

Back-to-Back: The Co-occurrence of DISH and Ankylosing Spondylitis from Early Modern
Poland

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Abstract

Objective: This case study describes an individual with DISH and ankylosing spondylitis.

Materials: The skeletal remains of a male, aged 50+ years from the early modern Polish (17th-18th century CE) site of Drawsko 1

Methods: Skeletal remains were examined for the presence of spondyloarthropathies.

Results: The individual presented with anterolateral fusion of the vertebral bodies of T6-T10 with a “dripping candle wax” appearance, fusion of the right costovertebral joint at rib 8, fusion of the left apophyseal joints of T8-T10, and the calcification of the supraspinous ligament at T3-T4. The left sacroiliac joint shows intra-articular and para-articular fusion; the right has bony changes consistent with ongoing fusion. Enteseal reactions were noted on the left clavicle, scapulae, first metacarpals, ulnae, and humerii. Diffuse idiopathic skeletal hyperostosis (DISH), ankylosing spondylitis (AS), reactive arthritis (RA), psoriatic arthritis (PA), and enteropathic arthritis (EA) are considered as differential diagnoses.

Conclusions: Based on the skeletal pattern of involvement, the individual suffered from both DISH and AS, which has previously been reported once in the paleopathological literature since 1950. The clinical literature indicates that co-occurrence of these two conditions is possible, with approximately 40 individuals affected.

Significance: This case study is significant for demonstrating the co-occurrence of DISH and AS in the paleopathological record. Additionally, this case contributes to the understanding of heterogenous frailty and syndemics.

Limitations: No radiographs were taken to confirm the differential diagnosis. No aDNA analysis was conducted.

Suggestions for Further Research: The remains have been reburied; no further analysis is possible.

1 Introduction

Spondyloarthropathies are a group of related chronic inflammatory diseases lacking the rheumatoid factor antibody (sero-negative) found in conjunction with rheumatoid arthritis (Cawley and Paine, 2015; Kataria and Brent, 2004; Khan, 2002). Spondyloarthropathies are associated with the HLA-B27 gene as well as enthesitis, a common pathologic feature in which the bony tendon, ligament, and joint capsule attachment sites are inflamed, especially those of the sacroiliac joint and axial skeleton. Some of the more common spondyloarthropathies include ankylosing spondylitis (AS), reactive arthritis (RA), psoriatic arthritis (PA), and enteropathic arthritis (EA) (Kataria and Brent, 2004; Khan, 2002). Diffuse idiopathic skeletal hyperostosis (DISH) is a non-inflammatory disorder of the spinal column known for its “dripping candle wax” appearance in which the anterior longitudinal ligament is ossified creating bony bridges between contiguous vertebral bodies (Arriaza, 1993; Forestier and Rotes-Querol, 1950; Nascimento et al., 2014; Resnick et al., 1975; Resnick and Niwayama, 1976).

Many of these conditions are well reported in the paleopathological literature. For example, DISH has been described from sites across many time periods, including a 73,000-40,000 yBP Neandertal skeleton (Crubézy and Trinkaus, 1992) and from a range of geographic locations in Asia (e.g., Kim et al., 2010; Suzuki et al., 1993), Europe (Fornaciari and Giuffra, 2013; Indra et al., 2020; Rogers and Waldron, 2001), Africa (Hussein et al., 2008; Mosothwane and Steyn, 2008), and the Americas (Smith et al., 2013). Paleopathological analyses of ankylosing

spondylitis have similarly been reported reflecting a range of temporal and geographic variability (e.g., Duyar, 2019; Feldtkeller et al., 2003; Hardy, 2012; Horváth et al., 1994; Martínez-Lavín et al., 1995; Šlaus et al., 2012).

Analysis of a 17th-18th century CE Polish skeletal sample yielded an individual with a variety of skeletal lesions, including involvement of the vertebral column and several extraspinal enthesal reactions. Numerous possible diagnoses, including spondyloarthropathies and DISH, were evaluated. We present here a description of the individual's pathological skeletal changes and a review of the potential diagnoses. Finally, we offer a differential diagnosis, which is unique in the paleopathological literature.

2 Materials and Methods

2.1 The Drawsko 1 Site

The 17th-18th century Drawsko 1 cemetery site is part of the small, rural village of Drawsko in west-central Poland (Fig. 1). Those inhabiting villages such as Drawsko at this time included farm owners, cottagers (farmers), craftsmen, and peasants (Guzowski, 2014). However, while there likely was some social differentiation present, the lack of items buried with individuals precludes assessment of individual status. Between 2008 and 2012, excavations as part of an archaeological field school conducted by the Slavia Foundation yielded more than 200 primary inhumations of human skeletal remains. These individuals were interred in supine, extended positions, frequently in coffins. Skeletal preservation at Drawsko 1 was good, characterized by intact and observable cortical bone, minimal missing portions of elements, and generally complete skeletons.



Fig. 1 Map of Poland, showing location of Drawsko. From earth.google.com. Accessed 2 June 2022.

2.2 Materials

Burial 12/2012 is an adult individual recovered during excavations in 2012. This individual was almost completely preserved with the exception of five ribs, some facial bones, the pubic symphyses, and phalanges of the hand and foot (Fig. 2). The individual was interred as a single inhumation, but not buried in a wooden coffin.



Fig. 2 Skeleton 12/2012 in situ. Image courtesy of Amy B. Scott.

2.3 Methods

For burial 12/2012, age was estimated based on changes to the auricular surface (Lovejoy et al. 1985). However, as some of the pathological changes discussed below involved the auricular surface, age estimates from it were deemed unreliable; therefore, tooth wear and suture closure were utilized to provide a general age estimate (Acsádi and Nemeskéri, 1970; Buikstra and Ubelaker, 1994; Meindl and Lovejoy, 1985). Sex was assessed based primarily on morphological features of the pelvis and secondarily on features of the cranium (Phenice, 1969; Buikstra and Ubelaker, 1994). Pathological data was collected according to the Global History of Health

Protocol (Steckel et al., 2006) and included assessments of stress (i.e., porotic hyperostosis, cribra orbitalia, linear enamel hypoplasia), nutritional deficiencies (i.e., scurvy, rickets), inflammation and disease (i.e., tuberculosis, treponemal disease, leprosy, periosteal new bone formation), trauma, and other conditions.

3 Results

Burial 12/2012 was estimated to be an older adult (50+ years) male. Five vertebral bodies (T6-T10) are fused antero-laterally (Fig. 3A) with a distinctive flowing candle wax appearance. The fusion is predominantly on the right anterior portion of the vertebrae. The intervertebral space does not appear to have been affected; however, radiographic confirmation of this was not possible. Additionally, the right 8th rib is fused to the vertebral column at the costovertebral joint (Fig. 3B), there is fusion of several apophyseal joints (Fig. 3C), including on the left side of T8-T10, and the supraspinous ligament has ossified on the third and fourth thoracic vertebral spinous processes (Fig. 3D), creating a pseudo-joint between the ossified ligament segments.

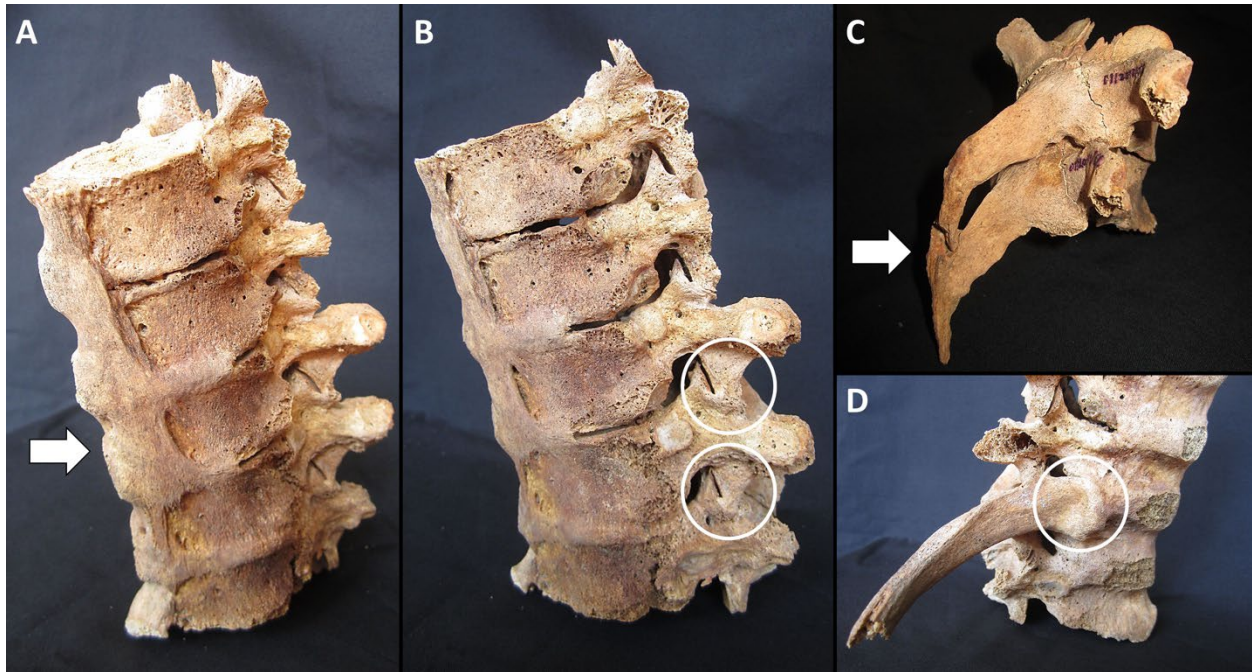


Fig. 3 Fusion in vertebral column showing (A) “dripping candle wax” appearance of ankylosis of T6-T10; (B) fusion of apophyseal joints, (C) ossification of supraspinous ligament, and (D) fusion of costovertebral joint at rib 8. Images courtesy of Amy B. Scott.

The enthesis of the left clavicular conoid tubercle (attachment of the conoid ligament) is raised and expanded into a large oval bony disc (Fig. 4). On the same clavicle, the subclavian groove (attachment site for subclavius muscle) is raised and expanded. The right and left scapular glenoid fossae have small osteophytes on the inferior and posterior margins.



Fig. 4 Enthesial expansion of conoid tubercle of left clavicle. Images courtesy of Amy B. Scott.

The left os coxa is fused to the sacrum, involving the auricular surface (intra-articular fusion) (Fig. 5A). During processing, the two bones separated, indicating the fusion was minimal at the time of death. The left os coxa also has two small openings on the ilium, just inferior to the iliac crest (Fig. 5B). The margins of the two holes are smooth and there is no evidence of infection or inflammation of the surrounding bone. It is unclear what caused the development of these holes, but they are clearly an antemortem manifestation. The posterior superior iliac spine has a large protrusion, which is likely para-articular fusion of the sacroiliac joint. The right os coxa, while not fused to the sacrum shows evidence of bony changes on the auricular surface, indicating the likelihood that fusion would have occurred if the individual survived longer.

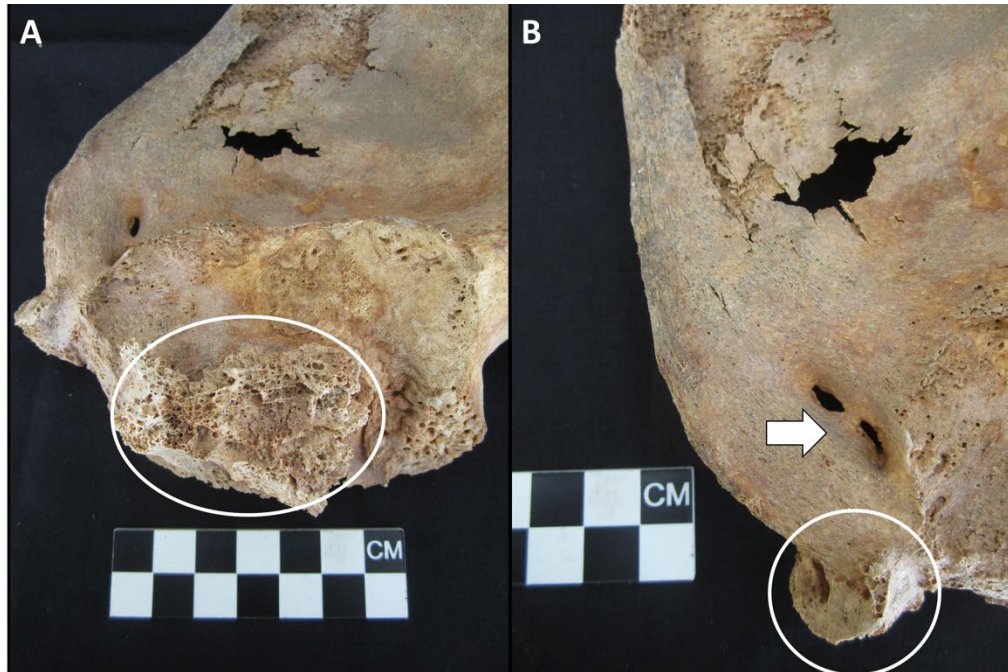


Fig. 4 Fusion of left sacroiliac joint showing (A) evidence of intra-articular fusion of auricular surface and (B) para-articular fusion at posterior superior iliac spine (circled). Note also the two holes just inferior to the iliac crest (arrow). Images courtesy of Amy B. Scott.

The entheses of the right and left ulnar olecranon (attachment of the triceps brachii muscle) are raised and expanded. The distal epiphysis of the right and left humeri have minor osteophytic lipping. The right and left first metacarpals have enthesal extensions on the palmar surface of the head. The left tibia exhibits moderate periosteal new bone formation on the medial surface of the distal end. No other pathological changes related to stress, nutritional deficiencies, infection and disease, or trauma were observed.

4 Discussion

To make a differential diagnosis of the pathological changes of Burial 12/2012, multiple conditions are considered, including DISH, AS, RA, PA, and EA.

4.1 Diffuse idiopathic skeletal hyperostosis (DISH)

The precise etiology of DISH is unknown, but it tends to affect individuals over the age of 40 and is more common among males. Metabolic disease is also a risk factor for its development (Arriaza, 1993; Foster et al., 2018; Nascimento et al., 2014; Rogers and Waldron, 2001). It predominantly affects the thoracic spine, followed by the lumbar and cervical regions (Resnick et al., 1975; Rogers and Waldron, 2001). DISH does not change the intervertebral disc space nor affects any synovial joints, including the apophyseal and costovertebral joints; however, this condition can cause inflammation of extraspinal entheses (Arriaza, 1993; Ghammam et al., 2019; Nascimento et al., 2014; Resnick et al., 1975). Peripheral sites of involvement include the iliac crest, ischial tuberosity, femoral trochanters, calcaneal tuberosity, bones of the foot, olecranon, and patella (Arriaza, 1993; Nascimento et al., 2014; Resnick et al., 1975). Sacroiliac joint fusion is also possible with DISH (Dar et al., 2007).

In clinical settings, DISH is diagnosed through radiographic analysis and is evaluated based on several criteria developed by Resnick and Niwayama (1976), including ossification of the anterior longitudinal ligament involving a minimum of four contiguous vertebral bodies; maintenance of intervertebral disc space height; and a lack of degenerative changes to the apophyseal joints (Ghammam et al., 2019; Nascimento et al., 2014).

4.2 Ankylosing spondylitis (AS)

AS is a form of spondyloarthritis more common among males, with onset occurring between 15 and 40 years of age (Arriaza, 1993: 265; Kataria and Brent, 2004; Khan, 2002; Waldron, 2012). AS causes inflammation of various joints of the vertebral column, including the apophyseal, costovertebral, and cartilaginous joints, as well as the bilateral involvement of the sacroiliac joints, possibly progressing to complete fusion. Extraspinal involvement, including inflammation and arthritis, occurs in the knees, hips, and shoulders and can include inflammation of entheses of the calcaneus (Arriaza, 1993:265; Horváth et al., 1994; Kataria and Brent, 2004; Khan, 2002; Martínez-Lavín et al., 1995; Waldron, 2012). AS causes production of syndesmophytes in the spinal column, creating bridges between adjacent vertebral bodies. It is not restricted to one side of the vertebral bodies, instead creating a “squaring” of the vertebral bodies known as “bamboo spine” (Arriaza, 1993:266; Cawley and Paine, 2015:72; Kataria and Brent, 2004:2855; Waldron, 2012). In its most extreme form, the spine, ribs, and pelvis may be entirely fused together (Waldron, 2012). AS begins in the lower regions of the spine, specifically the sacroiliac joint and moves upward. When the thoracic vertebrae are involved, the costovertebral joints may also be fused (Waldron, 2012).

The diagnosis of AS in clinical settings includes criteria such as onset before 45 years of age, pain improvement with exercise, and increased pain with inactivity. (Khan, 2002: 897). Uveitis (a type of eye inflammation), enthesitis, family history (HLA-B27 gene), and changes to spinal mobility are also indicators. The “radiographic hallmark” of AS is sacroiliitis, which is inflammation of at least one of the sacroiliac joints (Khan, 2002:898).

4.3 Reactive arthritis (RA)

RA is an ankylosing condition that more commonly affects males between 15 and 35 years of age. It results from a primary bacterial infection of the genitourinary or gastrointestinal tracts. Frequently several different joints of the lower extremities are affected (Arriaza, 1993; Kataria and Brent, 2004; Khan, 2002). Individuals with arthritis, conjunctivitis, and urethritis are diagnosed with Reiter's syndrome, a rare form of RA (Arriaza, 1993; Kataria and Brent, 2004: 2856; Khan, 2002: 899).

Clinical diagnosis of RA involves radiographic evidence of enthesitis with periosteal reaction, asymmetric sacroiliitis, and syndesmophytes formation on the lateral aspect of the vertebral body (Kataria and Brent, 2004:2856; Waldron, 2009). Fusion of vertebrae typically begins in the lower thoracic or upper lumbar and moves upward; however, discontinuous vertebrae are affected. These "skip lesions" involve unaffected vertebrae interspersed among fused vertebrae (Kataria and Brent, 2004; Waldron, 2009).

4.4 Psoriatic Arthritis (PA)

PA is a spondyloarthropathy associated with psoriasis (a skin condition) that affects individuals as early as 30 years of age and occurs equally in males and females (Arriaza, 1993:264; Cawley and Paine, 2015; Khan, 2002; Waldron, 2009). PA causes asymmetric effects in a varying number of joints of the upper and lower extremities, including the interphalangeal joints of the hands and feet, as well as the metacarpophalangeal, metatarsophalangeal, elbow, knee, and ankle joints. The costovertebral, intervertebral, and sacroiliac joints may also be impacted, and can include paravertebral ossification of the lower thoracic and lumbar vertebrae. When the vertebral

column is involved, the intervertebral disc space is unaffected and “skip lesions” are present (Arriaza, 1993:264; Cawley and Paine, 2015; Khan, 2002; Waldron, 2009). In diagnosing PA in clinical settings, radiographic evidence of erosive arthritis, especially of the distal interphalangeal joints, periosteal reaction, sacroiliitis, and spondylitis is evaluated (Kataria and Brent, 2004: 2858; Khan, 2002).

4.5 Enteropathic Arthritis (EA)

EA is a type of inflammatory arthritis affecting those with ulcerative colitis or Crohn’s disease (Kataria and Brent, 2004; Khan, 2002). Both inflammatory bowel diseases can affect individuals at any age, but most often presents before 30 years of age. Ulcerative colitis is equally prevalent in males and females, while Crohn’s disease is more common among females (Brant and Nguyen, 2008; Mayo Foundation, 2022a; 2022b). Sacroiliitis, ankylosing spondylitis, and peripheral enthesitis can all occur as part of EA (Khan, 2002). Joints of the lower extremities are affected asymmetrically, and spondylitis is “indistinguishable from idiopathic ankylosing spondylitis” (Kataria and Brent, 2004:2859). The skeletal lesion manifestation of EA cannot be differentiated from that of AS and PA; therefore, diagnosis of EA from skeletal remains is often impossible (Cawley and Paine, 2015).

4.6 Differential Diagnosis

Despite the similarity of skeletal effects in these conditions, a differential diagnosis is possible. RA is excluded as a diagnosis for Burial 12/2012, due to the lack of “skip lesions” and the location of the vertebral fusion on the anterolateral rather than lateral aspect of the vertebrae. The enthesal changes observed lack accompanying periosteal reaction, and the involvement of the

sacroiliac joint is symmetric, rather than asymmetric as noted in RA. Moreover, the joints of the lower limbs are not affected. Likewise, PA is excluded as it preferentially affects the joints of the hands, feet, and digits. There are no “skip lesions” observed in the vertebral column, and there is no evidence of periosteal reaction or erosive arthritis, which are used to diagnose clinical cases of PA. EA is also an unlikely diagnosis, as the lower limbs were unaffected.

The “dripping candle wax” appearance on the anterolateral surface of the vertebral bodies of T6-T10 meets two of the criteria for a diagnosis of DISH: ossification of the anterior longitudinal ligament involving at least four contiguous vertebral bodies and maintenance of intervertebral disc space height (Ghammam et al., 2019; Nascimento et al., 2014). The enthesal changes of the right and left ulnar olecranon and the involvement of the iliac crest are also consistent with a diagnosis of DISH. Moreover, the age and sex of the individual (50+ year-old male) fits the demographic profile of those most often afflicted (Arriaza, 1993; Nascimento et al., 2014).

The involvement of the costovertebral and apophyseal joints and the ossification of the supraspinous ligament are consistent with AS; however, the vertebral bodies are not squared, nor is there an appearance of “bamboo spine.” The bilateral involvement of the sacroiliac joint, including early fusion of the left joint and near fusion of the right joint also indicate a diagnosis of AS. The involvement of the entheses of the clavicle and margins of the glenoid fossae are also consistent with AS.

In considering all the skeletal evidence, it is likely that this individual suffered from both DISH and AS. While previously reported only once in the paleopathological literature (Costa and Weber, 1995 as discussed in Fornaciari and Giuffra, 2013), simultaneous occurrence of DISH and AS has been described in the clinical literature (see review by Kuperus et al., 2018).

Although the diagnostic criteria for DISH developed by Resnick and Niwayama (1976) excludes the co-occurrence of AS, 20 clinical reports of 39 cases suggest otherwise (Kuperus et al., 2018). For example, Jordana and colleagues (2008) describe an elderly male diagnosed with AS during life, who was determined to also have DISH during postmortem examination. There was bilateral fusion of the sacroiliac joint, including intra-articular ankylosis as well as para-articular bridging. While, bilateral sacroiliac fusion is considered more common with AS, it can occur in DISH as well (Dar et al., 2007). The right anterolateral surface of the vertebral column between T6 and L5 had a “flowing and undulating calcification” consistent with DISH (Jordana et al., 2009:355). Additionally, some apophyseal and costovertebral joints were fused, and portions of the interspinous and supraspinous ligaments were calcified, which are associated with AS. The case study presented by Jordana and colleagues (2009) has many similarities to Burial 12/2012 presented here.

The limitation of this study is the lack of radiographic evaluation of the skeletal remains. The remains of Burial 12/2012 have been reburied; thus, no radiographs can be taken in the future. Additionally, no DNA samples were analyzed, which may have been useful in identifying the HLA-B27 gene (e.g., Leden et al., 2009) that is associated with the spondyloarthropathies discussed here.

4.7 Significance

The case study outlined here is significant as it represents a unique co-occurrence of DISH and AS that has not been reported in the paleopathological literature since 1955 (Costa and Weber, 1995 as discussed in Fornaciari and Giuffra, 2013) despite a large body of evidence from clinical

literature. Additionally, and more importantly, the co-occurrence of these two conditions is essential for assessments of heterogeneous frailty and syndemics.

Heterogeneous frailty refers to intra-population variation in frailty, which was originally defined by Vaupel and colleagues (1979) as one's relative risk of death compared to a standardized cohort risk but has been used more generally to refer to susceptibility to disease and death (Wood et al., 1992). This variation is the result of the myriad factors that give rise to greater risk of death and disease, such as nutritional status, immunocompetence, genetics and epigenetics, sex hormones, risk-taking behavior, occupational hazards, exposure to disease vectors, or environmental pollution. Wood and colleagues (1992) emphasized the fact that much of the heterogeneous frailty that exists in living populations is unobservable in human skeletal remains. Considering this "hidden" heterogeneity in frailty, the aggregate patterns observed in skeletal samples are arguably compatible with multiple scenarios regarding patterns of health in the living population at the individual and sub-population levels. An important step in resolving the effects that heterogeneous frailty has on reconstructions of past health is documenting the presence of co-morbid conditions and ultimately determining patterns of co-morbidities (DeWitte, 2022).

Relatedly, evidence of co-morbid conditions is relevant to understanding of syndemics in the past, the study of which is emerging in bioarchaeology and paleopathology (see Larsen and Crespo, 2022; Robbins Schug and Halcrow, 2022). The term syndemics, first introduced by Singer (2009), refers to the co-occurrence and interaction of two or more diseases or health conditions, the health consequences of which are greater than the sum of their individual effects.

It also focuses on the interaction between the presence of multiple diseases and the biological, environmental, and social conditions that can exacerbate them (Hart and Horton, 2017; Singer et al., 2017). Though typically considered at the population-level, syndemic studies in bioarchaeology would benefit from multi-scalar analyses that consider the existence and effects of co-morbid conditions at the individual level as well.

5 Conclusion

Burial 12/2012 is unique as this 50+-year-old male presents with a co-occurrence of DISH and AS, which has been previously reported only once in the paleopathological literature (Costa and Weber, 1995 as discussed in Fornaciari and Giuffra, 2013), but has been described multiple times in clinical settings (Kuperus et al., 2018). This study has demonstrated that while DISH and several spondyloarthropathies have overlapping skeletal presentations, a differential diagnosis can be made. Moreover, it is important that bioarchaeologists recognize that a co-occurrence of these conditions is possible.

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