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BIODEMOGRAPHIC AND PALEOPATHOLOGICAL RECONSTRUCTION OF THE LOST ROMAN INSEDIAMENT OF CARBIA

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SUMMARY

BIOARCHAEOLOGY OF CARBIA

The hill of Monte Carru (Alghero) has brought to light a necropolis of Roman Empire, (1st-3rd century AD). The necropolis shows different burial rituals with 200 cremations and 150 inhumations. This necropolis can be attributed to the Roman settlement of Carbia, mentioned by the Antoninian Itinerary, a document written during Caracalla's time (212-217 AD), which was probably located in this area but it hasn't been found yet. The aims of the research are the preliminary constitutional and biodemographic reconstruction of this population, through sex and age determination, the reconstruction of the health condition and the lifestyle of the population. The analysis has shown higher percentage of adult individuals (47% males and 36% females) with average age of death of 19/35 years. Important the low percentage of pathologies

Key words: Sardinia - Paleoanthropology - Paleonutrion - Paleopathology

and a sexual dimorphism in enthesopathies. The paleodiet analysis of bones, performed by XRF of trace elements, showed an almost constant presence of Zinc and Stronzium due to an essentially omnivorous diet.

The necropolis of Monte Carru is located on a rocky slope near the present city of Alghero, along what was, in Roman times, the western coast line between *Turris Libisonis* (current Porto Torres) and *Sulci* (current S.Antioco). For its location, it is supposed to belong to the lost town of Carbia, an ancient Roman settlement located in this area, mentioned by the Antoninian Itinerary, a document written at the time of Caracalla (212-217 AD). The necropolis consists of 350 mixed ritual graves, 200 cremations, located on the western and northern plateau, and 150 inhumations, located mainly in the lower and western part of the necropolis. So far, the study has focused exclusively on inhumation burials (2nd century AD)[1] (Fig.1).

Fig. 1. Single burial in grave

Graves are mainly digged or carved into the rock. Other inhumations have a capuccine type of structure or are in *Enkytrismos*, this latter mainly for children. The investigated burials were analyzed in order to define individuals' biological profile, health status and lifestyle. In order to obtain a more complete picture, it was compared with a necropolis of the previous period: Sa Figu in Ittiri (Nuragic Age 1300-450 BC), and with a necropolis of the following one: San Nicola in Sassari (Middle Ages 1350- 1480 AD), both located in the same area.

Materials and methods

The burials, studied at the Department of Biomedical Sciences of the University of Sassari, have undergone preliminary cleaning, performed with water and with soft bristled brushes and bamboo sticks, to avoid altering the bone surfaces. The reconstruction, made to obtain a complete vision of each bone, was made by using vinyl glue, which is water-soluble and completely reversible.

Subsequently, the anthropometric study[2] and the classical anthropological study were carried out following the anthropological techniques already known in literature[3], supported, where necessary, by more recent techniques, in order to determine sex, age and possible pathologies of each individual[4]. The degree of enthesopathies[5] and their location were, then, evaluated in order to understand, as far as possible, the performed activities; at the moment only the lower limb has been analyzed, the upper limb will be analyzed as soon as possible.

After all, several studies were carried out on dental material, it is important to underline that mainly isolated teeth have been analyzed; therefore it was impossible, in many cases, to evaluate the dental alveoli status or, for example, the presence of abscesses. The teeth underwent a preliminary classical anthropological study with detection of the medial-distal diameters (MD) and vestibulo-lingual diameters

(VL)[6], indexes, degree of wear[7] and possible presence of pathologies and anomalies[8.] To better understand the diet, it was decided to analyze the presence of trace elements[9] in the 14 inferior molars by XRF (X-ray fluorescence) (50kV e 200μA at SSD with Multi Channel Analyzer (MCA)). All data, obtained from the individual studies, were then compared with those related to the necropolises of the same territory, one of the previous period (Nuragic Age) and one of the following (Middle Ages) in order to obtain a detailed picture of the studied population.

Results

60 of 150 inhumations have been analyzed so far, choosen mainly by topographic position and archaeological data. About the analyzed burials (Tab1), in 5 of them (9%) there are individuals whose age of death is below the age of 16, in the other (91%) burials the individuals are adults, mostly males, (47%), while females are 36%.

	M	F	I	S	TOT
Sa figu	23	26	22	28	93
Monte Carru	28	22	5	5	60
San Nicola	29	24	21	26	42

Tab 1 - Number of studied individuals in the necropolis divided by sex (M= male; F = female; I = indeterminate; S= subadults)

Comparing these data with those of the previous period (Nuragic Age) found in the necropolis of Sa Figu, it is easy to see a sharp decline in infant mortality in the Roman period: indeed in the Nuragic period infants are 28% and in the necropolis of San Nicola (Middle Ages) they are over 20% aswell. The percentage of male and female individuals is much more variable in all periods but, however, very close.

Tab 2, distribution by age, shows that most individuals are between 19 and 35 (34, about 60% of the total). 15 are between 36 and 45

years old. Mature adults, between 46 and 60 years old, are rare and those above 60 are totally absent.

AGE

2.1 Sa figu	S	M	F	I	TOT
<1	1				
1/3y	2				
4/8y	4				
9/17y	14				
18/25y		5	9	8	22
26/34y		7	9	7	23
35/45y		7	7	5	19
46/60y		2	2	4	8
>60		0	0	0	0

2.2 Monte Carru	S	M	F	TOT
<1	1			1
1./3	3			3
4./6	0			0
6./18	4			4
19/25		10	8	17
26/35		11	7	17
36/45		8	7	15
46/60		1	0	1
>60		0	0	0

2.3 San Nicola	S	M	F	TOT
<1	1			1
1/3y	4			4

2.3 San Nicola	S	M	F	TOT
4/8y	2			2
9/17y	5			5
18/25y		2	1	3
26/34y		4	4	8
35/45y		5	2	7
46/60y		0	0	0
>60		0	0	0

Tab 2 - Individuals, studied in necropolis, divided by sex and age group (M= male; F = female; I = indeterminate; S= subadults)

Regarding sub-adults, it is interesting to notice the total absence of individuals in the range of age between 6 and 4. The largest percentage is among those close to adulthood, while those up to 3 years old are less than 5% (3).

Data relating to the Nuragic (Tab 2.1) period differ only partially from those of Carbia. Sub-adult individuals are certainly more present, even here most of them are concentrated in the age group between 9 and 17. The percentages related to adult individuals are very similar, with a greater concentration of young adults (YA). Otherwise, in the Middle Ages (Tab 2.3) an high infant mortality can be observed, especially during the third year of life and in the age directly close to adulthood (9/17), while concerning adults, most of them seem to reach the age of 25 and over, with a shift towards the middle adult range (MA).

The age analysis, separated by gender, obviously only for adult individuals, shows that the most advanced age is related to male individuals, while female individuals have a maximum age of 45; both sexes show a greater percentage of individuals around the age of 40. The number of individuals up to 30 years of age is almost the same in both sexes.

Beside the differences already highlighted for the subadult individuals, in the Nuragic period we can notice a higher death percentage of female individuals in the range from 18 to 34 years of age, while in the up to 30 age groups it becomes equal in both sexes, unlike the following Roman period. In the Middle Ages, the situation is less homogeneous, with a spike of the mortality of over 35 years of age male individuals, more similar to the Roman period.

The height, calculated using Trotter and Gleser's formulas[10], is average for the period: 161 cm for female individuals and 165 for male individuals, the values are slightly lower than the ones calculated in previous periods in the same area, where the height average is 165 cm for female individuals and 170 cm for male individuals. This heights are much higher than those of Middle Ages, with an average of 158 cm for females individuals and 172 cm for males individuals.

Concerning the paleo-pathological aspects, pathologies have been analyzed through the study of the signs they leave on the skeleton. Above all the low percentage of individuals from the Roman period who have pathologies are worth mentioning. In fact only 10 individuals of the analyzed population have pathologies, 3 of these are femalea and 7 are males (Tab 3).

	Age	M/F	TOT
Monte Carru	<25	M	1
	26/35	M	2
	36/45	M	3
	46/55	M	1
	<25	F	1
	26/35	F	2
	36/45	F	0

Tab. 3. Number of skeletal pathologies, divided by sex and age group

There are no pathologies affecting sub-adult individuals. The percent-age is not very different from the one found in the Nuragic necropolis (Sa Figu) in which only 16% of the analyzed individuals present pa-thologies, while in the Medieval necropolis (San Nicola) about 10%. Considering the site of the single pathologies, in the necropolis of Monte Carru can be found exclusively arthritic pathologies (Tab 4), mainly on the lower limbs and, to a lesser extent, on the upper limbs and on the vertebral column.

PATOLOGIES

4.1 Sa Figu	TOT	artrosis	fractures	metabolics
skull	3		1	2
upper limb	2	2		
lower limb	6	6		
vertebrae	3	3		
tot	14	11	1	2

4.2 Monte Carru	TOT	artrosis	fractures	metabolics
skull	1			1
upper limb	4	4		
lower limb	5	5		
vertebrae	1	1		
tot	11	10		1

4.3 San Nicola	TOT	artrosis	fractures	metabolics
skull	7	7		
upper limb	78	78		
lower limb	123	123		
vertebrae	151	151		
tot	359	359		

Tab. 4. Number of skeletal pathologies, divided by type and anatomical district

The division of diseases differs over time. In the Nuragic period (Tab 4.1) there are both arthritic and metabolic diseases. About 21% (6) found on the skull, almost exclusively *Cribra orbitalia*: injuries related to iron deficiency or anemic states. In the Medieval period (Tab 4.3) the pathologies are almost exclusively arthritic, although with very different percentages compared to the Roman period: they affect a greater number of individuals and are mainly dependent on the spine (spondylopathies).

The data highlighted by the division of these diseases by gender, within the necropolis of Monte Carru, is certainly interesting. Indeed, female individuals present pathologies only on the lower limbs, while male individuals have greater variability, presenting, moreover, a greater number of arthritic pathologies affecting the upper limbs. In this case the comparison with the other sites considered was not possible, because assigning a sex to the skeletal elements was not always possible. Given the greater incidence of pathologies affecting the lower limbs, enthesopathies of adults individuals have been analyzed, in particular on the main muscles inserted on femur and tibia, in order to highlight an accentuated use related to specific actions, or perhaps to particular tasks.

In the case of the necropolis of Monte Carru, the most affected muscle in the femur (Tab 5) seems to be the medial vast, while the development of the ileopsoas and gluteus maximus seems almost identical. In this case, doing a study on enthesopathies for the Sa Figu site was not possible because of the fragmentary nature of the sample. The comparison with the remains of the site of St. Nicola shows a situation very similar to the Roman period. Regarding the tibia, a discreet development can be noticed in correspondence of the soleus muscle attack, and a lower incidence of enthesis to the tibial tuberosity.

This difference cannot be seen in individuals of the Middle Ages (Tab 6), which show the same development of the two muscles, however greater than those of the Roman period.

		female	male
femur	vl	1,32	1,37
	vi	1,30	1,39
	vm	1,39	1,51
	ip	1,66	1,69
	p	1,33	1,37
	gra	1,30	1,37
	al	1,30	1,37
	g		1,50
	grg	1,54	2,00
	q	1,34	1,39
	b		
tibia	eld	1,50	2,00
	qd	1,67	2,13
	gc	0,87	1,40
	ta	1,28	1,70
	sm		2,00
	s	1,58	1,97
	pp	1,43	1,42
	tp	1,28	1,52
	fld	1,38	1,59

Tab. 5. Average Degree of entheses evaluated at muscle insertions on the femur and tibia, in the necropolis of Monte Carru, evaluated by sex.
Femur: vl: m. vastus lateralis; vi: m. vastus intermedius; vm: m. vastus medialis; ip: m. ileopsoas; p: m. pectineus; gra: m. aductor magnus; al: m. adductor longus; g: mm. gemelli; grg: m. gluteus maximus; q: m. quadratus femoris; b: m. biceps femoris. Tibia: eld: m. extensor digitorum longus; qd: m. quadriceps femoris; gc: m. gracilis; ta: m.tibialis anterior; sm: m. semimembranosus; s: m. soleus; pp: m. popliteus; tp: m. tibialis posterior; fld: m. flexor digitorum longus.

ENTESOPATHIES

		Monte Carru	San Nicola
femur	m.gluteus maximus	0,70	1,61
	m.ileopsoas	0,72	1,50
	m.vastus medialis	1,45	1,52

		Monte Carru	**San Nicola**
tibia	tend. quadricipite	0,80	1,46
	m.soleus	1,21	1,46

Tab. 6. Average degree of entheses evaluated at muscle insertions on the femur and tibia, in the necropolis of Monte Carru and San Nicola

It was possible to analyzed enthesopathies by sex in the necropolis of Monte Carru, whilst for the other necropolises it was impossible. Roman necropolis shows more marked enthesopathies of the gluteus maximus and of the iliopsoas muscles in the femur of both sexes (left side of the graph). Twin muscles are very pronounced in male individuals and very poorly developed in women. A greater differentiation was instead found in the tibia (right side of the graph) where the male individuals show the most marked enthesopathies of the quadriceps muscle, followed by the semimembranosus and soleus muscles and female individuals have values for the extensor muscles of the fingers followed by the soleus and popliteal muscles. For the previously mentioned reasons, studying the enthesopathies by sex was not possible for the other necropolises because of the fragmentary nature of the sample. The dental analysis showed further interesting aspects. The study of dental wear in the Roman necropolis (Tab 7) is mainly estimated at grade 2 and 3 (wear of enamel and dentin), and does not appear to be linked to the age (Tab 8). The situation is slightly different compared to other periods. In the previous period a very similar incidence can be noticed but with a lower presence of wear at grade 5. The following period is totally different, most of the teeth show a wear at grade 1 and 2. This could be due to the change of the diet and food preparation, which led to less work of the toothing itself.

DENTAL WEAR

7.1 **Sa Figu**	Nr	%
none	100	17%

7.1 **Sa Figu**	Nr	%
enamel	200	34%
dentine	210	35%
dentine exposed	82	14%
at neck	1	0%

7.2 **Monte Carru**	Nr	%
none	37	7%
enamel	191	38%
dentine	167	33%
dentine exposed	74	15%
at neck	34	7%

7.3 **San Nicola**	Nr	%
none	36	45%
enamel	31	39%
dentine	7	9%
dentine exposed	6	8%
at neck	0	0%

Tab. 7. Degree of dental wear in the samples of each necropolis

	MAX	**MAND**	**AGE**	**M/F**
	2,71	2,73	<25	M
	2,69	3,02	26/35	M
	2,70	2,88	36/45	M
DENTAL WEAR /AGE **Monte Carru**	2	4	45/55	M
	2,53	3,16	<25	F
	2,50	2,74	26/35	F
	3,50	2,87	36/45	F

Tab. 8. Average dental wear divided by dental arch, age group and sex in necropolis of Monte Carru (Max = Maxilla; Mand = Mandible)

Another important factor related to the oral hygiene, and in part to the diet, is the incidence of individual dental pathologies[11], that are mainly present in definitive teeth (only two cases concern deciduous teeth). In the necropolis of Monte Carru (Tab 9) we can see a greater incidence of tartar which is more than 10%, present more or less uniformly throughout the arch, but in most cases this occurs in mild deposits.

9.1 Sa Figu	
	cavity
I	1
C	0
P	4
M	9

9.2 Monte Carru			
	cavity	calculus	hypoplasia
I	3	23	22
C	2	11	19
P	10	20	6
M	21	23	5

9.3 San Nicola			
	cavity	**calculus**	**hypoplasia**
I	5	11	5
C		7	4
P	3	9	5
M	2	11	2

Tab. 9. Number of dental diseases, divided by tooth type (I = incisor; C = canine; P = premolar; M = molar)

On the other hand, caries (around 4%) has a minor incidence, even if of a significant degree, and is concentrated mainly on molars. The last factor is hypoplasia, which is also relatively frequent on the inci-

sors. So, it seems that there is no relationship between age and severity of dental pathologies (Tab10)

	Grade	Age	M/F
	2	<25	M
	2,25	26/35	M
	2	36/45	M
CAVITY/AGE	3	46/55	M
Monte Carru			
	2	<25	F
	2	26/35	F
	2,5	36/45	F
	2	46/55	F
	2,5	<25	M
CALCULUS/AGE	1,8	26/35	M
Monte Carru	1	36/45	M
	2	<25	F
	1	26/35	F
	1	36/45	F

Tab. 10. Dental diseases divided by age group and sex in necropolis of Monte Carru

In the Medieval Ages (Tab 9.3), tartar has the highest incidence among dental pathologies, much more marked than in the previous period. The presence of caries and hypoplasia is much lower, even if they are distributed more evenly on the arch. This difference is linked to the improvement of oral hygiene. The data relating to the oldest necropolis (Sa Figu) unfortunately refer exclusively to caries (Tab 9.1), mainly of grade 3 on molars, even if with a total percentage of only 2%.
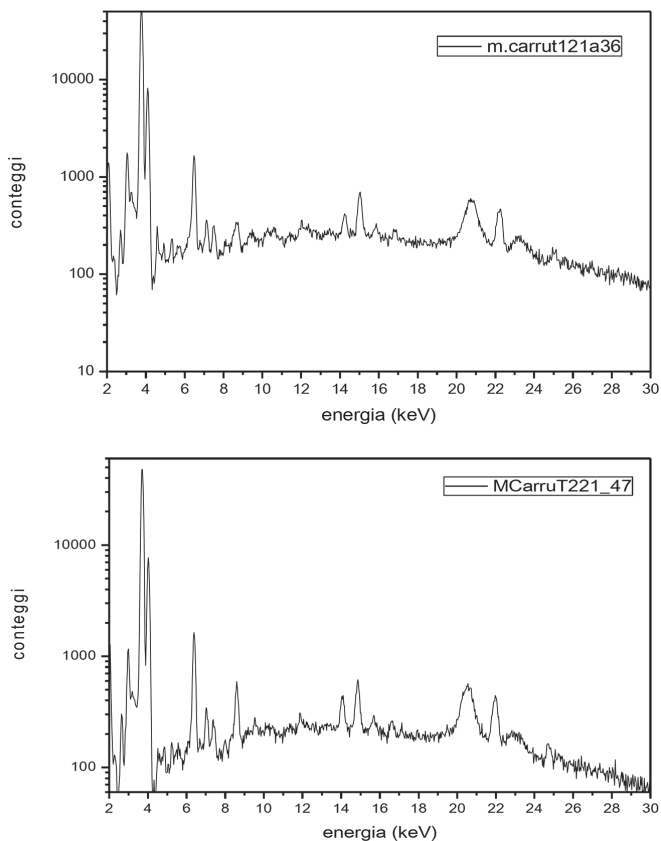
Fig. 2. Traces elements observed in burials 121 and 221 of Monte Carru Necropolis

The analysis of trace elements, evaluated on bones and teeth, can be correlated, with a reasonable approximation, with the type of food mainly consumed. The ions of many elements can enter, for different reasons, in physiological, pathological conditions and by post-mortem infiltration, in the composition of the inorganic part. Trace elements influence, on the basis of their percentage, the structure and resistance of the enamel crystals[12] besides being associated with the presence or absence of caries[13]. The percentage of trace elements

present in the organism can also vary from person to person[14] - because of age factors, sex, physiological/pathological states with consequent alteration of the metabolism. The concentration of trace elements[15] is quantified in the bones in parts per million (ppm) and an element is defined as such when present in amounts less than 0.01% of the body mass[16]. To be sure that the elements identified inside the bones were not a diagenetic consequence due to contamination by the deposition soil, the results were compared with those of the same analysis carried out on the deposition soil of the same individual.

Figure 2 shows the results related to grave 121 and 221 regarding dental elements. The two graphs are very similar to each other, the elements found are therefore the same. In Monte Carru samples, the peaks of calcium and iron, typical elements of the tooth, are visible. The same for the peak of strontium. It was then decided to compare the elements found in the teeth with those found in the bones and in the deposition soil (Fig. 3).

The plot relative to the ground shows the presence of numerous elements such as titanium, manganese, iron, zinc, lead, rubidium, stron-
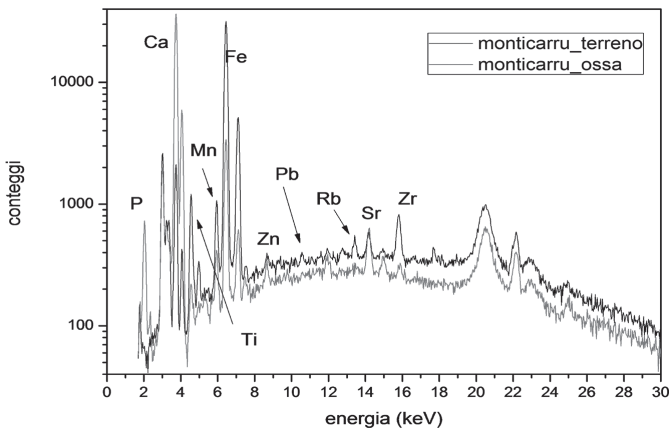

Fig. 3. Traces elements observed in bones and soil in Monte Carru necropolis

tium and zirconium. Most of these elements, on the other hand, are not found in the bones that present, next to calcium, a good quantity of iron, a high percentage of zinc and a percentage of strontium even higher than that found in the ground. These same elements were found inside the teeth. They are, therefore, directly derived from the
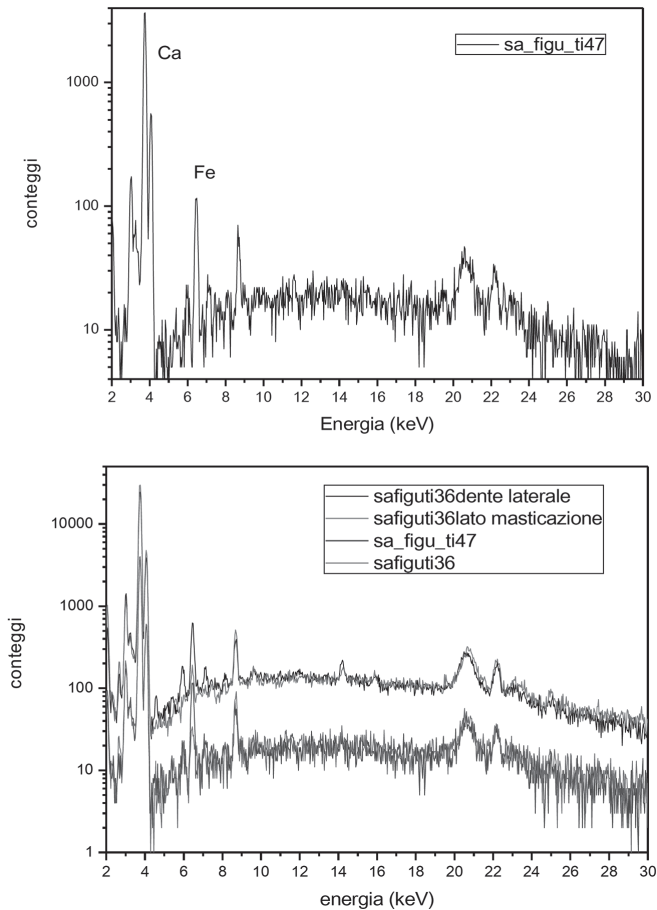

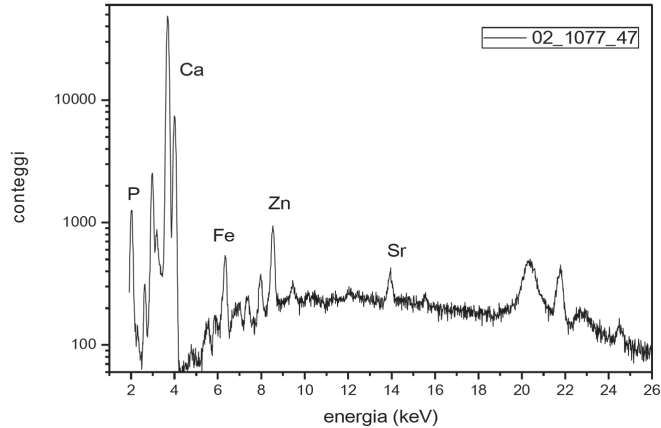Fig. 4. Traces elements observed in dental samples from Nuragic Age necropolis of Sa Figu

Fig. 5. Traces elements observed in dental samples from Middle Ages necropolis of San Nicola

bones and could be read as an indication of omnivorous diet rich in food derived from animals. In the Nuragic sample (Fig. 4), iron and zinc were found with manganese and titanium. In the Medieval necropolis (Fig. 5) on the other hand, phosphorus, zinc, strontium and iron were found which refer to both animal and vegetable food.

Discussions

The Roman necropolis of Monte Carru has returned a population composed mostly of adults, with a lower infant mortality than the average of the previous Nuragic Age and the following Middle Ages. The average age of adults only rarely gets over 46 years, and only in male individuals. The maximum age, as well as the average, when compared with the other periods, seems to actually decrease as time goes by, passing from a greater survival in the Nuragic period, with a good concentration up to 60 years, to the Medieval period in which most arrives only to 45 years.

Even the average height changes, both for men and women. It goes from an average of 165cm for women and 170cm for men in the

Nuragic Age, to an average of 161cm for females and 165cm for males in the Roman Age, up to 158 cm for woman and back to 172 cm for men for the Middle Age; therefore a stature that decreases just in roman age, and then increases back again, only for males individuals, in the Middle Ages.

Regarding the pathological picture, Roman bones show only arthritic lesions, affecting the upper limbs for male and lower limbs for female individuals. The pathologies of the Roman Age seem less differentiated than the ones in the other periods, that also show a presence of metabolic dysfunctions, such as anemia, not detected in the Roman Age. The incidence of diseases changes, especially in the spine, to disadvantage of the lower limbs. Unfortunately, to date, we have no data by sex for the Nuragic and Medieval period in the studied samples, so we do not know if there was a different distribution of diseases by sex, as noticed instead for the Roman Age.

Entesopathies, in general, seem to vary. Also in this case, it was not possible to analyse the data relating to the Nuragic period but, comparing the Roman and Medieval periods, we can see on the femur, a greater use of the medial vast in the Roman period and the gluteus maximus in the Medieval period instead. Considering that the gluteus maximus muscle extends and rotates the femur laterally, it participates in the forced extension of the hip as in running, climbing or rising from the sitting position but is not involved much in walking, while the medial vast is the most important stabilizer of the knee joint and at the same time the largest extender of the leg, it is therefore stressed in squat position. Understanding what activity is related to this difference is not simple but it is clear that a difference exists. Similar considerations can be made for the tibia. We can notice a different development between the soleus muscle and the femoral quadriceps tendon, in favor of the first, in the Roman period, while in the Medieval period the two muscles are equally developed, with an increase for the quadriceps tendon which contracting, extends the

leg; with the rectus femoris muscle participates in the flexion of the thigh and with the flexed knee participates to the flexion of the pelvis on the thigh. So, in this period, there is a greater development of the quadriceps muscle even with a lower use of the medial vast muscle, as seen for the femur. In the Roman period the subdivision by gender shows some differences in the use of the muscles both on the tibia and on the femur. These differences are evident, above all, in the tibia where, in correspondence with the soleus muscle, entheses are very pronounced in female individuals and almost entirely absent in male individuals.

Generally, a decline in osteological deseases can been seen over time. About teeth and diet we can notice a difference in wear, which remains stable between grade 3 and 4 in the Nuragic and Roman period, but is then reduced to grades 1 and 2 in the Medieval period. It must be probably attributed to a change in the diet, with less coriaceous food, perhaps better prepared, that could produce less wear of the dental enamel. Even other dental pathologies have a low incidence. Unfortunately, for the Nuragic Age we only have data related to caries. In Roman age is attested to 4%, against 2% of the Nuragic Age and 15% of the Middle Ages. Caries is caused by the organic acids that are produced during the bacterial fermentation of carbohydrates. Probably its increase is linked to a gradually higher consumption of carbohydrates, even though the most attested degree of wear remains constant, which turns out to be 3 so a caries that involves the dentin; without also neglecting the importance of oral hygiene in the onset of caries.

The most attested pathology is tartar, both for the Roman period and for the Medieval period, with a marked increase in the last one but, even in this case, the degree remained constant, attested between 1 and 2, therefore moderate deposits. Considering that tartar consists of mineral salts and organic residues deriving from food containing proteins or rich in calcium, it could be hypothesized that in this

case too, its increase is linked to a higher consumption of this kind of food in the Middle Ages, associated with a poor oral hygiene. There are differences also for hypoplasia which seems to decrease considerably in the Medieval period, even though an already low incidence was found in the Roman period. Considering that this is linked to nutritional deficiencies suffered in childhood, but analyzed at the same time with the percentage of infant mortality, we can say that the life of children, already good in Roman times, was improving in the Middle Ages, at least for those who reached adulthood.

These data suggest a balanced diet, with a gradually increasing percentage of sugars and proteins but with some nutritional deficiencies in the early stages of life. To better understand the nutritional framework, trace elements were detected both on the teeth and in the bones. During the Roman period there was a good quantity of strontium and zinc, due to a diet mainly linked to food of animal origin. These same elements and manganese and titanium, probably derived from storage and cooking pots, were found in the Nuragic necropolis. For the Medieval period there is a greater contribution of food of vegetable origin and an increased consumption of carbohydrates. In fact from the paleonutritional point of view we see a diet that gradually becomes more abundant and varied, probably also thanks to the change in the environment: we move from the Nuragic village, to the Roman settlement, to the typical Medieval city.

Conclusions

From all these data it seems to emerge a variable, although still preliminary, picture. The Roman period seems to refer to an agropastoral population with a good physical activity and a more than decent state of health.

This was a society that only partially differed from the previous one. This was deducted from our data of the excavation of the Nuragic age's site in the same area. These differences may be due to a change

in diet and lifestyle, especially in the following period. The state of health seemes to change, in some ways it worsens, with the approach of the Modern Age. The data presented here, although still preliminary, can be integrated with the further analysis of the other burials of the necropolis, thus leading to a greater and more accurate knowledge of the inhabitants of the city of Carbia.

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