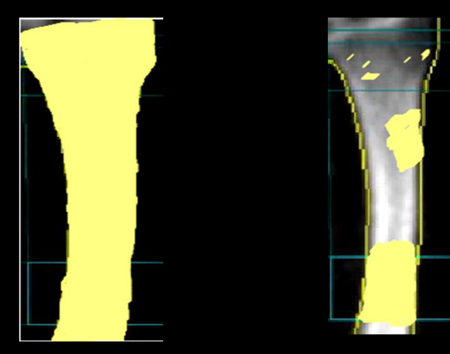

Figure 1:
BMD fully detected in the distal radius (left);
BMD only partially detected (right).

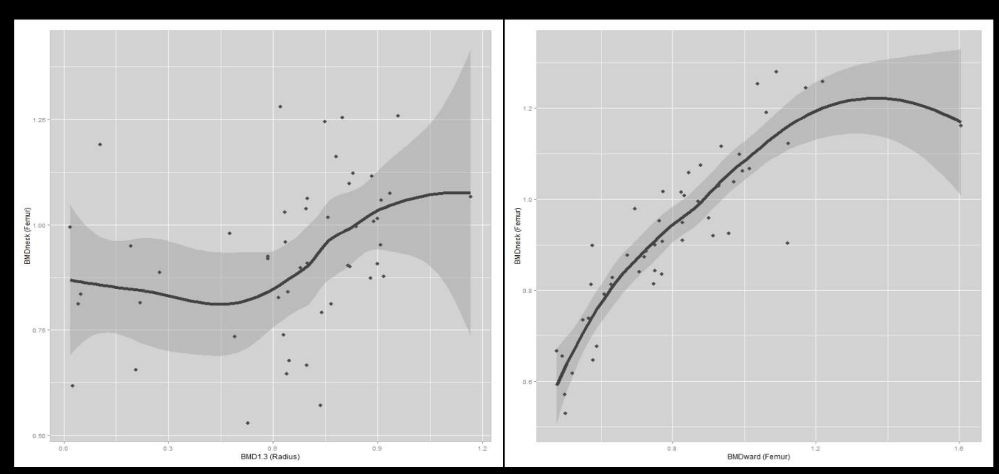

Figure 2:
Local polynomial regression fitting smooth (LOESS) for BMD*1.3* and BMD*neck* (left); LOESS smoothing for BMD*neck* and BMD*ward* (right). Note the utterly different patterns of association.

3 RESULTS

There is a significant and strong association among the three ROI of the proximal femur (Pearson's $r_{neck*trochanter}$=0.787, p<0.001; Pearson's $r_{neck*Ward's}$=0.851, p<0.001; Pearson's $r_{trochanter*Ward's}$=0.641, p<0.001) and at two ROI of the radius (Pearson's $r_{ultradistal*mid}$=0.797, p<0.001; Pearson's $r_{mid*1/3}$=0.685, p<0.001). The linear dependence between the BMD at the ultradistal radius and at the 1/3 radius is positive but moderate (Pearson's $r_{ultradistal*1/3}$=0.453, p<0.001). The linear relationship between the variables of the femur and the radius varies from non-significant (Pearson's $r_{trochanter*ultradistal}$=0.165, p=0.247; Pearson's $r_{trochanter*mid}$=0.198, p=0.164; Pearson's $r_{trochanter*1/3}$=0.274, p=0.052), through weak (Pearson's $r_{Ward's*ultradistal}$=0.300, p=0.031; Pearson's $r_{Ward's*mid}$=0.287, p=0.041; Pearson's $r_{Ward's*mid}$=0.294, p=0.036; Pearson's $r_{neck*mid}$=0.294, p=0.036) to moderate (Pearson's $r_{neck*1/3}$=0.334, p=0.017; Pearson's $r_{neck*ultradistal}$=0.370, p=0.007). It is noteworthy to mention that BMD in 20 radii (39,2%) was difficult to detect (both with software for radial scanning and for small mammals scanning), especially in the ultradistal region, and the densitometer operator manually filled the bone gaps (Fig. 1). Detection difficulties affected similarly the radii from all the archeological sites (Fisher's exact test: 3.197; p=0.372) and both sexes (Fisher's exact test: 1.887; p=0.248).

SITE	CHRONOLOGY	FREQUENCY (N)	PERCENTAGE
S. João de Almedina, Coimbra	12th – 15th AD	14 (♀: 7 / ♂: 7)	27,5
Poço Antigo, Cacela Velha	13th – 14th AD	16 (♀: 6 / ♂: 10)	31,4
Constância	14th - ? AD	8 (♀: 2 / ♂: 6)	15,7
S. Francisco, Santarém	13th – 17th AD	13 (♀: 7 / ♂: 6)	25,5

Table 1: Samples used in the pooled study base.

4 DISCUSSION

The high correlation among the three different ROI of the femur (and two of the radius) was expected since there is a close anatomical association among these areas[2]. A modest association between the BMD of the ultradistal radius and the 1/3 of the radius is also plausible, since the latter site is mostly composed by compact bone, while the ultradistal radius has a greater proportion of trabecular bone. Likewise, the non-existent to moderate correlations between the femur and radius sites (Fig. 2) is probably due to the consequence of ROI differences in macroscopical bone composition (trabecular *vs.* compact) and bone differences in weight bearing[3]. Thus, the results suggest that heterogeneity in bone mass is observable between bones and among regions in the same bone[4,5]. Notwithstanding, the densitometer was not able to fully detect BMD in a large number of radii with no apparent diagenetic change, independently of the archeological site. As such, BMD assessment at the radius in archaeological samples is problematic and should be used cautiously in paleopathological studies of bone loss.

5 REFERENCES

[1] Mays S. 2008. Metabolic bone disease. In R. Pinhasi & S. Mays (eds.): *Advances in human palaeopathology*, pp. 215-252. John Wiley & Sons, Chichester.
[2] McEwan J.M., Mays S. & Blake G.M. 2004. Measurements of bone mineral density in the radius in a medieval population. *Calcif. Tissue Int.*, 75: 157–161.
[3] Bonnick S.L. 2010. Bone densitometry in clinical practice - Application and interpretation. Humana Press, Totowa.
[4] Peck J.J. & Stout S.D. 2007. Intraskeletal variability in bone mass. *Am. J. Phys. Anthropol.*, 132: 89–97.
[5] Philipov G. & Phillips R.G. 2001. Skeletal site bone mineral density heterogeneity in women and men. *Osteoporos. Int.*, 12: 362-365.

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