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Introduction

Dual-energy X-ray absorptiometry (DXA) is a current technique utilized in radiology to assess bone mineral density (BMD) and facilitate the diagnosis and risk of osteoporosis in clinical practice. In recent years, DXA has been widely used to study bone health in ancient skeletons in order to compare past populations and modern ones, characterized by different lifestyles (Lees, 1993; Mays, 1999, 2008).

This preliminary study was performed to examine the value of DXA as a non-destructive approach in ancient human remains housed at the Museum of Anthropology and Ethnography of the University of Turin.

Materials and methods

Analyses were performed on the skeletal remains excavated from the cemetery of the San Michele Church in Trino Vercellese (Piedmont, North-West Italy) dated to the medieval and post-medieval periods (8^{th}-13^{th} and 17^{th} centuries) and presently housed in collections of the Museum of Anthropology and Ethnography of Turin (Italy). The archaeological excavations were performed by the University of Turin (Negro Ponzi Mancini, 1999) in different burial areas, in which more than 700 skeletons of both sexes, including adults, adolescents and infants, were found (Porro et al., 1999). The analyses of the spatial organization and the typology of burials and graves have suggested to archaeologists the presence of different social groups:

1) Inside group: 273 skeletons buried inside or along the walls of the church. Starting from the Early Middle Ages, the custom of burying inside the churches was documented for members of the clergy and privileged families. The archaeological evidence from Trino indicates that there is no reason to doubt the presence of noble families inside the San Michele Church.

2) Outside group: 219 skeletons buried outside the church in the parvis, close to the building. During medieval times, this burial area was dedicated to a plebeian cemetery. In the case of San Michele, this space may be referred to rural population burials.

3) North group: 99 skeletons buried outside the church in an area north of the building. These burials were not very close to the church and may be referred to different groups, such as soldiers or servants, probably not belonging to the rural population.

All the material included in the study was selected in relation to the state of preservation. The analysed bones were undamaged and showed neither pathological features nor signs of soil erosion and infiltration that might interfere with the accuracy of the measurements (Fig. 1). Using this criterion, lumbar vertebral bodies and/or proximal femora from 55 adult individuals (27 males and 28 females) were considered suitable specimens for the present study (Table 1). The estimated mean age was 42.52 ±11.94 (range 20-63) for males and 38.89 ±11.69 (range 20-60) for females.

Densitometric scans were performed with a Hologic Discovery DXA fan beam apparatus (Hologic Inc., Waltham, MA, USA). The precision coefficient was below 1% in vivo and ca. 0.5% in vitro. Scanned bones lay on a padded box to standardize the position. An x-ray generator was located below the bone and a detector was positioned above and slowly passed over the area, generating images on a computer monitor.

Results

Mean BMD values observed in the lumbar spine (L1-L4) and proximal femur (femoral neck and total) in both male and female groups are summarized in Table 2. When we divided the examined specimens according to their burial location, we observed statistically significant ($p < 0.05$) differences in BMD both among females and among males (Table 3). In particular, individuals buried inside the church (members of the clergy and privileged families) had significantly lower mean BMD values than individuals buried outside the church (members of the rural population, soldiers or servants). These differences may be related to a different lifestyle of the lower classes with respect to the upper classes: more calcium intake in the diet (dairy products), more sun exposure and vigorous physical activity.

Our findings are supported by the results of an earlier study on intrapopulation variations in stature and body proportions in relation to social status and sex differences performed on the same population from Trino Vercellese (Vercellotti et al., 2011)

Chemical analyses will be performed on the bones to provide additional data concerning digenesis effects.

References

Lees B, Molleson T, Arnett TR, Stevenson JC (1993) Differences in proximal femur bone density over two centuries. Lancet 341: 673 – 675

Mays SA (1999) Osteoporosis in earlier human population. J Clin Densitom 2:71-78.

Mays S (2008) Radiography and allied techniques in the paleopatholgy of skeletal remains. In: Pinhasi R, Mays S (Editors) Advances in Human Paleopathology. Wiley

Negro Ponzi Mancini MM (1999) San Michele di Trino (VC) Dal Villaggio romano al castello medievale. All’insegna del Giglio, Firenze

Porro MA, Boano R, Spani F, Doro Garetto T (1999) Studi antropologici sulla popolazione. In: Negro Ponzi Mancini MM. San Michele di Trino (VC. Dal Villaggio romano al castello medievale. All'insegna del Giglio, Firenze: 722-732.

Vercellotti G, Stout SD, Boano R, Sciulli PW (2011) Intrapopulation variation in stature and body proportions: social status and sex differences in an Italian medieval population (Trino Vercellese, VC). American Journal of Physical Anthropology, in press.

Fig. 1 Lumbar vertebral bodies and proximal femur

sex	male	female	total
inside church	12	8	20
outside churh (parvis)	8	10	18
outside church (north group)	7	10	17
total	27	28	55

Tab 1 distribution of the subsamples in the cemetery and relative sex and age at death.

	Lumbar spine BMD	Femur tot BMD	Femur neck BMD
Male	1.377±0.206	1.187±0.168	0.985±0.177
Female	1.369±0.24	1.275±0.249	1.045±0.222

Tab. 2. Mean BMD values (g/cm2) in males and females samples.

Groups	**Lumbar spine BMD**	**Femur tot BMD**	**Femur neck BMD**
inside church	0,910±0,148	0.886±0.119	0.718±0.10
outside churh (parvis)	1,140 ±0,203	1,468 ±0,248	1,205 ±0,243
outside church (north group)	1,540 ±0,140	1,25 ±0,144	1,001 ±0,151

Tab. 3 Mean BMD values (g/cm2) in females samples according to burial location ($p<0.05$ for inside churh vs other groups)