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Articoli/*Articles*

DIACHRONIC VARIATIONS (FROM THE 17TH TO THE 18TH CENTURY) OF SOME PALEOPATHOLOGICAL ASPECTS OF A SMALL MOUNTAIN COMMUNITY IN MODENA (ITALY): THE CASE OF ROCCAPELAGO

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SUMMARY

DIACHRONIC VARIATIONS (FROM THE 17TH TO THE 18TH CENTURY) OF SOME PALEOPATHOLOGICAL ASPECTS

During the restoration of the church of the Conversion of St. Paul, located in Roccapelago, 400 individuals were found, who had lived between 17th and 18th century CE. Thanks to the simple stratigraphy of the site and to the secure dating of the layers, it was possible to investigate the development of paleopathological and occupational aspects from the 17th to the 18th century. This study analyzes possible social and occupational changes through anthropological analysis, using a statistical method, to highlight a phase of social transition that took place in the community of Roccapelago during the 17th and 18th centuries.

Introduction

During the restoration of the church of the Conversion of St. Paul, located in Roccapelago, a small village of the Emilian Apennines (Northen Italy), a lost chamber was found containing the remains of

Key words: Paleopathology - Biomechanical stress indicators

over 400 individuals who had lived between the 17th and 18th century CE. Some of them were naturally mummified. Mummification was possible due to the particular location of the crypt, which was built on the ruins of the medieval fortress of Roccapelago and was therefore equipped with ventilation slots. Thanks to the simple stratigraphy of the site and to the secure dating of the layers, it was possible to investigate the development of certain phenomena from the 17th to the 18th century. The aim of this study is to understand better the possible social changes underlying the development of some pathological characters in the ancient population of Roccapelago during the available temporal interval.

Archaeological context

The excavation unveiled five main periods of use of the crypt. The most ancient skeletal remains, which are poorly preserved, belong to the stratigraphic unit (SU) 28. The chronology of this layer, dated between the end of the 16th and the beginning of the 17th century[1] is confirmed by archaeological findings such as pottery, tissues, and some personal effects. This layer was covered with a 3-4 cm-thick landfill (labelled SU27). Above the latter, SU26 yielded well-preserved anthropological remains. All the individuals found in this context were in primary deposition, but not necessarily in anatomical connection due to the continuous deposition of other corpses. They were quite evenly distributed in the room area, attesting that the crypt was still accessible during this phase, dated to the beginning of the 17th century, beginning of the 18th century[2]. These burials were in turn covered by a 3-4 cm-thick layer made of little rocky fragments (SU25), above which insisted SU23. The latter is the most recent layer and is dated to the end of the 18th century. This context is characterized by a pyramid made mostly of mummified bodies, whose peak was directly under a trapdoor on the ceiling[3].

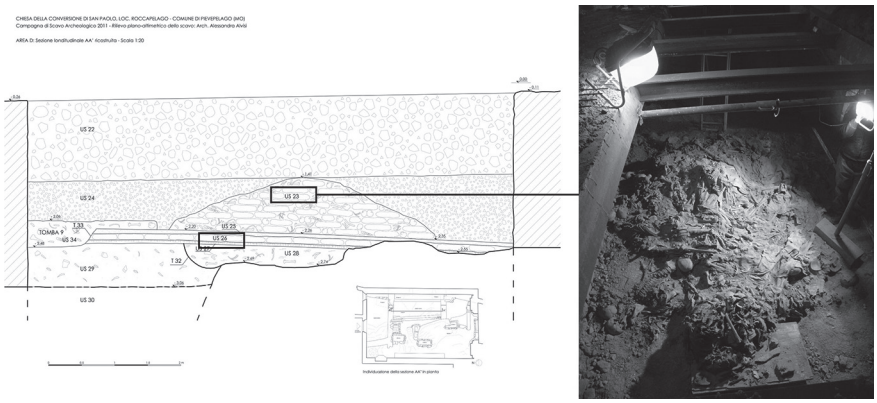

Fig. 1. On the left: stratigraphy of the pyramid of bodies, the boxes highlight SU23 (on top) and SU26 (below); on the right: View of the SU23 during excavation.

Most bodies were still wearing clothes with some mummified soft tissues (mainly tendons, skin and tissues with a lower percentage of water). Once they were unclothed during the preliminary phases of the study, they revealed many missing parts. Some anatomical regions were missing, probably due to bones falling or rolling during body decomposition while the crypt was being used as a cemetery[4]. The entire population that lived in Roccapelago between the end of the 16th century and 1786 (the year in which the cemetery was moved outside of the church) was buried in the crypt.

Material and Methods

A total of 67 adult individuals were analyzed from SU26 and 81 adult individuals were considered for SU23. In this study, individuals from the SU28 (n. 21) were not considered because of their poor state of preservation and because of the high level of disarticulation. Remains dated to the beginning of the 17th century are anyway well represented in the much more informative SU26[5]. Sex determination was made by observing the morphological characteristics of skull and pelvic girdle[6]. For assessment of age at death we combined different

methods: dental wear was evaluated by Lovejoy's approach[7]. Meindl and Lovejoy's[8] and Acsadi and Nemerskeri's[9] methods were used for judging cranial sutures degree of closure. The auricular surface was evaluated employing Schmitt's methodology[10] and pubic symphysis was compared with standards suggested by Brooks and Suchey[11] and Kimmerle et al.[12]. We referred to Trotter and Gleser's tables[13,14,15] to estimate the stature measuring long bones length (e.g. ulna, femur and tibia). Health conditions of the skeletal remains were examined through macroscopic observation. Any finding was compared to reference atlas[16,17]. Prevalence of tibial periostitis was detected, as well as the prevalence of osteoporosis of the spine (thin vertebrae, fragile texture, macroporous body surface). Spine analysis was completed by detecting the prevalence of biomechanical overload indicators (lipping and Schmorl's nodes), analyzing their prevalence divided by the vertebral section (cervical, thoracic, lumbar). The study of the asymmetry of the vertebral facets and degenerative processes of the coxo-femoral joint, have been performed to assess better the presence of arthritic phenomena. Prevalence is the number of cases in the group being studied, no time based, according to the formula:

$$P = \frac{n}{N}$$

where P= prevalence, n=number of cases and N=number in the study group.

The formal assessment of significant differences in the distribution of pathological observations between SU26 and SU23 was carried out through Pearson's Chi-squared test of goodness of fit and Wilcoxon signed rank test for paired study design. Both tests were run in R (R Core Team 2018)[18,19]. In order to quantify the overlap between SU26 and SU23 in terms of the relative frequency of observed pathologies, Euclidean distance was computed between the two levels using

the function distance in the package ecodist in R (Goslee and Urban 2007). Euclidean distance consists of the sum of the squared differences between the relative frequency of a particular pathology in one layer and the relative frequency of the same pathology in the second layer, and can be therefore used to explore the mutual relationship between pairs of sampling units (sites, layers, time-slices). Finally, to more formally ascertain the presence of extreme change over time in the incidence of individual pathologies, the distribution of differences in the relative frequency of each pathology recorded in SU26 and SU23 was explored through a number of summary statistics, measures of dispersion, confidence intervals, Z-scores and associated p-values. All the above mentioned measured were also computed in R using the relevant functions in the base package.

Results

The minimum number of individuals (MNI) recovered from SU26 is 67, the ratio of male to female, or sex ratio index (SRI at birth), is 1.03 (34 male, 33 female). The study of the age at death, referring to the four established classes (I=20-29, II=30-39, III=40-49 and IV=>50), shows an high male mortality in the first class (61% male, 39% female). In the second class female mortality is instead more prominent (34% male, 66% female). Values tend to form ties in class III (52% male, 48% female) and IV (52% male, 48% female). Estimated stature values for SU26 adults vary within a range of between 158.2 and 175.6 cm (±5) for male, 151.9 and 165.2 cm (±5) for female, with an average of 166.9 cm (±5) for male, and 158.5 cm (±5) for female. The prevalence of biomechanical stress indicators, investigated on the three spine segments, is lipping 46.7% on the cervical tract (162 pathological/347 observed), 63.3% thoracic (281/444) and 63,4% lumbar (97/153); Schmorl's nodes 1.4% on the cervical tract (5/347), 28.6% thoracic (127/444) and 22,2% lumbar (34/153). The prevalence of osteoporosis of the spine is 17.3% on the

cervical tract (60/347), 42.1% thoracic (187/444) and 35.9% lumbar (55/153). The comparison of right and left sides of the vertebral facets, shows asymmetry on 38.0% of the cervical tract (132/347), 25.5% thoracic (113/444) and 31.4% lumbar (38/153). Analysis of the tibial periostitis shows a prevalence of 58.3% (63/108). Signs that characterize arthrosis of a coxofemoral joint are present on 26.3% of the femurs analyzed (26/99).
MNI recovered from SU23 is 81, SRI at birth is 1.07 (42 male, 39 female). The study of the age at death, shows a high male mortality in the first class (58% male, 42% female), in the second class is female mortality prevalent (31% male, 69% female); relationships tend to align themselves in class III (48% male, 25% female) and IV (50% male, 50% female). Estimated stature values for SU23 adults vary within a range of between 158.5 and 176.8 cm (±5) for male, 148.9 and 168.6 cm (±5) for female, with an average of 167.6 cm (±5) for male, and 158.7 cm (±5) for female. The prevalence of biomechanical stress indicators, investigated on the three spine segments, is lipping 42.41% on the cervical tract (201/474), 59.56% thoracic (327/549) and 50,85% lumbar (90/177); Schmorl's nodes 0.63% on the cervical tract (3/474), 22.40% thoracic (123/549) and 16.95% lumbar (30/177). The prevalence of osteoporosis of the spine is 7.59% on the cervical tract (36/474), 25.13% thoracic (138/549) and 18.64% lumbar (33/177). The comparison of right and left sides of the vertebral facets, shows asymmetry on 32.91% of the cervical tract (156/474), 15.30% thoracic (84/549) and 20,33% lumbar (36/177). Analysis of the tibial periostitis shows a prevalence of 58.06% (90/155). Signs that characterize arthrosis of a coxofemoral joint are present on 24.51% of the femurs analyzed (38/155).

Assessment of statistically significant differences over time
As far as mortality rates are concerned, quantitative analyses do not support any significant relationship between sex and age class either

in SU26 (Chi-squared = 2.1073, df = 3, p-value = 0.5504) or in SU23 (Chi-squared = 2.1225, df = 3, p-value = 0.5474).
The distribution of observed pathologies does not show any significant differences between SU26 and SU23 when all spinal segments are considered at the same time (Chi-squared=154, df=143, p-value=0.25; Wilcoxon signed rank test V=55.5, p-value=0.8752). When individual spinal segments are examined, the result does not change, and no significant differences emerge.

	Test Statistic (V)	**P-value**
Cervical	3.5	0.712
Thoracic	7	0.583
Lumbar	10	0.1
Tibial+Coxofemur	0	0.37

Tab. 1. Results of Wilcoxon signed rank test for assessing significant difference in each segment between SU26 and SU23. Significance level α=0.05. No results suggest the presence of significant differences.

The lack of statistically significant differences is found also in the distribution of pathologies affecting tibia and coxofemoral portions. However, when change over time is measured as Euclidean distance between SU26 and SU23 for each segment, results show that the thoracic portion is the one exhibiting the lowest overlap in relative frequencies,

	Euclidean Distance SU26/SU23
Cervical	0.098
Thoracic	0.1127
Lumbar	0.085

Table 2: Euclidean distances computed on differences in the relative frequency of each pathology in each segment between SU26 and SU23.

followed by the cervical portion. The lumbar segment appears instead to be the most consistent over time.
To further explore this last result, additional analyses were carried out on the distribution of differences in the relative frequency of pathologies observed in the entire record of SU26 and SU23. The distribution of differences is in fact normally distributed (Shapiro-Wilk test W = 0.93916, p-value = 0.49), the average (absolute) difference over time is 8.5925% falling into a 95% Confidence Interval ranging between 5.62% and 11.56%. The dispersion is therefore quite high (s=5.25%). To compare better the differences recorded for each pair of observations, the differences were standardised into Z-scores.

		SU26		SU23				
		pat/obs	%	pat/obs	%	diff. SU23/ SU26	Z-score	P-value
Cervical	Lipping	162/347	46.68%	201/474	42.41%	-4.27%	-0,83	0.2
	Schmorl's nodes	5/347	1.44%	3/474	0.63%	-0.81%	-1,48	0.07
	Osteoporosis	60/347	17.29%	36/474	7.59%	-9.70%	0,21	0.42
	Vertebral facets asymmetry	132/347	38.04%	156/474	32.91%	-5.13%	-0,66	0.25
Thoracic	Lipping	281/444	63.28%	327/549	59.56%	-3.72%	-0,93	0.17
	Schmorl's nodes	127/444	28.60%	123/549	22.40%	-6.2%	-0,45	0.32
	Osteoporosis	187/444	42.11%	138/549	25.13%	-16.98%	1,6	0.055
	Vertebral facets asymmetry	113/444	25.45%	84/549	15.30%	-10.15%	0,3	0.38
Lumbar	Lipping	97/153	63.39%	90/177	50.85%	-12.54	0,75	0.23
	Schmorl's nodes	34/153	22.22%	30/177	16.95%	-5.27%	-0,63	0.26
	Osteoporosis	55/153	35.94%	33/177	18.64%	-17.30%	1,66	0.048
	Vertebral facets asymmetry	38/153	31.37%	36/177	20.33%	-11.04%	0,47	0.32

Table 3: Distribution of differences in the relative frequency of pathologies observed in the entire record of SU26 and SU23.

While the cervical portion exhibits 3 negative changes over time out of four pairs, thoracic spine exhibits two positive and two negative

values, and the lumbar segment shows three instances of increase over time matched by just one decrease. Overall, results suggest that there is a general decrease in the incidence of cervical pathology (although only Schmorl's nodes are below -1 standard deviations), and an ephemeral increase in osteoporosis. On the other hand, both thoracic and lumbar segments exhibit a quite extreme increase in the incidence of osteoporosis, while all the remaining pathologies show values below one standard deviation. When the probability of observing a more extreme change over time is computed (both higher and lower values than the observed ones), the only cases that approximate a 5% probability (α=0.05) are in fact Schmorl's nodes for cervical spine (p-value=0.07), osteoporosis in thoracic spine (p-value=0.055), and osteoporosis in the lumbar spine (p-value=0.048). The latter actually represents the only case below a possible 5% significance threshold (although, for a two-tailed test, significant results should more conservatively have $p < \alpha/2 = 0.025$).

Discussion and conclusions

The results of the anthropological study, first of all, made it possible to assess that in the osteological sample under examination there is a natural numerical balance between the sexes. The values of the sex ratio index (SRI), in the chronological period from the 17th to the 18th century, is between 1.03 (SU26) and 1.07 (SU23), values also confirmed by the data emerging from the parish registers, corroborating the good populistical representation of the humane sample examined. The range observed is in line with the values that are normally recorded at birth and in the first two years of life in natural human populations[20,21].

The trend of age at death remains constant and overlapping, even if not statistically significant there is a slight prevalence of male deaths in the first class (20-29), probably attributable to occupational deaths; while in the second class (30-39), the female sex is more represented, perhaps due to deaths linked to the numerous births.

The average stature is around values quite close to those of other coeval populations of the Emilia region[22]. It is possible to observe a very slight increase in the values of the stature in which the population of Roccapelago met over two centuries: in the male sex there is an increase of 0.7 cm, in the female sex 0.2 cm. Given that the average height, above all in its variations over time, can also be con-

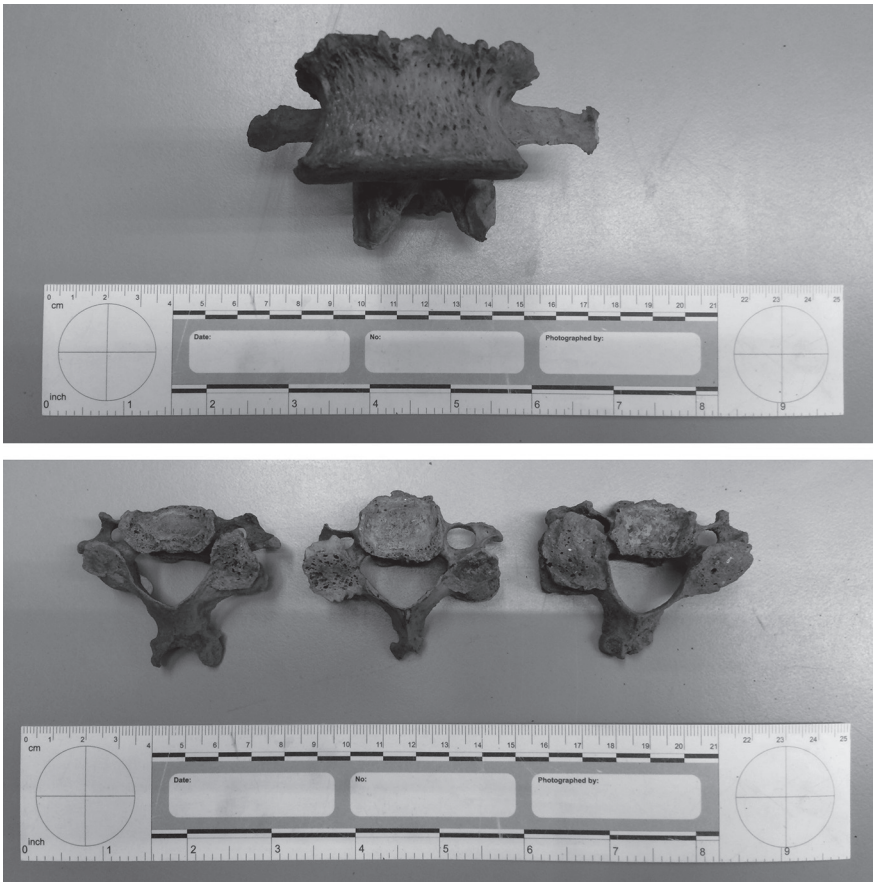

Fig. 2: Examples of asymmetries of the vertebral facet joints, on top coronal view of an L3 vertebra; below, transversal vision of some C4 vertebrae (from SU26).

sidered a useful parameter for assessing the conditions of life and health, as well as the nutritional status of the population[23], a certain stability of these aspects can be hypothesized in the territory of Roccapelago, between the 17th and 18th centuries.

Some paleopathological indicators due to a degeneration of the vertebral column due to biomechanical overloads, such as load lipping and the asymmetries of the facet joints (Fig. 2), show a decreasing trend along the time axis, even if they do not reach statistical significance. Also the observation of the Schmorl's nodes trend, caused by movements of weights on the vertical axis of the body such as transport of heavy materials, shows a tendency to decrease. (Fig. 3)

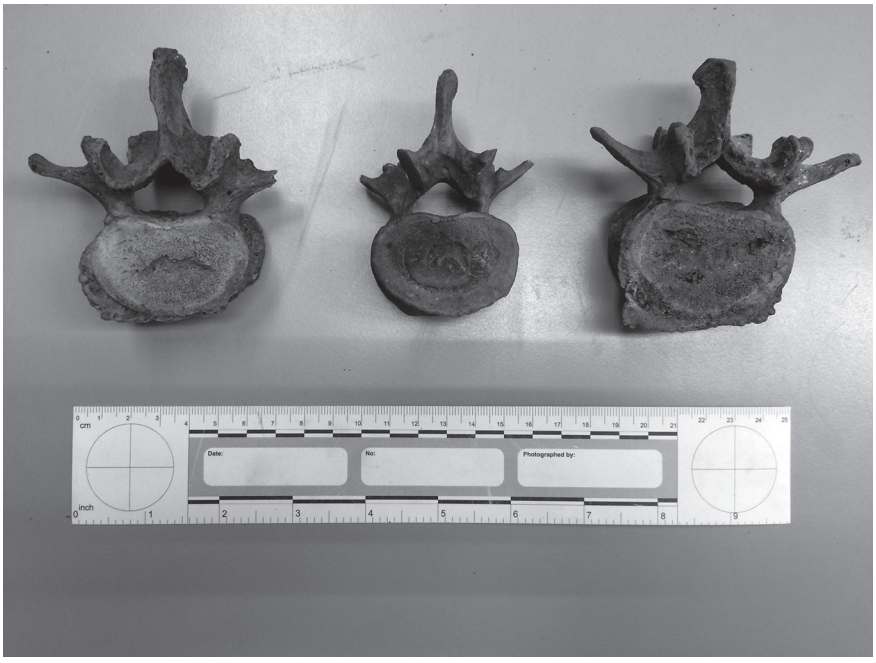

Fig. 3: Schmorl's nodes on the verebral endplate, some lumbar examples (from SU 26 and 23).

Fig. 4: Example of coxarthrosis with the typical ring/collar of osteophytes (from SU23).

The constant presence of coxarthrosis is directly related to the similar mortality trend observed on both SU. (Fig. 4)
The trend of osteoporotic phenomena of the axile skeleton, although rather stable, seems to indicate that individuals of US23 have benefited from more favorable factors than older individuals of SU26. If we exclude secondary osteoporosis, a heterogeneous group rich in variants, which make up only 5% of the pathology, primary osteoporosis remains, which are largely attributable to environmental and alimentary phenomena; this apparent diminished depletion of trabecular bone during the 18th century may have been induced by the introduction of novel foods. In this regard it is interesting to highlight that during this century, in the territory of Roccapelago, corn was introduced in a stable form, as was shown by palynological

studies conducted inside the crypt, which have identified the pollen of this plant in US23[24], food that has recently been shown to be of great importance for the osteoarticular system, especially for women in adolescence and post-menopause, in which the daily intake of only 10 grams corn and its derivatives, improves by 12% calcium absorption, which is equivalent to building a 1.8% more skeleton in a year, decreasing the risk of developing osteoporosis[25]. (Fig. 5)

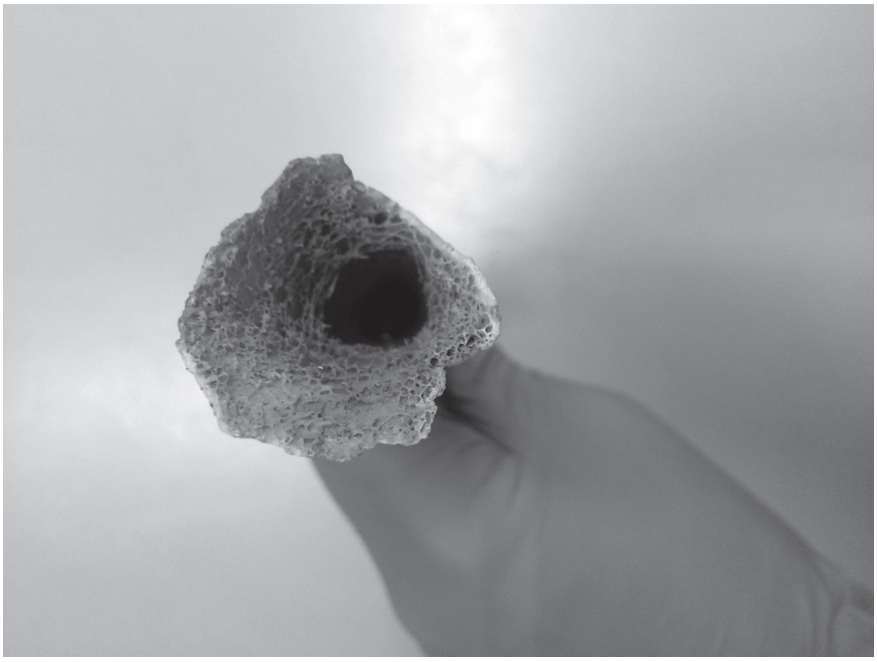

Fig. 5: A case of severe degree of tibial osteoporosis (from SU26).

All these findings, although not yet statistically significant, can be used to confirm an improvement, probably begun in the 18th century, of nutritional conditions and, at the same time, a reduction in the intensity and fatigue of occupational activities, which however, remain the same.

The social structure of the community of Roccapelago, during these two centuries, remains substantially the same. Anthropological analysis seems to highlight an initial phase of change in the food and occupational aspects, which perhaps going to consolidate during the 19th century. The prevalence of tibial periostitis remains absolutely stable, the study of clothes has in fact shown that there is no variation in the type of clothing used during the 17th and 18th centuries[26]. The relative stability of the aspects considered could therefore be related to the persistence, on the one hand, of the same activities in the sylvan environment and, on the other, the same methods of protection of the legs by means of inadequate clothing.

BIBLIOGRAPHY AND NOTES

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1. Figus C, Traversari M, Scalise LM, Oxilia G, Vazzana A, Buti L, Sorrentino R, Gruppioni G, Benazzi S, The study of commingled non-adult human remains: Insights from the 16th–18th centuries community of Roccapelago (Italy). J. Archaeol. Sci. Reports 2017;14:382-391.
2. Labate D, Mercuri L, Milani V, Traversari M, Vernia B, Notizie preliminari delle indagini archeologiche nella chiesa di San Paolo di Roccapelago nell'Appennino modenese. In: Roccapelago e le sue mummie: studio integrato della vita di una piccola comunità dell'Appennino tra XVI e XVIII secolo. 2016. pp. 27-32.
3. Traversari M, Minghetti C, Milani V, Gruppioni G, Frelat M, Gli ultimi inumati mummificati della cripta: osservazioni antropologiche preliminari. In: Roccapelago e le sue mummie: studio integrato della vita di una piccola comunità dell'Appennino tra XVI e XVIII secolo. 2016. pp. 217-224.
4. Traversari M, Feletti F, Vazzana A, Gruppioni G, Frelat MA, Three cases of developmental dysplasia of the hip on partially mummified human remains

(Roccapelago, Modena, 18th century): a study of palaeopathological indicators through direct analysis and 3D virtual models. Bull Mém Soc Anthropol Paris 2016;28:202-212.
5. Vellone VG, Repetto G, Traversari M, Vazzana A, Boano R, Gruppioni G, Fulcheri E, Pulmonary antracosis on natural mummies of XVI-XVIII century AD from Roccapelago (MO, Italy), 2015. Pathologica 2015;107(3-4):213-214.
6. Acsàdi G, Nemeskèri J, History of human life. Span and mortality. 1970. Bruzek J, A method for visual determination of sex, using the human hip bone. Am.J.Phys.Anthropol. 1970;117:157-168.
7. Lovejoy CO, Dental Wear in Libben Population: its functional pattern and role in the determination of Adult skeletal age at death. Am.J.Phys.Anthropol. 1985; 68:45-76.
8. Meindl RS, Lovejoy CO, Ectocranial Suture Closure: A Revisited Method for the Determination of Age at Death Based on the Lateral-Anterior Sutures. Am.J.Phys.Anthropol. 1985; 68: 57-66.
9. Acsádi G, Nemeskéri J, Determination of Sex and Age at Death from Skeletal Finds in History of human life. Span and mortality. Budapest: Akadémiai Kiadó; 1970. pp. 73-137.
10. Schmitt A, Une nouvelle methode pour estimer l'age au deces des adultes a partir de la surface sacro-pelvienne iliaque. A new method to assessadult-age at deathfrom the iliac sacro-pelvic surfac. Bull Mém Soc Anthropol Paris 2005;17(1/2):89-101.
11. Sheilagh S, Brooks T, Suchey JM, Skeletal Age Determination Based on the Os Pubis: A Comparison of the Acsadi-Nemeskeri and Suchey-Brooks Methods. Hum Evol 1990;5:227-238.
12. Kimmerle EH, Konigsberg LW, Jantz RL, Baraybar JP, Analysis of Age-at-Death Estimation Through the Use of Pubic Symphyseal Data. J Forensic Sci 2008;53(3):558-577.
13. Trotter M, Gleser GC, Estimation of stature from long-bones of American Whites and Negroes, Am J Phys Anthropol 1985;10:463-514.
14. Trotter M. Gleser GC, A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death Am J Phys Anthropol 1958;16:79-123
15. Trotter M, Gleser GC, Corrigenda to "Estimation of stature from long bones of American whites and Negroes". Am J Phys Anthropol 1977;47:355-356.
16. Mann RW, Murphy SP, Regional Atlas of Bone Disease: A Guide to Pathologic and Normal Variation in the Human Skeleton. Springfield: Charles C. Thomas; 1990.

17. Ortner DJ, Identification of Pathological Conditions in Human Skeletal Remains. Washington: Smithsonian Institution Press; 1985.
18. Goslee SC, Urban DL The ecodist package for dissimilarity-based analysis of ecological data. J Stat Softw 2007;22(7):1-19.
19. R Core Team, R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2018, URL https://www.R-project.org/.
20. Pettener D, Aspetti biodemografici nello studio delle popolazioni umane. In: Antropologia-Evoluzione, Uomo, Ambiente. Torino: 1995. pp. 492-500
21. Traversari M, Figus C, Petrella E, Piciucchi S, Vazzana A, Cilli E, Saragoni L, Benazzi S. Paleopathological analysis of a probable case of Jarcho-Levin Syndrome from the 18th century northern Italy. Med Histor, 2019;1(3):39-45.
22. Nicolini N, L'importante è la salute. Un nuovo approccio metodologico allo studio della mortalità nel comune di Modena. Verona; 2013. pp. 25-28.
23. Steckel RH, Health and nutrition in the preindustrial era: insights from a millennium of average heights in Northern Europe. National Bureau of Economic Research Working Paper 2011;8542:1-52.
24. Lugli F, Brunelli D, Cipriani A, Bosi G, Traversari M, Gruppioni G, C4–plant foraging in Northern Italy: stable isotopes, Sr/Ca and Ba/Ca data of human osteological samples from Roccapelago (16th–18th century AD). Archaeometry 2017;59:1119-1134.
25. Jakeman A, Henry CN, Martin BR, McCabe GP, McCabe LD, Jackson GS, Peacock M, Weaver CM, Soluble corn fiber increases bone calcium retention in postmenopausal women in a dose-dependent manner: a randomized crossover trial. Am J Clin Nutr 2016;104-3:837-843.
26. Lorenzini L, Schoenholzer Nichols T, Le vesti di sempre. Gli abiti delle mummie di Roccapelago e Monsampolo del Tronto, Archeologia e collezionismo a confronto. Istituto per i Beni Artistici, Culturali e Naturali Regione Emilia Romagna, Bologna, 2012.

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