

ANALYSIS OF SPINAL PATHOLOGIES IN SKELETAL REMAINS FROM THE TUMULUS OF CORVARO (BORGOROSE, RI)

Elena Dellù (Soprintendenza ABAP per la città metropolitana di Bari / Istituto Centrale per il Restauro) - Nunzia Libianchi (ricercatrice indipendente) - Silvia Mogliazza (Istituto Villa Adriana e Villa d'Este) - Ilaria Vigliarolo (ricercatrice indipendente) - Lucilla D'Alessandro (Istituto Villa Adriana e Villa d'Este)

THE ARCHEO-ANTHROPOLOGICAL CONTEXT OF CORVARO

The skeletal remains examined in this study were sourced from the tumulus (called “Montariolo”) located in the plain of Corvaro (Borgorose, RI - Italy). (Fig. 1) This area was used from the beginning of the Iron Age up to the mid-late Republican period. So far, 368 burials have been documented, from both the pre-Roman and Roman periods, each accompanied by their respective grave goods: weapons in the oldest burials, objects related to athletic ideals during the Republican period, and personal ornaments in both eras. The grave goods demonstrate a change in the funerary sphere of the community. Moreover, the oldest tombs are arranged on different levels and in a circular pattern around the center of the monument, while the more recent tombs are dug along the perimeter, both inside and outside the stone circle that defines the mound. These later tombs are mostly arranged orthogonally to the diameter, positioned very close to each other, and sometimes intersecting (Alvino 1996; Alvino 2014).

A total of 338 skeletons were analyzed in the collections of the Laboratory of Anthropology at the Sanctuary of Hercules Victor in Tivoli (Istituto Villa Adriana e Villa d'Este - Ministero della Cultura - Rome). The surveyed population sample consists of 109 individuals, 61 of whom date back to the mid-to-late Republican period (4th–1st century BC), 4 date to the Archaic phase (6th–5th century BC), and 44 individuals remain undatable due to the absence of grave goods. Within the entire sample, 21 individuals showed evidence of spinal pathological conditions (19% of the detectable population). Of these, only 12 can be dated to the 4th–1st century BC, representing 19% of the population datable to the Republican era, a percentage consistent with the overall sample examined. Conversely, the four individuals belonging to the Archaic phase of the necropolis (6th–5th century BC) showed no alterations attributable to pathologies.

METHODOLOGY

To assess age, the following were examined: the state of obliteration of the ectocranial sutures (Meindl and Lovejoy 1985); the morphological changes of the face of the pubic symphysis through the Suchey-Brooks system (Brooks and Suchey 1990) and of the auricular surface of the ilium (Lovejoy et al. 1985; Buckberry and Chamberlain 2002). Sex estimation was carried out by morphological analysis of the skull and coxal bone, according to the standards proposed by Buikstra and Ubelaker (1994), and when possible by measuring the ischiopubic and cotylosiatic indices (Sauter and Privat 1955; Hansda et al. 2023). Anthropometric data were collected according to the method of Martin and Saller (1956-1966) and the formulas of Trotter and Gleser (1952, 1958, 1977). Vertebrae preservation was assessed according to the Bone Representation Index (BRI) and the Anatomical Preservation Index (API) for the total spine and individual vertebral regions (Bello et al. 2006). For osteoarthritic changes, the standard methods proposed by Buikstra and Ubelaker (1994) were followed. To assess health status and quality of life, individuals' musculoskeletal stress (MOS) was analyzed using standardized robustness grades (Mariotti et al. 2007). Pathological investigation was performed through macroscopic observation.

RESULTS

Spinal alterations

Of the 21 individuals analyzed, 15 were male and 6 female, all adults. Specifically, 5 were between 35 and 40 years old, 11 between 40 and 50 years old, and 2 over 50 years old. The ages of 3 individuals were not precisely determined. The frequency of spinal pathologies and spinal preservation is reported in Table 1. The values appear to indicate a higher degree of preservation of the cervical spine, with only three individuals (T.206, T.278, and T.297) presenting the best-preserved spine in all three regions (100%). Vertebral fusion in the cervical region was the most common in the analyzed sample, affecting 13 of the 21 individuals, 12 males (T.32A, T.32B, T.82, T.91, T.104, T.149, T.168, T.206, T.253, T.278, T.323, T.324) and 1 female (T.303, Fig. 2). Three individuals suffered from a rheumatic disease called Diffuse Idiopathic Skeletal Hyperostosis (DISH), with the formation of a bony bridge between multiple vertebrae (T.107, T.201, T.226, Fig. 3). An adult woman (T.233) presents with vertebral fusion throughout the entire mid-spine, resulting in flattening of the vertebral bodies, which appear as a single bony mass. Analysis of other skeletal regions has identified this condition as Ankylosing Spondylitis (AS) (Sarigu et al. 2012; Samsel et al. 2014; Galova et al. 2022).

Osteoarthritis is prevalent both in the fused vertebrae and in the adjacent ones in the form of bone proliferation, such as osteophytic beaks, Osteophytic Rim of Vertebral Body (ORVB) formation, laminar spurs and erosion such as porosity and eburnation (Fig. 4). Pathological lesions of the spine also include flattening of the vertebral bodies and small depressions or grooves on the vertebral surface, which show the presence of various types of herniated discs (Rubini, 2008; Waldron, 2008) (Fig. 5).

Other principal alterations on the appendicular skeleton

The scapular girdle is the region most significantly affected at a pathological level; in fact, signs of severe osteoarthritis have been observed in as many as 10 individuals particularly regarding the sternal end of the clavicle (Fig. 6). In four cases, early evidence of costosternal synostosis was observed, attributed to the ossification of the hyaline cartilage connecting the first rib to the manubrium (T.32A, T.32B, T.82, T.91, T.107, T.168, T.201, T.206, T. 226, T.278, Fig. 7). It is noteworthy to report the presence of an individual with right coxal sacroiliac fusion, accompanied by evident signs of osteoarthritis (T.107). Additionally, multiple fractures were identified in one individual, with two located on the ribs and a displaced fracture of the left humerus (T.201). The same individual presents an alteration on the ilium of the left coxal bone, which may be attributed to a probable abscess. The subject diagnosed with AS also exhibits the following alterations: the left clavicle reveals a fracture associated with the presence of a bone cyst; in the area of the scapuloclavicular joint, a dislocation of the clavicle is observed, accompanied by the formation of accessory facets; there are signs of severe osteoarthritis in the femoral head, the coxal bone, both fibulae and the right talus.

Overall, the entire human sample shows a medium level of ergonomic strain, sometimes higher with the appearance of unilateral enthesopathy, observed in eight individuals (T.32B, T.107, T.201, T.233, T.278, T.297, T.323, T.324), mainly affecting the shoulder region (Table 1). On these, a special case is the individual suffering from AS, with high levels in all skeletal areas.

DISCUSSION

The study of vertebral fusion in an archaeological skeletal sample of 21 individuals revealed a significant prevalence of fusion in the cervical vertebrae, particularly in males, suggesting the presence of specific mechanical or pathological stress factors.

Vertebrae fuse due to congenital or acquired conditions, due to diseases such as tuberculosis, infection, excessive wear and tear, or trauma (Gunderson et al. 1967; Sherekar et al. 2006; Buikstra 2019). Most of the recent paleopathological literature seems to agree that the complete fusion of all vertebral elements is mainly congenital (Hukelová and Kroslová, 2021), such as that observed in cases of Klippel-Feil Syndrome (KFS), a rare malformation characterized specifically by the fusion of two or more cervical vertebrae (Saker et al. 2016; Fernandes and Costa 2017). In addition to congenital anomalies, aging is one of the main predisposing factors, and repeated trauma or prolonged exposure to mechanical stress can trigger reparative responses that accelerate ossification; osteoarthritis and inflammatory diseases can impair joint function and promote the development of vertebral fusions (Waldron, 2008).

A recently considered potential cause is SAPHO syndrome (Synovitis, Acne, Pustulosis, Hyperostosis, and Osteitis) (Ashwini et al. 2015; De Maeseneer et al. 2016), a chronic disease that affects the skin, bones, and joints. Although the pathogenesis of SAPHO syndrome remains unclear, it is believed that a combination of autoimmune factors, genetic predisposition, and infections may contribute to its onset (Okamoto et al. 2016). While rare, SAPHO syndrome represents an important area of study for understanding the inflammatory mechanisms that affect the skeleton, opening new avenues for research and clinical management of similar conditions.

CONCLUSIONS

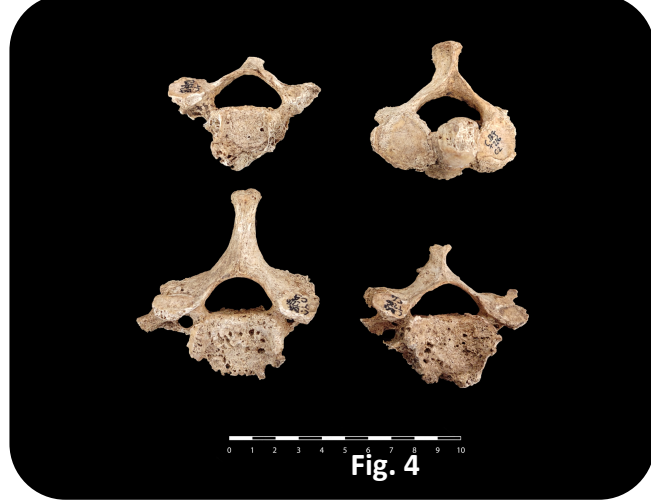
The integration of anthropological and paleopathological data with the archaeological framework described in the text allows for a detailed and evidence-based reconstruction of the health status and lifestyle of the community buried in the tumulus of Corvaro.

The analyses demonstrate a clear correlation between the chronology of the burials and the health status of the population. All twenty-one individuals presenting with spinal pathologies belong to the more recent phases of the necropolis or to contexts lacking grave goods, with twelve subjects confidently dated to the mid-to-late Republican period (4th–1st century BC). Conversely, the four skeletons attributable to the Archaic phase (6th–5th century BC) show no alterations or pathological conditions of the vertebral column. This evidence documents an increase or variation in the incidence of bone afflictions coinciding with cultural transformations, the reorganization of the funerary sphere, and a significant shift in the arrangement and density of the tombs within the monument.

The data regarding musculoskeletal stress markers (MOS) and the distribution of lesions reveal a marked sexual dimorphism in biomechanical wear patterns, strongly suggesting a clear gender-based division of daily physical activities. The male sample is characterized by mechanical stress heavily concentrated on the upper spine. Out of twenty-one pathological subjects, twelve males exhibit stable fusions of the cervical vertebrae, which are almost systematically associated with medium-to-high levels of ergonomic stress on the shoulder and severe osteoarthritis localized on the scapulae, clavicles, and sternal manubrium. This pronounced polarization supports the clinical hypothesis of prolonged mechanical or traumatic stress factors resulting from heavy, repetitive physical activities that specifically burden the male shoulder girdle. In contrast, the female sample displays a different biomechanical involvement, with non-systemic fusions concentrated primarily in the lower tract, specifically in the L5-S1 lumbosacral region. Furthermore, vertical compression of the spine—indicated by herniated discs and Schmorl's nodes—appears to be an almost exclusively male prerogative; males register six cases in the thoracic tract and five in the lumbosacral tract, compared to only two thoracic cases and none in the lumbar region among females, confirming a lower continuous exposure of women to heavy vertical axial loads.

In addition to osteoarthritis, which stands as the most widespread pathology within the sample and peaks in clinical frequency within the male spine, the study isolates precise and complex manifestations of systemic and immune-mediated rheumatic diseases. Diffuse Idiopathic Skeletal Hyperostosis (DISH) affects three individuals of mature or adult age, presenting with the formation of characteristic bony bridges across multiple vertebrae, such as in the T5-T12 tract of male T.107 or the thoracolumbar tracts of male T.226, and occurring alongside severe, diffuse osteoarthritic changes. Even more debilitating is the case of the adult female diagnosed with Ankylosing Spondylitis (AS), whose macroscopic diagnosis of complete vertebral fusion into a single bony mass corresponds to a high level of ergonomic stress across all observable skeletal districts. The severity of this arthropathy is evidenced by the accumulation of secondary appendicular lesions, including a scapuloclavicular dislocation, a fracture of the left clavicle associated with a bone cyst, and severe osteoarthritis that severely compromised lower limb mobility, affecting the femoral head, coxal bone, both fibulae, and the right talus.

Finally, the application of rigorous methodological criteria based on bone preservation indices (BRI and API) allows for a critical evaluation of the statistical reliability of the results. The data and deductions concerning the cervical spine possess substantial robustness, as this region exhibits the highest anatomical preservation rates within the entire collection, reaching one hundred percent integrity in seven individuals and fully validating the high frequency of identified cervical fusions. Conversely, the data for the lumbar segment are limited by taphonomic or recovery factors, given that six individuals register a zero percent preservation rate for this region at the time of analysis. Consequently, the low frequency of lumbar fusions observed among males could be partially biased by the loss or lack of detectability of bone tissue in that specific district. This objective limitation underscores the necessity, expressed by the authors in the research conclusions, to look beyond macroscopic observation alone and integrate the study with future genomic analyses to obtain deeper and more detailed insights into the pathologies that afflicted the population of Corvaro.



INDIVIDUALS FROM CORVARO WITH SPINAL PATHOLOGIES						
Vertebral region	21 subjects total					
	Females			Males		
	Fusion	Osteoarthritis	Herniated discs	Fusion	Osteoarthritis	Herniated discs
Cervical	1	4	0	12	13	2
Thoracic	1+1 (SpA)	4	2	3+2 (DISH)	12	6
Lumbo-sacral	2+1 (DISH)	2	0	1 (DISH)	8	5
PRESERVATION OF VERTEBRAL COLUMNS (%)						
Grave	Cervical region	Thoracic region	Lumbar region	Total spine		
32A	100.0	91.66	100.0	95.83		
32B	71.42	91.66	40.00	75.00		
56	85.71	16.66	60.00	45.83		
82	57.14	75.00	40.00	62.50		
91	100.00	83.33	40.00	79.16		
104	100.0	83.33	0.00	70.83		
107	85.71	91.66	100.0	91.66		
142	85.71	50.00	60.00	62.50		
149	57.14	0.00	0.00	16.66		
168	85.71	8.33	0.00	29.16		
201	100.0	100.0	60.00	91.66		
206	100.0	100.0	100.0	100.0		
226	85.71	50.00	60.00	62.50		
233	42.86	16.66	0.00	20.83		
253	42.86	75.00	60.00	62.50		
278	100.0	100.0	100.0	100.0		
297	100.0	100.0	100.0	100.0		
300	85.71	75.00	40.00	70.83		
303	28.57	75.00	0.00	45.83		
323	71.43	83.33	0.00	62.50		
324	71.43	33.33	0.00	37.50		

FIGURE CAPTIONS
Fig. 1 Localisation of the tumulus of Corvaro (Borgorose, RI - Italy) / **Fig. 2** Vertebral fusions. Grave 56 with C6-C7 fusion (a) and grave 32B with L5-S1 fusion (b). / **Fig. 3** Cases of Diffuse Idiopathic Skeletal Hyperostosis (DISH). Lateral view of fusion L3-L4 from grave 201 (a) and T3-T8 from grave 226 (b). Note the “candle-wax” appearance of the ossification along the anterior longitudinal ligament. / **Fig. 4** Grave 226: C2-C5 showing porosity, osteophytosis and erosion, considered diagnostic features of severe osteoarthritis. / **Fig. 5** Grave 91: thoracic vertebrae with inveterate herniations. / **Fig. 6** Grave 226: anterior view of both clavicles showing widening and osteophytosis of sternal ends (a); posterior view of right acromial end with porosity and eburnation (b) / **Fig. 7** Ossification of the hyaline cartilage connecting the first ribs to the manubrium from grave 135.

BIBLIOGRAPHY
Alvino G (1996) Alcune riflessioni sulla cultura etrusca nella piana di Corvaro. In: Identità e civiltà dei Sabini. Atti del XXVII Convegno di Studi Etruschi ed Italici (Rieti - Magliano Sabina, 30 maggio - 3 giugno 1993). Firenze, Leo. Olschki Editore:415-430 / Alvino G (2014) Ricerche recenti della Soprintendenza per i Beni Archeologici del Lazio nel territorio della provincia di Rieti. In: Formichetti G, De Simone M. (ed.) Le ricerche archeologiche nel territorio sabino: attività, risultati e prospettive. Atti della giornata di studi (11 Maggio 2013). Rieti, Museo Civico di Rieti:39-55 / Ashwini NS, Venkatesh KV, Venkatesh KV, Venkatesh KV (2015) Synostosis of First Manubriocostal (Sternozoostal) Joints: A Rare case report. International Journal of Recent Scientific Research 6(6):468-471 / Bello SM, Thomann A, Signori M, Dourou D, Andreu P (2006) Age and sex bias in the reconstruction of past population structures. Am. J. Phys. Anthropol. 129:24-38 / Brooks S, Suchey JM (1990) Skeletal age determination based on the os pubis: A comparison of the Acadè-Remedès and Suchey-Brooks methods. Human Evolution 5(3):227-238. DOI: 10.1007/BF02437238 / Buckberry J, Chamberlain AT (2002) Age estimation from the auricular surface of the ilium: a revised method. American journal of physical anthropology 119:231-239 / Buikstra J.E. (2019). Other's Identification of Pathological Conditions. In Human Skeletal Remains, 3rd edition. Academic Press, London / Buikstra J.E., Ubelaker DH (1994) Standards of data collection from human skeletal remains. Arkansas Archaeological Survey Research, Series 44, Fayetteville / De Maeseneer M, Lenchik L, Buls N, Boulet C, Döring S, de Mey J, Wilkens (2016) High-resolution CT of the sternoclavicular joint and first costochondral synchondrosis in asymptomatic individuals. Skeletal Radiol 45: 1257-1262 / Fernandes T, Costa C (2017) Klippel-Feil syndrome with other associated anomalies in a medieval Portuguese skeleton (13th-15th century). J Anat 211(5):681-685 / Galová I, Tokoljová S, Petřejšková E, Tajčik V, Balogh A, Chmelík M, Slovák P, Borováň I. Ankylosing spondylitis on unidentified individual from early modern times found in reformed church (Štádká Brezová, Slovakia): a case-based review. Rheumatol Int. 2022; 42(10):1873-1881 / Gunderson CH, Greenspan RH, Gleser GH, Lubis HA (1967) The Klippel-Feil syndrome: genetic and clinical reevaluation of cervical fusion. Medicine 46 (6):493-527 / Hansda S, Biwas A, Nandy S, Chowdhuri S, Ghosal S, Sukul B (2023) Forensic aspect of sexual dimorphism from anthropometric measurements on adult human dry hip bones. Journal of Forensic Medicine and Toxicology 40, pp. 67-71 / Hukelová Z, Kroslová M (2021) Klippel-Feil syndrome cases from Slovakia. Int J Paleopathol. Jan 33:188-195. Epub 2021 May 7. PMID: 33971397 / Lovejoy CO, Meindl RS, Prybeck TH, Mensforth RP (1985) Chronological metamorphosis of the auricular surface of the ilium: A new method for the determination of adult skeletal age at death. American journal of physical Anthropology 68(1):15-28 / Mariotti V, Facchini F, Belcastro M (2007) The study of entheses: Proposal of a standardised scoring method for twentythree entheses of the postcranial skeleton. Collegium Anthropologicum 31(1):291-313 / Martin R, Saller I (1956-1966) Lehrbuch der Anthropologie. Fischer, Stuttgart / Meindl R, Lovejoy CO (1985) Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior sutures. American journal of physical Anthropology 68(1):57-66 / Okamoto Y, Ishida H, Kimura R, Sato T, Tsuchiya N, Muryama S, Fukase H, Nagakita T, Adachi N, Toneda M, Weber A, Kato H 2016. An Okhotsk adult female human skeleton (11th/12th century AD) with possible SAPHO syndrome from Hamanaka 2 site, Rebun Island, northern Japan. Anthropological Science 124(2):107-115 / Rubini (2008) Elementi di paleopatologia. Atlante. Cui Editore Roma / Saker E, Loukas M, Oskoulas RI, Tubbs RS (2016) The intriguing history of vertebral fusion anomalies: the Klippel-Feil syndrome. Child's Nervous System. 30(9):1599-1602 / Samal M, Racz S, Villóris S (2014) Paleopathological diagnosis of spondyloarthropathies: insights from the biomedical literature. Int J Paleopathol. 7:70-75 / Sanga M, Floris G, Floris R (2022) Sardinian museum of anthropology and ethnography: a case of ankylosing spondylitis from Sardinia. Journal of Biological Research - Bollettino Della Società Italiana Di Biologia Sperimentale, 85(2) / Sauter RM, Privat F (1955) Sur un nouveau procédé métrique de détermination sexuelle du bassin osseux. Bulletin de la Société suisse d'anthropologie et d'ethnologie 31:60-84 / Sherekar SK, Yadav YR, Basor AS, Baghel A, Adam N (2006) Clinical implications of alignment of upper and lower cervical spine. Neurol. India 54 (3):264-267 / Trotter M, Gleser GC (1952) Estimation of stature from long bones of American Whites and Negroes. American journal of physical anthropology 10:463-514. / Trotter M, Gleser GC (1958) A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. American Journal of Physical Anthropology 16(1):9-123 / Trotter M, Gleser GC (1977) Corrigenda to estimation of stature from long limb bones of American Whites and Negroes. American journal of physical anthropology 47:355-356 / Waldron T (2008) Paleopathology (Cambridge Manuals in Archaeology). Cambridge University Press, Cambridge.