Palaeopathology of Human Remains from the Roman Imperial Age

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Key Words

Italy • Palaeopathology • Roman Imperial Age • Rome

Abstract

The increasing attention of archaeological and anthropological research towards palaeopathological studies has allowed to focus the examination of many skeletal samples on this aspect and to evaluate the presence of many diseases afflicting ancient populations. This paper describes the most interesting diseases observed in skeletal samples from five necropolises found in urban and suburban areas of Rome during archaeological excavations in the last decades, and dating back to the Imperial Age. The diseases observed were grouped into the following categories: articular diseases, traumas, infections, metabolic or nutritional diseases, congenital diseases and tumors, and some examples are reported for each group. Although extensive epidemiological investigation in ancient skeletal records is impossible, palaeopathology allowed highlighting the spread of numerous illnesses, many of which can be related to the life and health conditions of the Roman population.

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Introduction

In the last decades, archaeological excavations performed in the Roman countryside have revealed a few thousand burials, and most of them can be dated back to the Imperial Age, when the city of Rome reached its greatest demographic and urban expansion. Anthropological and palaeopathological investigations on this large amount of skeletal samples represent an excellent source of knowledge, not only to reconstruct the history of the Romans but especially to study their living and health conditions. Moreover, palaeopathological examination can help to increase the knowledge on Roman diseases and, in some cases, to evidence a biological response to the historical descriptions reported in ancient medical texts. These literary sources often describe in great detail the life and illnesses of the wealthier members of society but not of ordinary people.

The Special Superintendence to Archaeological Heritage of Rome, which has directed numerous archaeological excavation campaigns, collected detailed anthropological and taphonomical documentation for dozens of necropolises and thousands of tombs during the excavations. At the present state of research, it has not yet been possible to complete the anthropological examination

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Fig. 1. Map of Rome with the locations of the Imperial Age necropolises excavated by the Special Superintendence to Archaeological Heritage of Rome in the last 10 years.

and palaeopathology study of most of these samples, and for this reason it has been difficult to achieve an extensive epidemiological picture of the diseases. On the other hand, it has been possible to illustrate some of the diseases of the Roman population, which are often linked to the lifestyle or availability of resources, which may contribute to the reconstruction of the socioeconomic framework, hygienic conditions, health and quality of life in Imperial Rome.

The skeletal changes observed in the Roman archaeological records have been grouped into the following categories: articular diseases, traumas, infections, metabolic or nutritional diseases, congenital diseases and tumors. Most of the palaeopathological observations were performed in two of the most extensive necropolises of the Imperial Age: the suburban necropolis of Osteria del Curato and the urban necropolis of Collatina.

The Collatina necropolis, placed in the eastern part of modern Rome, is the largest funerary area of the Imperial Age (1st century BC to 3rd century AD), close to the Urbe (Rome), with 2,200 burials of different typologies: great monumental tombs, inhumation graves and crema-

tion burials, many of which are placed along the ancient Via Collatina, an important commercial route of the Roman Imperial Age. Archaeological data suggest the presence of different social classes of the Urbe [1].

The necropolis of Osteria del Curato is situated at the VIIIth mile of the ancient tract of the Via Latina, about 15 km from the ancient center of the City at the intersection with the 'Grande Raccordo Anulare' (Great Ringroad; fig. 1). The excavation campaigns conducted between 1998 and 2005 highlighted different nuclei of a Roman necropolis, which revealed >700 graves dated between the 1st and 3rd century AD. The necropolis was related to two important villae: Lucrezia Romana and Sette Bassi. The latter is one of the major villae of the Roman suburbs. The numerous burials of the Osteria del Curato were probably related to the rural catchment area of the villae and may have belonged to slaves and liberti (freed slaves) working the land, as the archaeological evidence seems to reveal [2].

The demographic distribution of the two samples is reported in table 1: in the Collatina necropolis, the best represented age classes are 30–39 and 40–49 years, fol-

Table 1. Age at death and sex in the skeletal samples of the Collatina and Osteria del Curato necropolises

Age classes	Males	Females	Sex?	Total	%
<i>Collatina necropolis</i>					
0–6 years	0	0	46	46	18.4
7–12 years	0	0	29	29	11.6
13–19 years	1	7	13	21	8.4
20–29 years	13	28	3	44	17.6
30–39 years	18	27	5	50	20.0
40–49 years	26	20	2	48	19.2
50+ years	6	5	1	12	4.8
Total	64	87	99	250	100
Adults (age?)	3	3	9	15	
Total	67	90	108	265	
<i>Osteria del Curato necropolis</i>					
0–6 years	1	0	44	45	13.5
7–12 years	0	0	20	20	6.0
13–19 years	3	14	27	44	13.2
20–29 years	24	40	23	87	26.1
30–39 years	37	30	11	78	23.4
40–49 years	25	14	6	45	13.5
50+ years	10	3	1	14	4.2
Total	100	101	132	333	100
Infants (age?)	0	3	24	27	
Adults (age?)	9	22	49	80	
Total	109	126	205	440	

lowed by young adults (20–29 years), while the younger age classes are represented (mainly 20–29 and 30–39) in the Osteria del Curato necropolis. Older subjects (>50 years) are hardly present. Subadult individuals are more represented in the Collatina necropolis, where 38% of the individuals died before reaching adulthood, while the frequency in the Osteria del Curato sample is 33%. The differences between the two samples may be due to the combined effects of a shorter life span in the Osteria del Curato samples and also to the different social background, as the burials in this necropolis were probably those of farm workers (table 2).

Joint Diseases

The most common skeletal diseases are those affecting the joints, with osteoarthritis being the most widespread. The causes of osteoarthritis are not well identified, but

related to biomechanical stress and advancing age (very common in those ≥ 40 years). Other factors are related to the expression of the disease in males and females, e.g. systemic disorders and genetic predisposition [3]. Osteoarthritis is a chronic disease causing degeneration of the articular cartilage and subsequent subchondral bone reaction, with marginal new bone proliferation (osteophytes), pitting on the joint surface and eburnation. The joints subjected to mechanical stress, such as the spine, hips, knees, hands and feet, are the most commonly affected [3, 4].

Osteoarthritis is widespread in skeletal material and considered an indicator of both biomechanical stress and age; however, there are many other different erosive and proliferative joint diseases sporadically observed in skeletal remains, such as ankylosing spondylitis.

In an Imperial Roman sample from the Collatina necropolis, a case of ankylosing spondylitis was observed in the skeleton of an old woman (>50 years at death) with slender bones and short stature (~150 cm measured in situ) [5]. This individual was buried in an anomalous slightly flexed right-hand side position in a small oval ditch. This individual presented some alterations due to age, such as loss of almost all the teeth and severe osteoarthritis on the articular surface of the condyles in the right femur.

Pathological evidence related to the spine showed almost complete fusion, and the occipital condyles and atlas were completely deformed. The other cervical and first thoracic vertebrae showed fusion of the neural arches, spinous processes and articular facets; the bodies of C7 and T1 showed initial fusion on the left side. In the thoracic tract, the neural arches and articular facets of T4, T5 and T6, as well as T8 and T9, were fused. Bony bridges, caused by ossification of the common anterior ligament, produced the typical ‘bamboo spine’ appearance (fig. 2). In the lumbar spine, L1, L2 and L3, which were partially destroyed post mortem, also showed fusion of the articular facets. The sacrum and the iliac bones were not well preserved. Cervical lordosis and thoracic kyphosis were abnormally marked and leftward scoliosis of the cervical spine completed this severe clinical picture. X-ray examination revealed fusion of the intervertebral spaces in the thoracic spine.

Differential diagnosis suggested an advanced case of ankylosing spondylitis: the ossification of ligaments (syndesmophytes) was evident, connecting the vertebrae and creating the appearance of a ‘bamboo spine’, a typical feature of ankylosing spondylitis [6, 7]. The effects of the disease on this aged woman may have had implications

Table 2. Skeletal samples from Roman Imperial Age necropolises

Necropolises	Individuals ^a	Dating	Site	Socioeconomic class
Osteria del Curato	27 M, 21 F	I–III century AD	rural	lower class, farmers and slaves?
Collatina	49 M, 54 F	I BC to III century AD	urban	mixed classes
Casal Bertone	47 M, 21 F	I–II century AD	urban (fullonica)	lower class, slaves?
C. Bertone Mausoleum	15 M, 12 F	I–II century AD	urban	middle class/wealthy people?
Padre Semeria	34 M, 22 F	II–III century AD	rural	lower class, farmers?
Castel Malnome	87 M, 39 F	I–II century AD	suburban (saline)	lower class, slaves?

^a Number of individuals (males and females) for the observation of fractured bones.

Fig. 2. Spine affected by ankylosing spondylitis in an aged woman from the Collatina necropolis; the fusion of vertebral bodies produced the typical appearance of a ‘bamboo spine’. **a** Cervical and thoracic tract: left lateral view. **b** Thoracic tract: anterior view.

on social behavior and burial rites, indeed the atypical funerary context suggests a very rapid and careless burial, possibly related to the sinister appearance of the woman. Her unnatural posture, exacerbated by ankylosing spondylitis and short stature, absence of teeth, possible anorexia, red eyes, lacrimation and skin rash (occurring in 25–30% of modern patients [8], probably confined her to the fringes of the Roman society.

Trauma

Signs of traumatic injuries are commonly observed in skeletal remains due to traumatic events during the course of life; they often directly affect the skeleton with bone fractures and a history of previous bone reactions. The study of traumatic patterns of a population provides useful information about work-related activities and

Fig. 3. Frequencies of the adult sample with at least one fractured bone: comparison between men and women in the Roman Imperial Age necropolises.

Fig. 4. Distribution of fractured bones in different anatomical districts in the Roman Imperial Age samples.

risks, and documents the degree of interpersonal violence within or outside the population.

Data on the frequency of fractured bones found in Roman populations are available for some skeletal samples with different socioeconomic and environmental background. Table 2 lists the skeletal samples of the Imperial Age used for comparison. The socioeconomic status of those buried was hypothesized based on the topographical localization of the sites and their proximity to settlements, because extensive archaeological studies in this regard are not available.

Figure 3 shows the frequencies of adults with at least one fractured bone: in almost all samples, men were more affected than women, with the exception of the burials of the mausoleum where men presented a very low prevalence of

fractures. Female samples were less frequent in the Osteria del Curato necropolis and most frequent in the Castel Malnome necropolis, with 31 and 35% of women and men, respectively, being affected by at least one fracture.

Data seem to suggest that the traumatic events were linked to socioeconomic standards; in fact, the highest frequencies were observed in Castel Malnome (both sexes) and in the necropolises of Osteria del Curato and Casal Bertone (in men), and the buried people were most likely slaves, for whom strong work activities are attested. The mausoleum of Casal Bertone presents the lowest frequencies of traumatic events (especially for men), suggesting that they were reduced in the upper classes. However, there is no difference between the rural necropolis of Padre Semeria and the urban necropolis of Collatina,

Fig. 5. The skull of an old woman from the Collatina necropolis showing the results of multiple traumatic injuries. **a** Six broad deep depressions on the parietal and occipital bones. **b** X-ray examination showing the result of five traumas and enlargement of the meningeal artery sulcus of the right parietal bone [8].

although the causes that produced strong traumas in the two settings may have been different.

Figure 4 shows the prevalence of fractures in different anatomical areas in skeletal samples of the Imperial Age. The high variability of frequencies observed between anatomical sites and skeletal samples may depend on the work done and the environmental conditions in which people lived. For example, in contrast to others, in the two samples of Osteria del Curato and Padre Semeria the lower limbs are more often affected than the upper ones, probably as a result of agricultural work.

Work activities are not the only cause of traumatic events, because aspects relating to the social life and personal sphere should also be considered. One example is the case of a woman found in the Collatina necropolis, with multiple skeletal signs of violent trauma.

The skeletal remains were excavated from a burial site in tuff rock; the upper part of the body was covered only by a tile, with no funerary goods. The skeleton, fairly well preserved and almost complete, belongs to a mature female aged >50 years, of medium stature (153 cm, calculated by long-bone length [9]). Despite the delicate skeleton, muscular attachments are strong, indicating considerable work activity. Furthermore, physical stress and age seem to have been the main causes of spinal osteoarthritis, which, combined with numerous Schmorl's nodes (which are the result of herniation of a part of

the nucleus pulposus into the vertebral plate), indicates heavy activities and repeated carrying of loads on the back [10, 11].

The skeleton reveals the consequences of several traumatic events, the majority of which were well healed. The skull shows severe injuries with six broad deep depressions on the parietal and occipital bones (fig. 5), and one on the frontal bone, near the bregma, testifying different, severe, not contemporary, traumatic episodes. These lesions were caused by different traumatic events, because the depressions are limited by circular, in some cases overlapping, edges, suggesting repeated and long-term injuries. The endocranial surface presents an altered aspect along the meningeal groove which appears to be large and deep, likely to have been caused by hemorrhagic-inflammatory meningeal reactions. X-ray examination confirmed the evidence of well-recovered traumatic lesions, and enlargement of the meningeal artery sulcus of the right parietal bone was also noted (fig. 5b).

The jaw shows the results of bilateral fractures of the mandibular ramus, with condilar arthritic changes. The right mandibular ramus reveals bone remodeling secondary to a well-repaired fracture, while the reparation process is incomplete in the left ramus with two separated stumps and pseudoarthrosis (fig. 6). The range of causes of pseudoarthrosis may be long and vary from

Fig. 6. The jaw of an old woman from the Collatina necropolis showing an unrepaired fracture of the left mandibular ramus with two separated stumps and pseudo-arthritis (black arrows).

fracture of the extremities to lack of immobilization and insufficient vascularization.

The post-cranial skeleton shows other signs of injuries and self-protective reaction: the right forearm displays the results of a 'parry fracture', a typical bone fracture caused by raising the forearm when trying to parry a blow during an aggression. The right radius indicates bone thickness and diaphyseal bowing of the distal tract (fig. 7); the incomplete ulna shows similar bowing and alteration at the same diaphyseal point. X-ray examination confirms the traumatic cause of the lesions, which are completely repaired in the radius.

Both clavicles show signs of traumatic events: on the right acromial extremity, the articular surface is modified by bone remodelling and new bone apposition at the attachment of the trapezoid ligament secondary to muscle tear and possible clavicle subdislocation. Extensive bony spur is present on the attachment of the conoid ligament in the left clavicle. This kind of enthesopathy is usually due to tear of the coracoclavicular ligament, which joins the acromial extremity of the clavicle with the coracoid apophysis of the scapula.

The skeletal markers of repeated childbirths are evident, in particular the very deep and enlarged preauricular sulcus of the hip bones [12, 13].

The results of multiple traumatic events in the skeleton of this old woman reveal living conditions characterized by numerous episodes of violence, hypothesizing that the individual may have been the victim of repeated ill-treatment during the course of her life. The social role of this

woman is unknown, although the absence of funerary goods and the simplicity of the burial suggest humble origins; she might have been a slave.

The role of women was very low in the ancient Roman society. For the Roman law, a woman was not a real *civis romanus* (Roman citizen), and she was subdued to male authority. Many cultures have seen the male as a more dominant figure, therefore causing the female figure to be the most common victim of abuse. The Roman law allowed no domestic violence of a husband to his wife, but historical sources rarely describe the life of the female population [14]. Very few examples of abusive husbands or domestic violence are reported in Roman history, and most examples concern the upper social classes whose behavior was considered worth recording. We know very little about real life conditions and domestic violence, and it is impossible to provide crime statistics relating to 2,000 years ago. In this respect, palaeopathology can help reconstruct aspects of the social life and female condition in Imperial Rome.

Infectious Diseases

Infectious diseases are caused by different microorganisms (e.g. viruses and bacteria) which may affect humans in many ways, for example through the ingestion of contaminated food and water, contact with pets or interpersonal disease spread. Infection among people was favored in highly populated areas, e.g. Imperial Rome with its million inhabitants, and hygienic conditions were very important for the spread of infections. In the Roman suburbs, breeding and close man-animal contacts could enhance the spread of infections, many of which are caused by microorganisms producing typical bone responses, for example tuberculosis, syphilis, leprosy and brucellosis, or viral infections such as polio, for which it is possible to perform a differential diagnosis.

In Roman samples, the most common infectious diseases encountered are related to tuberculosis and brucellosis.

Skeletal remains affected by tuberculosis were observed in the Collatina necropolis, where at least 3 suspected cases were found. A case of Pott's disease was also described in the skeletal remains from the necropolis of Via Nomentana (I–II century AD) [15].

Tuberculosis is currently considered a disease of the poor and is widespread among lower socioeconomic classes of large cities, and disease spread increases with

Fig. 7. The right radius and ulna of an old woman from the Collatina necropolis showing the results of a healed fracture in the distal end of the diaphyses (**b**; black arrow). **a** X-ray (the white arrow indicates the fracture point).

urbanization and social degradation [16]. This was probably also the case in the past, especially in the more urbanized areas with higher demographic pressure. Therefore, tuberculosis affects the bone in only 10–20% of cases [17], but tuberculosis-associated diseases must have been widespread in Imperial Rome and its suburbs.

Alterations in the endocranial plate due to infectious disease were observed in the skull of a young woman (18–30 years old) from the Collatina necropolis. The skeletal remains were poorly preserved and only a few fragmented bones were available. The endocranial surface of the frontal bone showed marked engravings called *serpens endocrania symmetrica* (fig. 8). These endocranial alterations have often been attributed to tuberculous meningitis [18], although other authors have emphasized that they might refer to intrathoracic infections and not specifically to tuberculosis [19]. Other diseases related to these endocranial changes may be trauma, neoplasm,

Fig. 8. Endocranial surface of the frontal bone showing marked engravings (*serpens endocrania symmetrica*) in a young adult female from the Collatina necropolis.

Fig. 9. Prevalence of periostitis in the Imperial Age necropolises of Collatina and Osteria del Curato; the total sample includes individuals of undeterminable sex.

chronic meningitis and bacterial infections [20]. *Serpens endocrania symmetrica* were observed at least in 4 individuals from the Collatina necropolis.

Most infectious diseases produce similar bone responses, such as osteomyelitis and periostitis, which are rather common in archaeological records, and can be caused by different types of microorganisms or can result from traumatic events (e.g. inflicted blows or hematomas). In Roman samples, the cases of osteomyelitis were few, while periostitis was more frequent. Periostitis is an inflammatory process affecting the connective tissue membrane that covers the bone and can be caused by unspecific bacterial infection (staphylococci and streptococci) or traumatic events (e.g. hematomas), or varicose veins generating venous stasis with subsequent ulceration can result in a chronic infection [21, 22].

Figure 9 shows the prevalence of periostitis in the necropolises of Collatina and Osteria del Curato. Periostitis was observed in the long bones of the lower limbs [23] and the frequencies were calculated on affected individuals. Periostitis was widely distributed in the study samples, in particular in the necropolis of Osteria del Curato, where 77.6% of individuals were affected, versus 50.3% in the Collatina necropolis (highly statistically significant: $p = 0.000825$). Male samples show higher frequencies than female samples, but the differences were not significant. The higher frequencies in males and in the Osteria del Curato necropolis are probably related to small traumatic episodes caused by rural work activities and the higher pathogenic risk with respect to the urban life reflected by the Collatina necropolis.

Fig. 10. Ankylosis, collapse and strong left distortion of the thoracic spine in an adult woman affected by rickets from the Collatina necropolis. **a** Anterior view. **b** Posterior view.

Metabolic Diseases

Metabolic diseases involve the normal metabolism of the organism and in some cases affect the skeleton, for example osteoporosis, Paget's disease, rickets, osteomalacia and scurvy [4].

The metabolic diseases observed in the Roman Imperial Age samples are more frequently due to vitamin deficiencies, in particular to the lack of vitamin D, which causes rickets in infants and osteomalacia in adults. Major sources of vitamin D are found in food (especially oily fish) and in sunlight exposure: 90% of the vitamin D absorbed by the human body derives from skin photosynthesis [24]. Vitamin D controls the intestinal assimilation

Fig. 11. a Tibiae showing the typical bow-legs due to rickets in an adult woman from the Collatina necropolis. **b** X-ray showing thickening of the cortex along the concave side.

of calcium and phosphorus, indispensable elements of the bone matrix. Therefore, the lack of vitamin D during childhood causes lack of mineralization in the growing cartilage and bone, resulting in rickets. The consequences of rickets are curvature of the long bones with flattened metaphysis, thickening of the bone cortex and lower stature. Bowlegs are typical, but the effects of bone demineralization may also be observed in other skeletal sites, such as the spine and skull bones [25].

The most common type of rickets is caused by vitamin D deficiency. Archaeological evidence of rickets is scarce from Prehistory to the Modern Age [26, 13], but some cases of rickets were also observed in the urban necropolis of Collatina. The presence of the disease in Rome was documented by the physician Soranus of Ephesus (1st century AD). He wrote that ‘the legs become twisted at the thighs when the child wishes to walk about’ and the disease was ‘observed to happen particularly in Rome’ (Gynaikeia 2.43ff.) [27, 28].

We report a case of rickets [29] affecting an adult woman (27–37 years old) with a very short stature (about 144 cm, calculated by Sjøvold’s [9] formula,) from the Collatina necropolis. The skeleton presented important pathological lesions, in particular involving the thoracic spine: the posterior margins of the T3–T5 vertebral bodies were fused, with preservation of the intervertebral spaces. The

neural arches, articular facets and spinous processes, from T3 to T7, were also fused. Collapse of the T3, T4 and T5 vertebral bodies, with typical wedge-shaped aspects, produced a strong lateral curvature to the left, in the form of severe scoliosis, angulated at 105° (fig. 10). Other bone alterations affected the mandibular rami, which showed an anomalous inverted curve of the gonial angle and the lower limbs. Both femurs are slightly curved anteroposteriorly while the tibiae are markedly curved laterally (fig. 11), producing typical bowlegs and reduced stature. X-ray examination of the tibiae discloses thickening of the cortex along the concave side (fig. 11b). The left fibula (the only one present) is also laterally curved.

The bone deformities observed are in agreement with a delay in the mineralization of growth cartilage and newly formed bone collagen. Moreover, alterations such as bowlegs are typical of rickets. The diagnosis of rickets is also supported by the recurring enamel defects (hypoplasia) [30–32].

Although cases of rickets during the Imperial Age have not been reported in Rome, the disease was probably widespread in particular in the strongly urbanized area of the Urbe, where alimentary inadequacy and scarce exposure to sunlight should be a common condition. In the Roman quarters dominated by insulae and high buildings, the sunlight was scarce, and children rarely re-

Fig. 12. Child (aged 3–5 years) from the Collatina necropolis affected by scurvy. **a** Left parietal bone showing strong cribra cranii on the ectocranial surface. **b** Endocranial plate of the frontal bone characterized by marked engravings.

Fig. 13. Child (aged 3–5 years) from the Collatina necropolis affected by scurvy. **a** Right orbit affected by marked cribra orbitalia with deposits of periosteal new bone. **b** Jaw showing periosteal new bone apposition, tooth loss and alveolar resorption.

maintained outdoors. As Galenus reports: ‘the women, namely mothers, remained indoors, neither engaging in strenuous labor nor exposing themselves to direct sunlight’ (Galenus XI 164) [27].

Another metabolic disease due to vitamin deficiency observed in the Roman sample is scurvy, caused by a lack of vitamin C. This is an important element for the normal development of collagen, cartilage and bone matrix, and

its lack causes defective bone formation with disastrous effects on skeletal growth, particularly in children [31, 33, 34]. Vitamin C must be consumed in the diet and is present in a wide variety of foods, mainly in fresh fruit and raw vegetables.

Skeletal changes related to scurvy were noted in the (incomplete and badly preserved) skeletal remains of a 3- to 5-year-old child from the Collatina necropolis. Some

fragments of the skull show strong periostitis on both the internal and external plate (fig. 12), and severe cribra orbitalia with proliferative new bone formation affect both orbital roofs (fig. 13a). The process of periosteal reaction was active at the time of death because there are no signs of reparation. The sphenoid bone shows abnormal mineralization and high porosity of the inner surface; there are periostitic reactions with new bone apposition in the zygomatic, maxillary and mandibular bones (fig. 13b). Finally, periostitis is also prevalent along the diaphyses of the femur and tibia.

The observed changes are the effects of scurvy caused by capillary bleeding and subperiosteal hemorrhages, resulting in diffuse periostitis [35–37].

Congenital Diseases

Congenital disorders are anomalies or malformations with inherited transmission and consist of abnormal bone development due to genetic alterations. They are rare diseases in the archaeological records, since affected patients rarely survived into childhood or to the reproductive age. Abnormalities commonly observed in Roman samples were the fusion of the last lumbar vertebra to the sacral bone (sacralization), or the rarer disjunction between the first and second sacral vertebrae of the sacrum (lumbarization), the foramina in the body of the sternum and spina bifida occulta.

Two cases of very rare congenital diseases in Roman samples presented with opposed disorders of growth: a case of dwarfism and one of gigantism, i.e. conditions that manifest very low stature and considerable growth, respectively.

A skeleton with very short stature was found in the Collatina necropolis, which was buried in a simple soil grave and poorly preserved. The individual was probably between 20 and 25 years of age, but accurate age estimation is difficult, as growth pathologies are likely to modify the expression criteria currently used for skeletal aging. Sexual determination was not possible.

Unfortunately, the skull remains consisted in few fragments and two upper teeth. For this reason, the diagnosis was performed only on the postcranial bones, where all the long bones were reduced in length. The upper limbs presented moderate robustness with alterations in muscular attachments and diaphyseal morphology, while the proximal end of the ulna showed enlargement of the ulnar metaphyseal area likely to cause modifications in elbow articulation (fig. 14). Epiphyses

Fig. 14. Right upper limb (from left to right: humerus, ulna and radius) of an individual affected by dwarfism from the Collatina necropolis. All the long bones are shorter with modified morphology.

of the lower limbs were not affected by evident alterations, but the tibia and femur were about 10 cm shorter compared to the standard length of the Roman coeval population, and the diameter and circumference were inferior as well. The acetabulum, the only preserved fragment of the hip, presented irregular shape and osteoarthritic changes that may have been a consequence of pelvic inclination and lumbar lordosis, typical of achondroplastic dwarfism.

Stature, estimated using Sjøvold's formulas [9], ranges from 131.4 to 138.6 cm (average 134 cm), with a 22-cm decrease compared with the mean stature of females, and a 33-cm decrease compared with mean stature of males from the same necropolis. Short stature, generally between 100 and 140 cm, is known by the term 'dwarfism', and can be due to different disorders: genetic defects, hormonal deficits, and metabolic and nutritional disorders [32]. Considering the forms of dwarfism characterized by micromegalia and morphological alterations in the limbs extending into the adult age, differential diagnosis sug-

Fig. 15. Comparison between the lower limbs of the Collatina dwarf and the giant. **a** Femurs. **b** Tibiae.

gests that this individual was affected by achondroplasia, a congenital and hereditary disorder characterized by shortened extremities with a normal-sized trunk. In achondroplasia, the proximal segment of the limbs is shorter than the distal one, with enlargement of metaphyses but normal epiphyses. Articulation of the shoulder and elbow are often limited. The affected individuals have normal intelligence and almost normal life expectancy; the maximum stature is 140 cm [25, 32, 38].

The presence and role of dwarfs in Imperial Rome is largely documented by literary and iconographic sources: dwarfs were particularly appreciated as personal attendants, animal tenders, dance and music entertainers, and jewelers [39]. In particular, the emperors Tiberius, Alexander Severus and Marcus Antonius retained achondroplastic dwarfs as counselors [40]. Despite the possible frequency of dwarfism in the Roman Imperial Age, the anthropological records are scarce; only few cases are known in Rome: in particular, a case of proportionate dwarfism was found in the same necropolis of Collatina [41].

Another extraordinary finding concerning growth disorders comprises a skeleton recovered in the necropolis of Torre Serpentana (I–III century AD) in Fidenae, an ancient village of the Roman age, situated about 8 km north of Rome [42]. A grave which was longer with respect to the others in the necropolis was found and the skeletal remains of a very tall individual also appeared [43]. The skeleton, complete and well preserved, was of male sex and aged 17–20 years on the basis of the stages of epiphyseal closure [44–46]. The pathological condition may have delayed the epiphyseal union, as the cranial suture synostosis [47] suggested an age range of 35–45 years and dental wear suggested an age range of 20–30 years [48].

The skull presented normal dimensions and morphology, but the thickness of the frontal and parietal bones was irregular, with a slight form of hyperostosis frontalis interna. The pituitary area, observable in a preserved fragment of the hypophyseal fossa of the sella turcica, appeared enlarged and depressed, although it was only partially observable.

The jaw was very large and long with big mandibular condyles and a prominent chin. The postcranial bones were very long with regular morphology except for the proximal epiphysis of the femurs which showed vertically rotated head orientation. The muscular attachments were regular, indicating normal muscle development.

The stature, calculated on the basis of the long limb bones [49], ranged from 197 to 206 cm. The individual exhibited a very tall but normally proportioned stature; some long bones and vertebral bodies did not show complete epiphyseal union, and therefore the stature would probably have been taller, had he lived longer. The average stature for males in the Roman Imperial Age samples is 168.4 cm and the difference is 33.3 cm, indicating an overgrowth disease.

Skeletal evidence is characteristic of a form of gigantism, a rare growth disease that may be linked to different syndromes. The very long proportionate bones and delayed epiphyseal closure, combined with probable alterations of the sella turcica, agree with hypophyseal abnormality. Other elements, such as alterations in the frontal bone and slipped femoral head, support the diagnosis of pituitary gigantism [4, 50, 51].

Gigantism is a very rare disease (modern annual incidence: 3/1,000,000), which is rarely documented in ancient skeletal remains [52]; therefore, this case represents an important contribution to the palaeopathological literature. Figure 15 shows the lower limbs of the Collatina dwarf compared to the giant.

Fig. 16. Osteosarcoma affecting the proximal third of the left tibia diaphysis of an adult male from the necropolis of Castel Malnome. The periosteal new bone formation shows a sun-burst appearance. **a** Anterior view. **b** Posterior view.

Tumors

Tumors are abnormal productions of tissue that may originate directly in the bone (primitive neoplasms) or in other organ systems of the body, and secondarily spread to the bone. Many tumors develop rapidly, infiltrate the surrounding tissue and spread to secondary tumors in other parts of the body (metastases); they are called malignant as they are more likely to cause health problems and death. The most common primitive malignant tumors involving the bone are osteosarcomas and multiple myelomas, which originate in the hematopoietic bone marrow and then spread to the bone. Different malignant tumors originate in different organs and then affect the bone via the blood or lymphatic system, such as metastatic carcinoma [4].

Many tumors are benign because they lack the invasive ability to metastasize and have few negative health effects. The most common benign tumors in skeletal tissue are those originating in the cartilage (chondroma and osteochondroma) and in the bone tissue (osteoma).

Tumors in Roman samples from the Imperial Age are rare, because they usually occur in old age, while the average life span at the time was <35 years. Moreover, many carcinogens, such as pollution, food additives, pesticides or cigarette smoke, were not present.

Only 1 case of malignant tumor was found in the necropolis of Castel Malnome, an osteosarcoma affecting an adult male. The neoplasm was located along the proximal third of the left tibia diaphyses, on the anterior and posterior surface, in the form of large osteophytes with radiating spicules of periosteal new bone (fig. 16). The sun-burst appearance is typical of the osteosarcoma, the most common primary malignant tumor of bone, which commonly occurs in adolescents and the young, and most often in males. It affects the areas of most active endochondral growth such as the distal femur, the proximal humerus or the proximal tibia, like in this case [7, 4].

Benign tumors such as osteomas are more common. They were observed in 5 individuals of Castel Malnome, 4 individuals of Collatina and 2 subjects from the C. Bertone necropolis. For example, one of the osteomas observed in the Collatina necropolis affects the skeletal remains of an adult male (aged 40–50 years). A small rounded new bone formation (1 cm in diameter) was observed inside the right frontal sinus, characterized by compact bone and smooth surface. It was an osteoma, the most common benign neoplasm that can affect the skull, occurring in adulthood and affecting males and females alike [32, 53, 54]. The origins of osteomas are uncertain, but commonly accepted theories propose embryologic, traumatic or infectious causes [55].

Conclusion

The palaeopathological examination of skeletal remains from the Imperial Age has increased the knowledge on diseases occurring in Rome and its suburbs, and in some cases it has been possible to provide biological responses to historical questions regarding the diseases described in ancient medical texts.

Some diseases can be related to the conditions of life and health, and a comparison of the results of the two major necropolises, the Collatina and Osteria del Curato, suggest very few differences between the diseases, testifying the health conditions in rural and urban environments. While the skeletal alterations linked to strong work activities (such as periostitis and trauma) were more frequent in the rural context of Osteria del Curato, many diseases observed in the skeletal remains of the Collatina

necropolis may be related to urban life and in particular to the hygienic and sanitary decline which the inhabitants of the city of Rome must have suffered, with its crowded and dirty streets, where the spread of infections and diseases was certainly favored. While the increase in the population went hand in hand with extensive city planning, organization of water and sewers, the demographic pressure and poor sanitation is likely to have endangered the health of the population, especially in the lower socioeconomic classes.

Further investigations are necessary in order to understand the health issues and living conditions of the Roman population.

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