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Anthropological analysis and paleo-demographic study of human skeletal remains from the late ancient necropolis of Biverone (4th-5th c.AD), San Stino Di Livenza (Venice, Italy)

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Abstract: The study of the osteological collections preserved at the Museum of Anthropology – University of Padua coming from archaeological excavations dated to the end of 19th and 20th century, is a great opportunity to disseminate still unpublished anthropological data. The aim of this work was the analysis through modern anthropological methodology of the human skeletal remains brought to light in 1983 at the necropolis of Biverone, municipality of San Stino di Livenza (Venice, Northeast Italy). The site, close to Livenza River, began its decadence in the Late Ancient period (4th-5th c. AD) as a result of regional morphological variations and barbarian invasions, that caused an important local depopulation.
The study focused on the anthropological analysis of 121 skeletal individuals, trying to better understand the paleodemographic profile, the state of health and the way of life of the ancient population of Biverone. A preliminary identification of the ancestry was attempted, considering the general lack of information about the Late Ancient Venetian populations.

Key words: early medieval population; physical anthropology; paleopathology; past-life conditions, ancestry

Introduction

In spring 2015, the collections of the Museum of Anthropology, University of Padua, were transferred in a single location – Palazzo Cavalli – after many decades of alternate events. In the new building, it was possible to finalize the complete cataloguing of the Tedeschi Osteological Collection, a project that began over a decade ago. Prof. Enrico Emilio Tedeschi (1860-1931) was the founder of the Institute of Anthropology in 1897 and the collector of the human remains dated from the late 19th and the early 20th century (Alciati et al. 1996). At the beginning of 2016, the project was extended to many unpublished osteological collections coming from archaeological excavations.

In the present study, result of a Bachelor's Degree in Natural Sciences, we present the results of the anthropological analysis on the human skeletal remains coming from the late ancient necropolis of Biverone, near Venice (Italy).

The necropolis of Biverone, San Stino di Livenza (Venice, Italy)

Biverone is a village in the municipality of San Stino di Livenza, situated

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in the eastern part of the Venice province (Fig. 1). The village is located close to the banks of the Livenza river. A section of the Via Annia – the consular Roman road that connected Adria to Aquileia, through Padua, Altino and Concordia – passed to the South of the village. The road began its decline during the Late Antique period due to variations in the territorial morphology and to the barbarian invasions that caused depopulation in that area.

In 1983, the Archaeological Superintendence of Veneto initiated a preliminary survey on a 300-sq.m. area that ended with the discovery of the necropolis. The skeletal stratigraphy indicated that the necropolis had been used for a long time, with an estimated presence of three generations at least: the most recent skeletons were heavily compromised or completely removed by the modern agricultural activities.

The first skeletons completely *in situ* and well-preserved were found at a depth of about 68 cm, surrounded by a blackish soil rich in organic matter, immediately under the humus and surrounded by brick structures slightly higher (50 cm). Skeletons at the lower levels were buried with East-West orientation, with head oriented to West and face oriented to North, while upper ones showed a more random arrangement around the masonry remains and without grave goods. South of structures A and B a quadrangular pit used as a mass grave was found, as well as a large burnt area with numerous remains in terracotta, glass and wood. (Fig. 2)

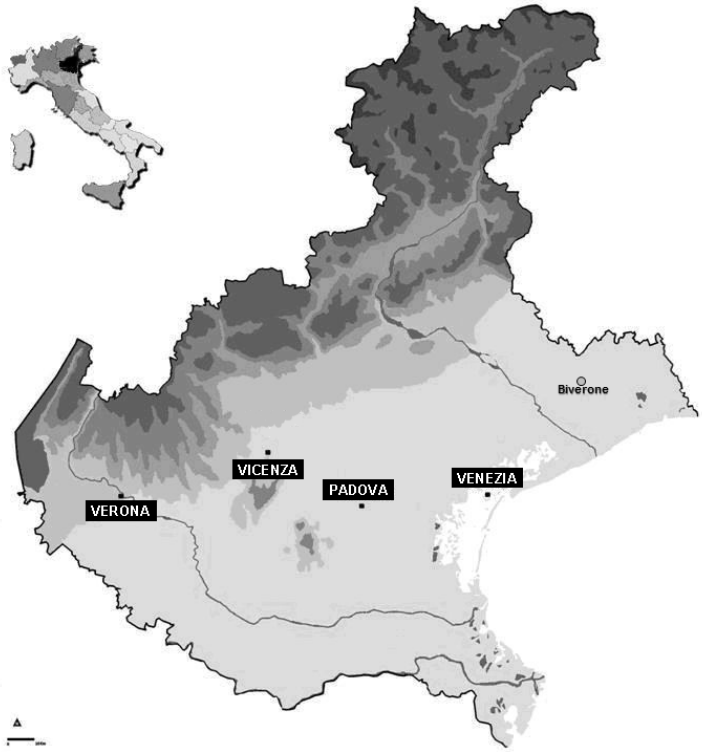

Fig. 1. Geographical map of Veneto Region

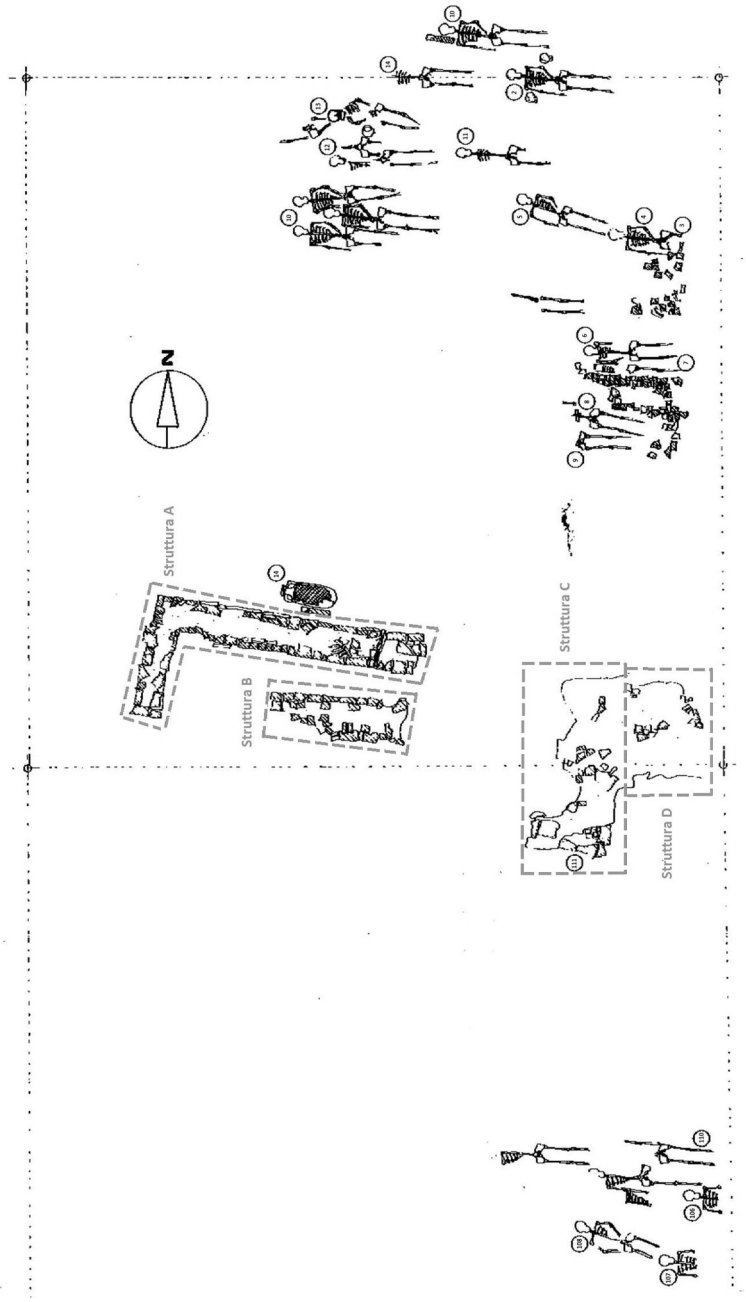

Fig. 2. Excavation planimetry (changed by Croce Da Villa 1984)

The presence of masonry structure and burned area suggests the spread of the funeral meal, which was celebrated near the tombs and consisted in consumption of food in honor of the deceased. The discovery, among the human skeletal remains, of animal bones (particularly of cattle and pigs) and fragments of *ollae*, *amphorae*, dishes and colored glasses - presumably used for the ritual of libation - support this hypothesis. This practice was very ancient: already spread in Italy by Etruscans, it was also utilized during Roman Age. With the arrival of Christianity, it persisted but assumed the meaning of passage from mortal to eternal life, the so-called *refrigerium*.

The archaeological finds allowed to date the oldest necropolis layer necropolis around the 4th-5th century AD; the higher layer dated around the 6th century AD. The East-West orientation of the buried bodies further confirms the dating. The upper layer was not datable, because it was too much affected by modern farming activities.

The presence of the mass grave may refer to the tragic events of that period, as the barbaric invasions by the Huns and Avars – in 452 and in 510 AD – and the famine that affected the entire region in 494 AD (Croce Da Villa 1984).

Materials and Methods

After the excavation campaign in 1983, the skeletons found at Biverone were collected by Dr. Marco Tonon and Dr. Alessandro Bonardi and then sent to the Institute of Anthropology of the Padua University (Croce Da Villa 1984), currently represented by the Museum of Anthropology, where they are still preserved. The human remains were contained in plastic bags which included labels indicating the number of tombs and the place of discovery. Before starting the anthropological analysis, the bones were cleaned with running water and then dried in the air.

Age determination

Skeletons have been classified into eight age groups: five sub-adults (fetuses, less than 1-year-old, 1-4 years, 5-9 years, 10-14 years and 15-19 years) and three adults (20-39 years, 40-59 years and 60+ years). Recommendations suggested by Ferembach et al. (1980) and the criteria described by Krogman and Isçan (1986) were followed for the classification of sub-adult skeletons. The dental development (Ubelaker 1989; AlQahtani et al. 2010) and the degree of ossification and epiphyseal union criteria of adult bones were also observed (Brothwell 1981; Ferembach et al. 1980; Krogman and Isçan 1986). To classify the adult skeletons, the recommendations suggested by Ferembach et al. (1980) and Buckberry and Chamberlain (2002) were followed, and the multi-factorial approach was preferred when possible (Lovejoy et al. 1985a). Then, the degree of cranial sutures synostosis (Meindl and Lovejoy 1985), dental wear (Brothwell 1981), morphological changes of the pubic symphysis (Meindl et al. 1985; Krogman and Isçan 1986), and metamorphosis of auricular surface of the ilium (Lovejoy et al. 1985b) were employed.

Sex determination

Considered that skeletal dimorphism is not evident in immature skeletons, and that no consensus exists on the methodology that should be adopted, sex diagnosis was not attempted for individu-

als under 15 years of age. With juvenile and adult skeletons, the classic criteria proposed by Ferembach et al. (1980), Sjøvold (1988), Buikstra and Ubelaker (1994), Bass (1995) and Walker (2005) were adopted.

Minimum Number of Individuals (MNI)

The estimation of Minimum Number of Individuals (MNI) in each tomb was based on the procedure outlined by White (1953).

Anthropometric methodology

Following the directions made by Martin and Knussmann (1988), skeletons have been studied from point of view morphometric. All measurements, expressed in millimeters, were carried out on the best preserved anatomical districts, in particular on skulls and long bones, to determine the physical indices and the stature, to be able to compare the data with other medieval skeleton series. Stature was calculated according to the method proposed by Trotter and Gleser (1958) and Sjøvold (1988).

Paleodemographic methodologies

Alesan et al. (1999) summarised the necessary assumptions in order to make a realistic palaeodemographic reconstruction: first, that the cemetery was used by only one population, community or group and that they did not use other cemeteries at the same time; second, that all the individuals of that community were buried in the necropolis; third, that the archaeological excavation was complete and anthropological recovery was meticulous and not differential. These assumptions were made to create a stable population model. A population is stable when death rates and birth rates are constant. Under these conditions, the growth rate and the age distribution of a population will become constant and stable in only a few generations (Pennington 1996).

While the archaeological data seem to make the first assumption valid, the second and third assumptions leave some doubts (see paragraph 4.1).

Despite the above-mentioned limits, these methods are a useful and important tool for understanding the demographic dynamics of ancient populations (Ubelaker 1989).

Skeletal disorders and anomalies methodology

The most common type of *ante mortem* evidences found in archaeological contexts include fractures, arthritis, vertebral pathology, osteomyelitis, periostitis, congenital conditions or anomalies and infectious diseases. Diagnosis of pathological conditions were determined following the recommendations of important clinical journals, books and paleopathological texts (Ortner and Putschar 1981; Merbs 1989; Cattaneo and Grandi 2004; Mann and Hunt 2005; Baxarias and Herrerín 2008; Waldron 2008; Fornaciari and Giuffra 2009; Aufderheide and Rodriguez-Matin 2011).

Results

The histogram in Figure 3 summarizes the percentage of individuals excavated at Biverone, divided by sex. It can be noted that there is a high percentage of individuals of indeterminate sex (52.3%), because of the general bad conditions of conservation due to: a) animals and human activities; b) floods related to the Livenza river; c) the precarious condi-

tions in which human remains were preserved from the time of excavation to that of the study. With regard to the greater presence of males (31.4%) than females (16.3%), there are no historical-archaeological references to the practice of differentiated burials between the two sexes and it is probably due to random factors.

The tombs investigated are represented by 33 with only one individual, 20 with two individuals, 3 with three individuals and 1 with four individuals. Immature individuals are all in multiple tombs, except one (B-007 S.11), aged between 10 and 14 years.

Paleodemographic analysis

The life table for the population of Biverone is shown in table 1.

Given the scarcity of individuals in early childhood (0-4 years of age), it is not possible to draw precise conclusions on the infant birth rate and mortality, although it is known that, as in the current developing populations, infant mortality was high (20-30%) and many did not exceed the first year of age (Barbiera, Dalla Zuanna 2007). In the Figure 4 it can be seen that the population of Biverone had essentially three critical stages for

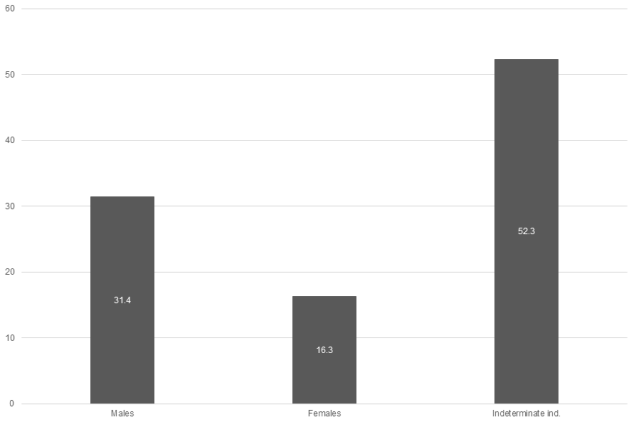

Fig. 3. Percentage of individuals, divided by sex

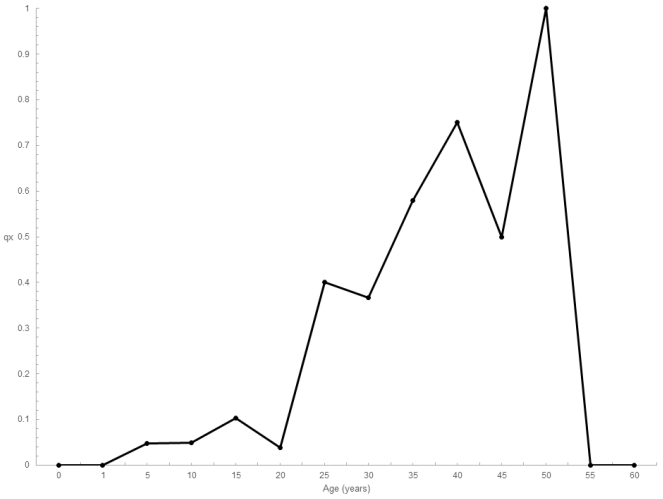

Fig. 4. Mortality quotient (q_x)

Table 1. Life table for age groups (86 individuals)

x	*Dx*	*dx*	*d'x*	*qx*	*lx*	*ex*	*Cx*
0	0	0.000	100.000	0.000	100.000	3.395	3.395
1	0	0.000	100.000	0.000	400.000	14.058	14.058
5	3	4.688	100.000	0.047	488.281	19.968	19.968
10	3	4.688	95.313	0.049	464.844	22.639	22.639
15	6	9.375	90.625	0.103	429.688	26.096	26.096
20	2	3.125	81.250	0.038	398.438	30.469	30.469
25	20	31.250	78.125	0.400	312.500	36.765	36.765
30	11	17.188	46.875	0.367	191.406	25.521	25.521
35	10	17.188	29.688	0.579	105.469	19.550	19.550
40	7	9.375	12.500	0.750	39.063	8.929	8.929
45	1	1.563	3.125	0.500	11.719	2.344	2.344
50	1	1.563	1.563	1.000	3.906	1.563	1.563
55	0	0.000	0.000	0.000	0.000	0.000	0.000

x = age (years); D*x* = number of deceased individuals per age group; d*x* = percent of individuals who died during the age range *x*; d'*x* = percent of deceased individuals during the age range of *x* after cubic interpolation; q*x* = probability of dying during the age range *x*; l*x* = percent of survivors at the beginning of the age range *x*; e*x* = life expectancy at the beginning of the age range *x*; c*x* = part of living population in the age class (with the stationary status).

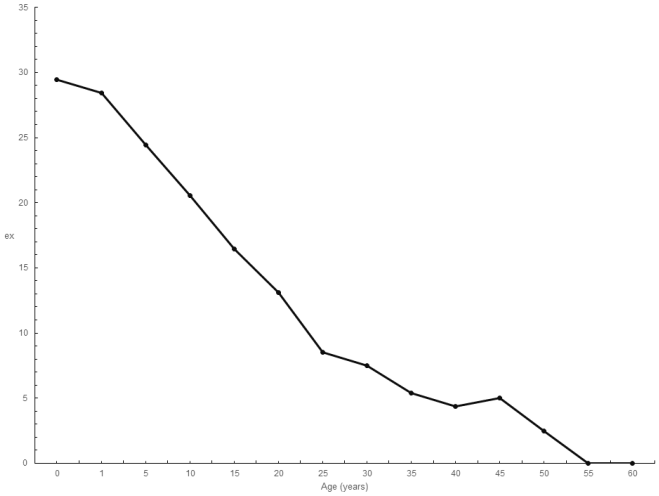

Fig. 5. Expectancy of life (e_x)

survival: the first around 25 years of age (q_x=40%); the second to 40 years of age (q_x=75%) and the last to 50 years of age. Life expectancy (e_x) shown in Figure 5 reveals that life expectancy at birth was about 30 years (e_0=29.5) and it was more or less constant up to 25 years of age (e_{25}=8.5): these data correspond to the average life expectancy of that historical period (Barbiera, Dalla Zuanna 2007).

The population pyramid in Figure 6 is heavily affected by the absence of the infant component in the skeletal sample of Biverone. The expected pyramid with broad base and narrow top – typical of the ancient populations but also of the present undeveloped populations (Drusini et al. 2001) – was not observable at Biverone.

Anthropometric analysis

Table 2 shows stature for females and males, following the methods proposed by Manouvrier (1893), Trotter and Gleser (1958) and Sjøvold (1988); stature estimation for unsexed individuals was calculated with the Sjøvold's method only.

The male stature was estimable for 9 individuals out of 27, whereas for female stature was estimable for 6 individuals out of 14. The stature estimation with the Manouvrier's method was 166.9±2.8 cm for males and 156.0±2.9 cm for females. Following the TG's method, stature was estimated in 169.2±3.7 cm for males and 156.5±3.4 cm for females; according to Sjøvold's method, stature was 168.9± 4.1 cm for males and 158.5±4.4 cm for females. For unsexed individuals (n=5) stature was estimated in 161.4 ± 8.9 cm. Barbiera and Dalla Zuanna (2007) reported that the average stature in the North-East Italy during the Late-Ancient period was about 167 cm for males and 156 cm for females.

Table 3 shows the physical indices calculated for the population of Biverone, separated per sex, following the numbering suggested by Martin and Knussmann (1988): what emerges is a substantially uniform population. The mean value of the humeral diaphyseal index (90.9 for indeterminate individuals, 85.5 for males and 86.7 for females) indicates – for all three fractions of the population – rounded homers for all individuals for which it was calculated; all males and females presented rounded radii with an average value of radial diaphysal index of 82.3 and 81.8

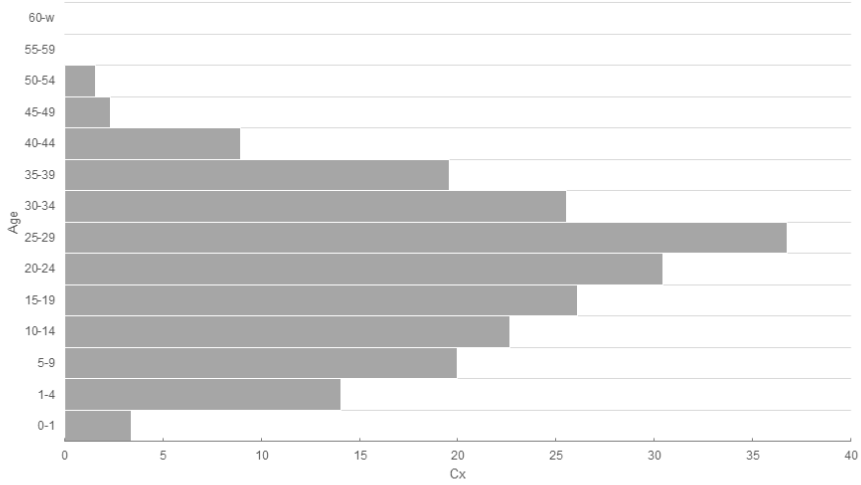

Fig. 6. Population pyramid (c_x)

Table 2. Stature estimation in Biverone

	Manouvrier	Trotter and Gleser	Sjøvold
Sex Indeterminate			
Mean (cm)	-	-	165.7
SD (cm)	-	-	5.2
n	-	-	5
Maximum (cm)	-	-	170.5
Minimum (cm)	-	-	156.2
Males			
Mean (cm)	166.9	169.2	168.9
SD (cm)	2.8	3.7	4.1
n	9	9	9
Maximum (cm)	170.7	173.3	177.5
Minimum (cm)	161.5	161.1	159.4
Females			
Mean (cm)	156.0	156.5	158.5
SD (cm)	2.9	3.4	4.4
n	6	6	6
Maximum (cm)	160.5	162.0	164.4
Minimum (cm)	153.0	152.7	152.8

Table 3. Physical indices in Biverone

	Humerus	Radius	Ulna	Femur		Tibia
	Diaphyseal Index	Diaphyseal Index	Diaphyseal Index	Pilastric Index	Platymeric Index	Cnemic Index
Sex Indeterminate						
Mean	90.5	-	-	103.0	119.7	73.4
SD	9.5	-	-	7.6	10.2	5.2
n	2	-	-	9	10	5
Maximum	81.0	-	-	85.7	95.5	66.7
Minimum	100.0	-	-	111.1	133.3	82.3
Males						
Mean	85.8	82.3	95.0	103.1	123.3	75.4
SD	7.5	6.5	21.6	10.3	6.9	9.1
n	14	6	11	14	15	13
Maximum	72.7	73.3	71.0	84.9	110.3	68.8
Minimum	97.6	92.9	133.3	122.7	136.0	91.7
Females						
Mean	86.7	81.8	78.6	99.4	127.8	74.4
SD	3.9	-	-	7.6	5.8	6.0
n	4	1	1	5	6	6
Maximum	80.1	-	-	90.0	118.3	66.7
Minimum	89.5	-	-	108.0	136.1	85.8

respectively. Regarding the femoral pilastric index, 60% of females were characterized by a weakly developed linea aspera, while in 40% it was absent. In males, linea aspera was absent in 7% of cases, weakly developed in 50%, developed on average in 29% and strongly developed in 14%. Finally, the average cnemic index (73.4 for indeterminate individuals, 75.4 for males and 74.4 for females) showed generally flattened tibias (67% of the population), while in 33% the tibias showed a slightly accented flattening.

Skeletal disorders and anomalies

The analysis of human remains revealed that 34% of the population of Biverone showed signs of skeletal and/or dental pathologies or abnormalities.

The main diseases found mainly concerned the spine, with an incidence of 14% of spondyloid arthritis with more or less developed osteophytic beaks, located on the antero-lateral margins of the vertebrae. Half of these individuals were affected by osteoarthritis associated with Schmörl hernias (Fig. 7). The other half, slight crushes of some vertebral bodies have been observed. In the other half, the vertebral bodies appeared slightly crushed in the front. The spinal osteoarthritis was more present in adult male individuals and may be linked to the performance of a particularly heavy work that underwent the spine for continuous mechanical/functional stress, such as agricultural labor.

Masticatory apparatus diseases affected the 16% of the analysed individuals. Dental wear – probably related to extra-masticatory activity or caused by abrasive elements present within the foods (Fornaciari and Giuffra 2009) – was marked and caused, in most individuals, the teeth loss *intra-vitam* (Fig.8). Poor oral hygiene or nutrition based on carbohydrate consumption has caused abundant presence of tartar, resulting in alveolar reabsorption following periodontitis and severe gingivitis.

Sedentariness, practice of breeding and organization in small housing centres give rise to favourable conditions for the development of infectious diseases

Fig. 7. Case of spondyloarthrosis associated with Schmörl hernia (Tb.35)

Fig. 8. Extra-chewing activity at level of the first left molar (Tb.B-15)

such as tuberculosis (Fornaciari and Giuffra 2009). Recent studies have shown that only in 1-4.3% of infected patients the disease compromises the skeletal system (Arathi et al. 2013), because tuberculosis usually has a rapid epilogue that leads the patient to death and rarely becomes chronic. In the ancient population of Biverone have been observed bone alterations attributable to tuberculosis in 13% of investigated individuals (Fig.9).

In four individuals, there was an abnormal thickening of tibial tuberosity (Fig. 10) which can be explained by an enthesopathy of degree 3 (Mariotti et al. 2007) or due to the Osgood-Schlatter syndrome (Capasso et al. 1998). In both cases, signs may derive from occupations requiring excessive loads placed on the back resulting in gait with knees slightly bent, or because of long periods spent remaining kneeling.

Fig. 9. Probable pathological tuberculosis evidence (Tb.B-110)

Fig. 10. Probable enthesopathy of tibial tuberosity (Tb.35)

Two cases of osteochondritis dissecans in two male subjects belonging to Tb.B-33.2 (45-55 years of age) and to Tb.B-3 (35-40 years of age) were also observed. In both individuals, the lesion affected the sternoclavicular joint surface with signs of a circumscribed necrosis caused by the isolation of the bone-cartilage area. This articular pathology may depend on heavy work that implied great efforts by the upper limbs such as, for example, the use of the plow (Capasso 2001).

Finally, 3.5% of individuals presented the olecranon foramen in one or both humeri, an hereditary character that could indicate a certain degree of kinship between the individuals presenting it (Burns 1999).

Brief remarks on the mass grave

The analysis of human remains from the mass grave revealed the presence of 35 individuals: 7 males (20%), 4 females (11%), 24 unsexed individuals (69%). They do not fall into the paleodemographic study and the metric analysis presented above, because of the poor representativeness and bad conservation conditions. These factors did not allow to acquire relevant metric data and, secondly, it was never possible to attribute the remains to a single individual.

The human remains were all in very poor condition and very fragmentary: only in 31% of cases it was possible to identify the sex; age estimation was possible in 77% of cases.

Ancestry of the population of Biverone

As mentioned above, the population of Biverone lived in a time of great change that saw the beginnings of mixing between the native and Germanic populations, especially Lombards – who began to invade Italy between the 4th and 5th centuries.

The population of Biverone was compared with those from the Lombard necropolis of Dueville in the province of Vicenza (7th-9th c. AD; Carrara 2013), from the early Christian remains found in the Basilica of San Vigilio (6th-7th c. AD; Corrain et al. 1990) in Trento and the necropolis of Collecchio, in the province of Parma (7th c. AD; Brasili et al. 1989). The archaeological record of this latter necropolis attests to the presence of individuals with characteristics that can be related in some ways both to the Lombards that the indigenous peoples. For this reason, it is well suited to clarify whether the Biverone necropolis may or may not be a primitive early Christian settlement and whether its population was native, Lombard or mixed.

Physical indices, separated by sex except for Trento, were used for comparison purposes. The humeral diaphyseal index in the population of Biverone generally indicates round diaphysis (*euribrachia*) as well as in the three comparison necropolis. Values of *euribrachia* were also found for radius in Biverone, regarding males (for females it was possible calculated only a value, so it isn't considered for the comparison); differently in Trento and Collecchio individuals, on average, radius was more flattened (*platibrachia*); no data was reported about Dueville. Concerning the ulna index, also in this case it is evaluated only for males and the value of Biverone revealed non-protrusive conformation of the inter-bone crest, most similar to the index calculated for both male and female individuals in Collecchio. However, observing the totality of individuals, appears prevalent the average developed crest (46%), a result that is similar also to the

average of Trento. As for the indices of the lower limbs, it can be noted that the femoral pilastric index revealed that the *linea aspera* was weakly developed in males of Biverone, a characteristic found for males of all three comparison necropolis; *linea aspera* was absent in females, as was also pointed at Dueville. The platimeric index indicated a slight cross-flattening in the skeletons under examination, which deviated from the results obtained both in Trento and Collecchio, while in Dueville the data was missing. Finally, the tibia was on average round, with null flattening in Biverone, as well as for Trento, Collecchio and Dueville.

Regarding the statures, the male and female averages of individuals from Biverone, calculated using the Manouvrier's method (1893), were respectively 166.9±2.8 cm and 156.0±2.9 cm,similar to the estimated values both for the remains of Trento (169.0 cm for men and 154.5 for females, calculated with Manouvrier's method (1893) and Dueville (170.9±3.9 cm in males, 156.9±6.0 cm in females, calculated using the average between the results of TG's method (1958) and Manouvrier's method (1893). However, comparing the stature of the remains of Collecchio, determined with the Manouvrier's method (1893), with the stature of Biverone, it appears that the average male stature of Biverone results to be almost the same (169.6 cm), while the female stature of Collecchio is average taller (163.6 cm).

From what emerges from comparisons, the population of Biverone has similar physical characteristics both to Paleo-Christian and Lombard populations. However, this is not sufficient for certain attribution of ancestry for two reasons, at least:

- some measurements that would allow us to draw more conclusions about the physical aspect of the inhabitants of Biverone are missing, especially with regard to crania;
- in literature, there are no statistically significant anthropometric data for native populations of Veneto dated 4th-5th c. AD.

It is important to note that one of the aims of this work is to disseminate data describing the physical characteristics of populations yet little investigated, both in their historical and geographic context.

Conclusions

Understanding the archaeological value of necropolis of Biverone is still conditioned by several question marks, because it could be, in fact, one of the oldest early Christian necropolis ever discovered in Italy.

More definite, however, is the anthropological value of human remains found: they are a sample of a certain numerical consistency in an almost empty framework. This work on the physical anthropology of the inhabitants of the ancient Biverone provides useful metric data on the populations of Veneto during the Late Ancient period; it acquires an important added value in case of investigation with current techniques of ancient DNA. With this in mind, the remains from Biverone could serve as a point of comparison with other coeval populations of this area, in order to understand not only the migratory flows, but also the spread of some diseases (such as tuberculosis) in the past.

Authors' contributions

GG anthropological analysis; CS anthropological analysis; NC paleo-demographic study and supervision.

Conflict of interest

The authors declare no conflict of interests.

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