

# An exploration of the changing understandings of physical impairment and disability in early medieval England: a bioarchaeological, funerary, and historical approach

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## Appendix A

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Table 1

*Summary of the palaeopathological analysis, possible diagnoses, functional restrictions, grave goods, and notable funerary treatment for the individuals with physical impairment from the pre-Christian cemeteries.*

SK no. <sup>a</sup>	Age/ sex <sup>b</sup>	Physical impairment + possible diagnoses <sup>c</sup>	Possible functional restrictions <sup>c</sup>	Notable funerary treatment <sup>d</sup>	Grave goods <sup>d</sup>
<b>Apple Down<sup>1</sup></b>					
AD-7B	35–40, F	Ankylosis of L3 + L4 via reactive bone formation; four cloacae within bone formation → TB or vertebral osteomyelitis <sup>2</sup>	- Tenderness, pain, swelling, limited movement, + neurological deficit if leakage into spinal canal (sensory loss, weakness) <sup>3</sup> - If TB: fever, malaise, + weight loss <sup>4</sup>	Normative	None
AD-39	20–25, M	Well-healed, mis-aligned fracture of proximal R femur <sup>5</sup>	- Abnormal/restricted gait	Normative	None
AD-60	16–17 <sup>6</sup> , US	Gracile, shortened long bones (more marked in lower limbs); increased FNAs; length of L tibia provides age estimate of 10–11 years <sup>7</sup> (extreme stunting) → para/quadruplegia (various possible causes: neuromuscular disease? poliomyelitis? cerebral palsy? stroke? spinal tumour? etc) <sup>8</sup>	- Paralysis of lower limbs → restricted movement - Urinary/anal incontinence, muscle spasms, + pressure ulcers <sup>9</sup> - Visible disuse atrophy of arms + legs - Possible mental impairment <sup>10</sup> (depending on condition) - May have required long term external care to ensure survival <sup>11</sup>	L side (7.8%); flexed (16.8%); legs bent L (10.8%); stone packing (12.0%) indicative of the presence of a coffin (21.6%)	None
AD-111	45+, F?	Severe osteophytic lipping of R femoral head resulting in medial rotation of femur → OA <sup>12</sup>	- Adduction deformity <sup>13</sup> → probable restriction of movement + abnormal gait - Pain with radiation to buttocks, knee, shin + difficulty with long periods of walking <sup>14</sup>	R side (10.3%); flexed (16.8%); S margin	Pottery rim (3.2%)
AD-152	20–25, M	Diffuse porous + smooth PNB throughout appendicular skeleton; destruction of central/L frontal bone (some lytic, some taphonomic) → treponemal disease <sup>15</sup> ? HOA <sup>16</sup> ?	- <u>Treponemal disease</u> <sup>17</sup> : bone pain, soft tissue swelling, fever, tenderness, rash, syphilitic meningitis (confusion, deafness, ocular deficiencies), gummatous syphilis, + late neurosyphilis (vertigo, seizure, dementia, etc.) - <u>HOA</u> <sup>18</sup> : deep, aching/burning pain in affected areas, joint swelling, restricted movement, possible cutaneous involvement, + secondary HOA associated with severe internal illness	Normative	Knife (40.8%) Spear (12.8%) Shield (2.4%)
<b>Butler's Field<sup>19</sup></b>					
BF-6	30–35, F	Bilateral pseudarthroses on posterior surfaces of both scapulae → posterior subspinous glenohumeral joint dislocation <sup>20</sup>	- Pain, swelling, limitation of shoulder movement, + abnormal upper body posture <sup>21</sup> - May have been caused by epileptic seizure <sup>22</sup>	Unphased; R leg bent, L leg straight (3.7%); narrow grave; buried away from main burial concentration (c.24 m)	None

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)	Grave goods <sup>d</sup> (continued)
BF-65	45+, M	Well-healed trauma to R frontal/zygomatic with displacement; anteroposterior shortening of R side of face with asymmetrical orbits	<ul style="list-style-type: none"> <li>- Possible neurosensory disturbance → lock jaw + double vision<sup>23</sup></li> <li>- Possible blindness from damage to orbit/eyeball</li> <li>- Possible brain damage from trauma to cranium<sup>24</sup></li> <li>- Facial asymmetry + probable noticeable scarring</li> </ul>	5 <sup>th</sup> – 6 <sup>th</sup> century ('Migration phase'); NW/SE (3.3% of 'Migration phase' burials); supine (78.2%); flexed (32.4%); stone lining (8.1%); multiple consecutive burial (2.7%)	Buckle (18.1%) Knife (33.0%) Spear (11.3%) Shield (5.0%)
BF-75	30–35, M	Fusion + kyphosis of T11–L2 with smoothed out lytic lesions on T6–T10 + large, smoothed out cavity between L1 + L2; lytic lesions with smoothed out interiors on superior aspects of 3 rib heads → TB <sup>25</sup>	<ul style="list-style-type: none"> <li>- Gibbus deformity → hunched over appearance</li> <li>- Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait<sup>26</sup></li> <li>- Pulmonary TB: fatigue + persistent cough<sup>27</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>28</sup></li> </ul>	7 <sup>th</sup> – early 8 <sup>th</sup> century ('Final Phase'); skull propped up against side of grave (0.7%); lower half of skeleton absent; directly in line with (+ oppositely oriented to) burials forming clear SW margin of 'Migration phase' cemetery	Knife (33.0%)
BF-134	14–16, US	Distal + posterior displacement of L proximal humeral epiphysis + shortening of L humerus; angulation of L radial head → lateral angulation of L forearm; some flattening of R humeral head; deformation of R radial head + swelling of proximal diaphysis → lateral angulation of R forearm → traumatic injuries <sup>29?</sup> multiple epiphyseal dysplasia <sup>30?</sup>	<ul style="list-style-type: none"> <li>- Shortening of L humerus + abnormality of L shoulder joint → restricted or abnormal L arm movement + possible pain<sup>31</sup></li> <li>- Abnormality of R elbow → possible restricted or abnormal R arm movement</li> </ul>	5 <sup>th</sup> – 6 <sup>th</sup> century ('Migration phase'); buried in row of similarly oriented burials near SE margin	Brooch (21.3%) Pin (20.8%) Bronze balance pan (0.5%)
<b>Edix Hill<sup>32</sup></b>					
EH-42B (Grave 18)	17–25, F	Rounding of nasal aperture margins, resorption of nasal spine + porosity of interior of nasal aperture; bilateral tibial periostitis [observed in Malim and Hines, 1998] → lepromatous leprosy <sup>33</sup>	<ul style="list-style-type: none"> <li>- Rhinomaxillary syndrome → nasal discharge, clogged airway, lips/tongue/palate nodules, + saddle nose deformity<sup>34</sup></li> <li>- Pain, loss of sensation in extremities, muscular paralysis, probable infection of foot via plantar ulcer, + difficulty with some activities involving feet<sup>35</sup></li> <li>- Possible: skin lesions, hair loss, lagophthalmos, + blindness<sup>36</sup></li> </ul>	Bed burial (1.5%) including wooden planks, metal cleats + eyelets; long grave; vertical sequential multiple burial (8.1%) → incomplete remains of 2 further individuals overlying grave	Unique grave goods → see below*
*Grave goods for EH-42B: 2 knives (39.2%); bead (26.4%); rod (25.0%); comb (6.1%); 2 necklace silver necklace rings (4.7%); sheep astragalus (0.7%); spindle whorl (2.0%); key (0.7%); iron bucket hoops + handle from oakwood bucket (0.7%); iron weaving batten (modified sword, 0.7%); sea urchin fossil (0.7%); funerary bed (11 iron eyelets, 6 iron cleats, 2 iron headboard stays)					

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)	Grave goods <sup>d</sup> (continued)
EH-130 (Grave 40)	15–16, US	Diffuse, irregular porous PNB across R ilium, ischium, + pubis → non-specific infection/inflammation or osteomyelitis?	- Pain in hip + buttocks, weakness, fever/chills, difficulty walking, + abnormal gait <sup>37</sup>	Prone (2.1%); flexed (25.6%)	Pot sherds (4.1%)
EH-146 (Grave 46)	23–59, M	Irregularly shaped lytic lesions with sharp edges throughout axial skeleton → metastatic carcinoma <sup>38</sup>	- Possible bone pain, cranial nerve palsy, + headache <sup>39</sup> - Pain in neck, back, + lower legs <sup>40</sup> → abnormal gait? - Hypercalcaemia → fatigue, deterioration of mental functioning, dysfunction of gastrointestinal, kidney, rectal, + central nervous systems <sup>41</sup> - May have required short term external care to ensure survival <sup>42</sup>	Normative; long/wide grave	Knife (39.2%) Buckle (30.4%) Spear (14.2%) Shield (10.8%)
EH-322A (Grave 66)	Adult, M	Collapse of anterior L5 + ankylosis with S1 through smooth bony bridging; large oval cloacae within bony bridging → TB <sup>43</sup>	- Hypolordosis → back pain <sup>44</sup> - General symptoms of TB: weakness, fatigue, weight loss, + fever <sup>45</sup>	Normative; long grave	Buckle (26.4%) Spear (14.2%) Shield (10.8%) Vessel mounts (2.0%)
EH-440A (Grave 84)	25–35, F	Deformation of R elbow joint surfaces → OA + possible infection of R elbow <sup>46</sup> + fixed pronation of R forearm	- Restricted use of R arm due to pronation fixation <sup>47</sup>	Skull resting on neonate (EH-440B); possible marker post (7.4%); stone inclusions (6.8%) around pelvic area	Buckle (30.4%) Beads x32 (26.4%) Nail (12.8%)
Finglesham <sup>48</sup>					
FS-94	30–40, M	Medial + posterior angulation of distal ends of L radius + ulna, + smooth bony ankylosis through proximal 1/3 of the diaphyses → traumatic fracture <sup>49</sup>	- Supination fixation → difficulty performing everyday tasks <sup>50</sup>	Buried in coffin (28.6%); W margin in area of females + non-adults; buried adjacent to FS-93's ring ditch (indicates burial mound)	None
Norton East Mill <sup>51</sup>					
NEM-91	c.20, M	Posterior + medial bowing of distal half of R femur + shortening of R femur → traumatic fracture <sup>52</sup>	- Limb length discrepancy + abnormal angle of articulation with knee → abnormal gait + restricted <sup>53</sup> use of R leg	Prone (12.7%); R leg straight, L leg bent (2.7%); R elbow projecting vertically out of grave; deep grave	None
St Anne's Hill <sup>54</sup>					
SAH-111 (Grave 110)	26–45, M	Amputation of distal ends of L ulna + radius with evidence of healing <sup>55</sup>	- Absence of L hand → restricted use of L upper limb <sup>56</sup> - Fixation of L forearm in partial pronation - Unlikely to have worn prosthesis <sup>57</sup>	Normative	Spear (9.9%) Knife (41.1%)

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)	Grave goods <sup>d</sup> (continued)
SAH-346 (Grave 345)	Adult, M??	Midshaft swelling of L femur; enlargement + macroporosity of L acetabulum + contour change of L femoral head → bone tumour <sup>58?</sup> (osteoid osteoma, osteoblastoma, simple bone cyst) or healed fracture + osteitis <sup>59</sup> + primary or secondary hip OA <sup>60?</sup>	<ul style="list-style-type: none"> <li>- Possible pain mid femur<sup>61</sup></li> <li>- Possible abnormal gait leading to secondary OA of L hip</li> </ul>	Adjacent to circular empty area of cemetery → possibly used as a social 'arena' for funerary activities or communal gatherings <sup>62</sup> ; probable non-normative leg position but cannot be confirmed due to poor preservation	None
SAH-481 (Grave 472)	Adult, M	Flattening/rounding of margins of nasal aperture + some resorption of anterior nasal spine; porous PNB on R/L MCs + distal resorption of 3 proximal manual phalanges + 1 distal manual phalanx; PNB on fragments of tibiae + fibulae → probable lepromatous leprosy <sup>63</sup> (limited by poor preservation)	<ul style="list-style-type: none"> <li>- Rhinomaxillary syndrome → nasal discharge, clogged airway, lips/tongue/palate nodules, + saddle-nose deformity<sup>64</sup></li> <li>- Hand deformity<sup>65</sup> → restricted use?</li> <li>- Pain, loss of sensation in extremities, muscular paralysis, probable infection of foot via plantar ulcer, + difficulty with some activities involving feet<sup>66</sup></li> <li>- Possible: skin lesions, hair loss, lagophthalmos, + blindness<sup>67</sup></li> </ul>	Buried away from main burial concentration; L side (2.1%); 'other' body position (2.7%) → between flexed + crouched; both legs bent L (2.7%) → R leg bent severely up towards body	Copper intaglio (incised peacock decoration, late 4 <sup>th</sup> -5 <sup>th</sup> C) for a bezel (finger ring) (0.5%)
SAH-1049 (Grave 1048)	18-25, M??	Collapse + kyphosis of 3 TV → TB <sup>68</sup>	<ul style="list-style-type: none"> <li>- Gibbus deformity</li> <li>- Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait<sup>69</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>70</sup></li> </ul>	W margin in a group of similarly oriented burials	None
Watchfield <sup>71</sup>					
WF-5 (Grave 5)	40-45, M	Deformation of R humeral head/glenoid cavity + R humerus 76 mm shorter than L; R ulna 15 mm shorter than L → traumatic fracture <sup>72</sup>	<ul style="list-style-type: none"> <li>- Shortening + abnormal shoulder joint → restricted use of L arm<sup>73</sup></li> </ul>	SW-NE orientation (5.1%)	Spear (9.5%) Buckle (23.8%) Knife (42.9%)
WF-312 (Grave 315)	20-25, F	Probable fractures to proximal R radius/ulna + distal R humerus → deformation of R elbow (not examined by lead author) → traumatic injury + secondary OA	<ul style="list-style-type: none"> <li>- Limited range of motion, instability, + nerve damage<sup>74</sup></li> <li>- Restricted use of R elbow → possible fixation of elbow joint</li> </ul>	SW corner	Saucer brooch x2 (28.6%) with evidence of repair Knife (42.9%) Pin (11.9%) Toilet pick + scraper (2.4%) Brush casing (2.4%) Pierced Roman coin (4.8%)

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)	Grave goods <sup>d</sup> (continued)
Windmill Hill <sup>75</sup>					
WMH-10	35-45, F??	Ankylosis + kyphosis of 6 or 7 TV→ TB <sup>76</sup>	<ul style="list-style-type: none"> <li>- Gibbus deformity</li> <li>- Disruption of spinal cord→ possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait<sup>77</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>78</sup></li> </ul>	Funerary information not available	?Buckle (9.4%)
WMH-18	21-28, F	Slender, gracile upper + lower limb long bones (not as severe in upper limbs) + increased FNA→ para/quadruplegia (various possible causes: cerebral palsy? neuromuscular disease? poliomyelitis? stroke? spinal tumour? etc) <sup>79</sup>	<ul style="list-style-type: none"> <li>- Lower limb paralysis→ restricted movement, urinary/anal incontinence, muscle spasms, + pressure ulcers<sup>80</sup></li> <li>- If there was paralysis of arms→ restricted use of upper limbs</li> <li>- Possible mental impairment (depending on condition)<sup>81</sup></li> <li>- May have required long term external care to ensure survival<sup>82</sup></li> </ul>	Flexed (31.0%); probably L side (20.0%) but cannot confirm; stone inclusion (20.8%)→ possible stone lining?	?Pin (2.4%)
WMH-54	35-45+, M	Posterior angulation of distal R radius + cloaca; non-union fracture of distal R ulna→ traumatic injury + osteomyelitis <sup>83</sup>	<ul style="list-style-type: none"> <li>- Pain, tenderness, + chronic/intermittent drainage of fistulae<sup>84</sup></li> <li>- Abnormal angle of R wrist + restricted use of R forearm</li> </ul>	R side (12.7%); flexed (31.0%); buried within ring ditch (4.7%)→ indicative of burial mound; neat, wide, rectangular grave; possibly initial focal burial of cemetery; only individual buried with weaponry	Spear (1.2%) Shield (1.2%) Tweezers (1.2%) Buckle (9.4%) Knife (15.3%) Ceramic cup (1.2%)
WMH-71	21-25, F	Asymmetry in size of forearms→ R radius considerably more slender than L + R ulna somewhat more slender than L→ some form of paralysis (stroke? brachial plexus palsy? monomelic amyotrophy? direct trauma? neuromuscular disease?) <sup>85</sup>	<ul style="list-style-type: none"> <li>- Weakness of R forearm→ restricted use of R upper limb<sup>86</sup></li> </ul>	Normative	Brooch x3 (14.7%) Beads x87 (16.5%) Coin pendant (1.2%) Coin (2.4%) Ceramic pot x2 (9.4%)
WMH-75	40+, M??	Fusion of L radius + ulna in distal 1/3 of diaphysis via smooth, compact bone→ traumatic injury <sup>87</sup>	<ul style="list-style-type: none"> <li>- Supination fixation→ decreased forearm functionality<sup>88</sup></li> <li>- Abduction + internal rotation of shoulder necessary to use forearm in pronated position→ fatigue<sup>89</sup></li> </ul>	Oriented E-W (8.2%); stone inclusion (20.8%)→ possible stone lining?	None
WMH-89	14-17, US	Bilateral, diffuse woven bone (+ smoother striated compact bone) throughout skeleton→ mandible, pectoral girdles, ribs, upper/lower limbs, pelvic girdle, + hands/feet→ HOA <sup>90</sup>	<ul style="list-style-type: none"> <li>- Secondary HOA associated with severe internal illness<sup>91</sup></li> <li>- Deep aching or burning pain in affected areas + joint swelling<sup>92</sup>→ restricted movement</li> <li>- Possible cutaneous involvement<sup>93</sup></li> </ul>	R side (12.7%); crouched (17.2%); NE margin	Ceramic pot base (9.4%) Knife (15.3%) Unidentified bronze object

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)	Grave goods <sup>d</sup> (continued)
Worthy Park <sup>94</sup>					
WP-2	50+, F	Anterior collapse of L3 + ankylosis of L3 + L4 → traumatic injury <sup>95</sup>	<ul style="list-style-type: none"> <li>- Kyphosis + right-side angulation of lumbar spine → hunched over appearance + abnormal gait</li> <li>- Forward-facing gaze restricted, pain, + fatigue<sup>96</sup></li> </ul>	Both legs bent inward (1.3%) → possibly buried with both knees projecting vertically above horizontal plane of body which then collapsed inward upon decay <sup>97</sup> ; buried in grave that was too small; buried in cluster	Pin (12.4%)
WP-14	40+, M	Severe malalignment of R forearm → distal 2/3 radius + ulna displaced medially; R forearm shorter than L → traumatic injury <sup>98</sup>	<ul style="list-style-type: none"> <li>- Visually distinctive R forearm</li> <li>- Restricted use of R forearm due to abnormal angulation<sup>99</sup></li> </ul>	Normative; buried in cluster	Knife (54.6%)
WP-39	40–50, F	Fusion + deformation of T1–T6 (not examined by lead author) → TB <sup>100</sup>	<ul style="list-style-type: none"> <li>- Gibbus deformity</li> <li>- Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait<sup>101</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>102</sup></li> </ul>	Normative; buried in cluster	Pin (12.4%) Knife (54.6%) Tweezers suspended from ring (7.2%)
WP-45	18–30, M	L upper limb long bones more slender than R → some form of paralysis (stroke? brachial plexus palsy? monomelic amyotrophy? direct trauma? neuromuscular disease?) <sup>103</sup>	<ul style="list-style-type: none"> <li>- Weakness of L arm → restricted use of L upper limb<sup>104</sup></li> </ul>	Normative; buried in cluster	Spear (16.3%) Knife (54.6%)
WP-73	35–45, M	Four oval perforating lesions with rounded edges on distal end of L MT5 → osteomyelitis (diabetes? gangrene?) <sup>105</sup>	<ul style="list-style-type: none"> <li>- Localised inflammation, discharging fistula, + pain<sup>106</sup></li> <li>- Difficulty with ambulation → abnormal gait</li> </ul>	Normative	None

<sup>a</sup> AD= Apple Down; BF= Butler's Field; EH= Edix Hill; FS= Finglesham; NEM= Norton East Mill; SAH= St Anne's Hill; WF= Watchfield; WMH= Windmill Hill; WP= Worthy Park

<sup>b</sup> M/F (male/female); M?/F? (probable male/female); M??/F?? (possible male/female); US (unsexed); age range is provided in years

<sup>c</sup> FNA (femoral neck angle); HOA (hypertrophic osteoarthropathy); L (left); L# (lumbar vertebra #); MC (metacarpal); MT (metatarsal); OA (osteoarthritis); PNB (periosteal new bone); R (right); S# (sacral vertebra #); T# (thoracic vertebra #); TB (tuberculosis); TV (thoracic vertebrae)

<sup>d</sup> E (east); L (left); NE (northeast); NW (northwest); R (right); S (south); SE (southeast); SW (southwest); W (west); ? (possible); Parenthetical percentages indicate the percent of the entire burial assemblage in which a specific funerary variable occurred.

Table 2

*Summary of the palaeopathological analysis, possible diagnoses, functional restrictions, and notable funerary treatment for the individuals with physical impairment from the Christian cemeteries (based on new osteological analysis).*

SK no. <sup>a</sup>	Age/ sex <sup>b</sup>	Physical impairment + possible diagnoses <sup>c</sup>	Possible functional restrictions <sup>c</sup>	Notable funerary treatment <sup>d</sup>
Black Gate <sup>107</sup>				
BLG-442	25–35, M	Upper/lower limb long bones very gracile + slender with few muscular attachments → para/quadruplegia; volar grooves on 5 proximal manual phalanges <sup>108</sup> ; severe asymmetry in TV + LV; asymmetrical curvature of R/L ribs + deformation of rib necks → scoliosis <sup>109</sup> ; slightly increased R/L FNAs + elongation of femoral necks <sup>110</sup> ; hypoplastic R fibula (shorter/more slender than L) <sup>111</sup> ; deformation of R calcaneus with increased angle of articulation with talus, extra lateral facet on R/L calcanei, elongation of R talus with inferior + medial displacement of talar head → possible club foot <sup>112</sup>  Overall: Probable neuromuscular disease <sup>113</sup> → muscular dystrophy? poliomyelitis? cerebral palsy?	<ul style="list-style-type: none"> <li>- Disuse atrophy of arms/legs → restricted movement</li> <li>- Possible flexion deformity<sup>114</sup> → restricted use of hands</li> <li>- Severe scoliosis → abnormal gait, pain, + incontinence<sup>115</sup></li> <li>- Definite inversion of R foot (club foot?) + probable but lesser inversion of L foot → abnormal gait, restricted movement<sup>116</sup></li> <li>- Possible mental impairment (depending on condition)<sup>117</sup></li> </ul>	Normative
BLG-587	35–45, F	Lateral bowing of distal halves of both radii; eburnation on distal R radius + R scaphoid; short tibiae in comparison to femora; stature of 151 cm (4'11") → Lérid-Weill dyschondrosteosis <sup>118</sup> with bilateral Madelung's deformity <sup>119</sup>	<ul style="list-style-type: none"> <li>- Pain, fatigue, + restricted movement<sup>120</sup></li> <li>- Short stature<sup>121</sup> → visually distinctive</li> </ul>	Supine, extended (but no information about head/limbs)
Elstow Abbey <sup>122</sup>				
EA-17	25–35, F	Hypertrophy of proximal L tibia; 11 perforations with rounded edges (cloacae) on all aspects of proximal end → osteomyelitis <sup>123</sup>	<ul style="list-style-type: none"> <li>- Pain, tenderness, + chronic/intermittent drainage of fistulae<sup>124</sup></li> <li>- Probable abnormal gait</li> </ul>	Completely disturbed → no funerary information available
EA-25	35–59, M	Indentation proximal to capitulum of L humerus for articulation with convex, eburnated radial head; posterior + medial angulation + hypertrophy of proximal L ulna; bony outgrowth on midshaft of L ulna + L radius (early ankylosis or pseudarthrosis?) → Monteggia fracture-dislocation <sup>125</sup>	<ul style="list-style-type: none"> <li>- Limited range of motion → restricted use of L arm<sup>126</sup></li> <li>- Ankylosis in progress? → possibly fixed in partial pronation → difficulty performing some tasks<sup>127</sup></li> </ul>	Probably supine/extended (100%/100%)*, legs probably extended (100%)*
EA-37	30–40, M	Anterior collapse of L2 → kyphosis of LV; crescentic lipping on superior border of L2 with possible perforation; scalloped osteophytosis on inferior L2 + superior L3 → traumatic injury with osteomyelitis <sup>128</sup>	<ul style="list-style-type: none"> <li>- Kyphosis of lumbar → forward-facing gaze restricted, pain, fatigue, + hunched over appearance<sup>129</sup> → abnormal gait</li> <li>- If vertebral osteomyelitis → tenderness, pain, swelling, limited movement, + neurological deficit if leakage into spinal canal (sensory loss, weakness)<sup>130</sup></li> </ul>	Only lower half of skeleton present → legs probably extended (100%)*

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
EA-52	23-32, M	Two instances of severe ankylosis + kyphosis → upper TV + thoraco-lumbar junction; porous, visceral PNB deposition on several ribs; diffuse PNB deposition (long bones of both upper limbs, lower limbs, + right MCs) → TB <sup>131</sup> with secondary HOA <sup>132</sup>	<ul style="list-style-type: none"> <li>- Double gibbus deformity</li> <li>- Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait<sup>133</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>134</sup></li> <li>- Pulmonary TB: fatigue + persistent cough<sup>135</sup></li> <li>- From HOA → deep aching or burning pain in affected areas + joint swelling<sup>136</sup></li> </ul>	Truncated mid femur → supine (100%); R arm bent slightly + L arm unknown <sup>†</sup>
EA-310	45+, M	Complete ankylosis of R SIJ + probable ankylosis of L SIJ; fusion of L1-L5 via smooth syndesmophytes; fragments of c.5 probable TV fused via smooth osteophytic growth; fusion of at least 6 TV + 8 ribs → ankylosing spondylitis <sup>137</sup>	<ul style="list-style-type: none"> <li>- Stiffness, pain in back, pain radiating to lower limbs, tenderness, fatigue, restricted movement, + limited chest expansion<sup>138</sup></li> </ul>	Only upper half of skeleton present → supine (100%) with arms extended (59.4%)
EA-360	25-35, M	Anterior collapse, ankylosis, + kyphosis of L2 + L3 → TB <sup>139</sup>	<ul style="list-style-type: none"> <li>- Gibbus deformity</li> <li>- Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait<sup>140</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>141</sup></li> </ul>	Only upper half of skeleton present → R arm unknown + L arm bent across abdomen <sup>†</sup>
* % is based only on individuals that could be definitively categorised; † % not calculated for category but note that 21.9% of burial assemblage had both arms bent; NB: stoness/coffins absent (99.0%/99.7%) in graves of all individuals with physical impairment at Elstow Abbey.				
Priory Orchard <sup>142</sup>				
PO-1049	32-45, M	Severe disruption in proximal L femoral diaphysis resulting in a proximal segment which does not connect with medullary cavity; medial displacement of L femoral head; L femur is 54 mm shorter than R → subtrochanteric femoral fracture <sup>143</sup>	<ul style="list-style-type: none"> <li>- Limb length discrepancy → abnormal gait + restricted use of L leg<sup>144</sup></li> </ul>	Normative; buried near N margin (c.1.25 m)
PO-1074	OA, M?	Large, oval perforation (2 lobes) in trabecular bone of R ischium + evidence of smoothed out trabecular remodelling → aneurysmal bone cyst <sup>145</sup>	<ul style="list-style-type: none"> <li>- Local pain, increased temperature, swelling, limited movement of hip, + possible abnormal gait<sup>146</sup></li> </ul>	Normative
PO-1079/ 3123	40-60, M	Complete fusion of L femur + tibia in the flexed position with posterior angulation of tibia → tuberculous arthritis? <sup>147</sup> septic arthritis? <sup>148</sup> traumatic injury?	<ul style="list-style-type: none"> <li>- Abnormal flexion of L knee → visually distinctive</li> <li>- Fatigue, pain, + abnormal ('crouch') gait<sup>149</sup> → restricted use of L leg</li> </ul>	L knee bent + raised above the horizontal plane containing the remainder of the body; buried near W margin (c.2.5 m)
PO-3169	35-45, M	Severe deformation of distal L humerus → no articular surface on anterior aspect of distal humerus; deformation of L radial head (loss of concavity) + severe deformation of proximal L ulna (coronoid process severely flattened + eburnation) → traumatic injury	<ul style="list-style-type: none"> <li>- Articulation requires slight flexion of elbow, but full flexion probably not possible</li> <li>- Joint stiffness + restricted use of L arm<sup>150</sup></li> </ul>	Stone included (14.9%) as part of grave lining (3.3%); only upper half of skeleton present

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
Raunds <sup>151</sup>				
RD-5046	18–25, M	A) Rhinomaxillary syndrome (diffuse porous bone deposition on oral/nasal surfaces of hard palate + rounding of inferior + lateral margins of nasal aperture); diffuse PNB on R/L tibiae + fibulae → lepromatous leprosy <sup>152</sup> B) Significant hypertrophy of distal R femur + slight lateral angulation → traumatic injury + infection/osteitis? <sup>153</sup>	<ul style="list-style-type: none"> <li>- Rhinomaxillary syndrome → nasal discharge, clogged airway, lips/tongue/palate nodules, + saddle nose deformity<sup>154</sup></li> <li>- Pain, loss of sensation in extremities, muscular paralysis, probable infection of foot via plantar ulcer, + difficulty with some activities involving feet<sup>155</sup> → abnormal gait? (possibly exacerbated by lateral angulation of distal R femur)</li> <li>- Possible: skin lesions, hair loss, lagophthalmos, + blindness<sup>156</sup></li> </ul>	SE corner (on the S margin, c.3 m from E margin); c.21.5 m from church
RD-5062	36–45, M	A) Deformation of L humeral head (concavity, eburnation, porosity, posterior rotation) + L glenoid cavity (flattening, osteophytes, porosity); L humerus 99 mm shorter than R → traumatic injury <sup>157</sup> B) Inferior displacement of R femoral head; femoral head conical in shape with thick osteophytes, macroporosity, + eburnation → SCFE <sup>158</sup>	<ul style="list-style-type: none"> <li>- Shortening of humerus + abnormal shoulder joint<sup>159</sup> → restricted use of L arm</li> <li>- Reduction in abduction + internal rotation of R hip, abnormal gait, + pain in hip, knee, + thigh<sup>160</sup></li> </ul>	SE corner (c.2.5 m from S margin; c.2.5 m from E margin); c.20 m from church; pillow stones beneath/behind/on sides (8.0%)
RD-5074	26–35, M	Multiple lytic lesions with evidence of trabecular remodelling in proximal end of L tibia; PNB on proximal + midshaft of L tibia + on fragments of L fibula → tuberculous arthritis? <sup>161</sup> septic arthritis? <sup>162</sup>	<ul style="list-style-type: none"> <li>- Swollen, hot, + painful knee<sup>163</sup> → abnormal gait + restricted use of L leg</li> </ul>	Knee supported by stones; clay layer over most of body (3.3%); stone over face (3.3%); L hand at pelvis, R hand at side (4.4%), feet apart (7.5%); near W margin; c.9.5 m from church
RD-5218	18–25, M	<u>L upper limb</u> : Flattening of L humeral head, diaphyseal bowing + 95 mm shortening → traumatic injury <sup>164</sup> <u>Thorax</u> : PNB on visceral surface of ribs, irregular osteoblastic + osteoclastic activity on T9–T12, destruction of inferior T11 + superior T12 → probable TB <sup>165</sup> <u>R lower limb</u> : A) atrophy of femur/tibia/fibula + deformation of R ankle joint → secondary to destruction of R knee? <sup>166</sup> poliomyelitis? <sup>167</sup> ; B) flexion fixation of tibia, patella fused to tibia → tuberculous arthritis? <sup>168</sup> septic arthritis? <sup>169</sup>	<ul style="list-style-type: none"> <li>- Shortening of humerus + abnormal shoulder joint<sup>170</sup> → restricted use of L arm</li> <li>- No evidence of kyphosis; pulmonary tuberculosis → fatigue + persistent cough<sup>171</sup></li> <li>- General symptoms of TB: weakness, fatigue, weight loss, + fever<sup>172</sup></li> <li>- Hot, swollen, + painful knee<sup>173</sup></li> <li>- Abnormal flexion of R tibia + atrophy/shortening of R lower limb long bones → abnormal gait + restricted use of R leg<sup>174</sup></li> </ul>	On N margin; c.7.5 m from church; buried with stone in mouth; pillow stones beneath/behind/on sides (8.0%)

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
St Peter's Church <sup>175</sup>				
SPC-585	45+, M	Large, oval perforation with sharp margins in R side of occipital + R parietal; smoothed out cavities in R pelvis; x-rays of humeral head, manubrium, + ilium (not available) confirm appearance of metastases or multiple myeloma <sup>176</sup> → metastatic carcinoma <sup>177</sup>	<ul style="list-style-type: none"> <li>- Skull: possible bone pain, cranial nerve palsy, + headache<sup>178</sup></li> <li>- Pain in lower back + legs + functional instability<sup>179</sup></li> <li>- Hypercalcemia→ fatigue, deterioration of mental functioning, dysfunction of gastrointestinal, kidney, rectal, + central nervous systems<sup>180</sup></li> <li>- May have required short term external care to ensure survival<sup>181</sup></li> </ul>	L side (2.3%); flexed (3.7%); L arm bent over chest (3.8%); R arm bent over abdomen (13.6%); legs bent L (2.7%); nails present (5.7%); wooden grave furniture present (55.0%)→ possible coffin; adjacent to church
SPC-893	AD, US	Complete ankylosis of R (+ probably L) talus, calcaneus, + cuboid via spiky, reactive bone growth + PNB on R/L distal tibiae→ ankylosing spondylitis? <sup>182</sup> Reiter's syndrome? <sup>183</sup> trauma + non-specific infection?	<ul style="list-style-type: none"> <li>- Variable symptoms for tarsal fusion→ chronic pain, restricted mobility, peroneal muscle spasm, + limited inversion/eversion of ankle<sup>184</sup></li> <li>- Ankylosing spondylitis→ stiff back, pain in back + limbs, tenderness, restricted movement, + limited chest expansion<sup>185</sup></li> <li>- Reiter's syndrome→ tenderness, back pain, stiffness, limited motion of spine/joints, chronic diarrhoea, + ocular/genital/cardiac/cutaneous issues<sup>186</sup></li> <li>- Non-specific→ possible foot deformity causing gait alteration + swelling/pain in lower legs<sup>187</sup></li> </ul>	No grave drawing available
SPC-976	45+, M	Diffuse, spiculated + HOE PNB formation (scapulae, sternum, ribs, pelvis, sacrum, proximal femora); perforating holes (dorsal ribs, laminae of CV + TV)→ metastatic carcinoma (probably of the prostate) <sup>188</sup>	<ul style="list-style-type: none"> <li>- Pain in lower back + legs + functional instability<sup>189</sup></li> <li>- Hypercalcemia→ fatigue, deterioration of mental functioning, dysfunction of gastrointestinal, kidney, rectal, + central nervous systems<sup>190</sup></li> <li>- If due to prostate→ fatigue, bone/nerve pain, urinary incontinence, blood in urine, problems urinating, constipation, diarrhoea, faecal urgency/incontinence, bowel obstruction<sup>191</sup></li> <li>- May have required short term external care to ensure survival<sup>192</sup></li> </ul>	?R side (1.8%); ?truncated mid femur

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
SPC-1068	45+, F	<u>R upper limb</u> : complete ankylosis of carpals + MC2; macroporosity + lytic lesions on proximal end of fused unit; severe osteophytic lipping of distal radius → RA <sup>193</sup> septic arthritis <sup>194</sup> trauma + infection <sup>195</sup> <u>Spine</u> : fusion of T11–L1 with minor collapse of ?T11 + reactive PNB → early TB <sup>196</sup> RA <sup>197</sup> trauma + infection? <u>R lower limb</u> : inferomedial squishing/displacement of R femoral head (mushroom-shaped) + thick osteophytic lipping + eburation; severe enlargement of R acetabulum with diffuse lytic destruction → Legg-Calvé-Perthes <sup>198</sup> disease or SCFE <sup>199</sup>	<ul style="list-style-type: none"> <li>- R wrist: only possible impairment<sup>200</sup> → possible restricted range of motion + stiffness</li> <li>- Spine: only possible impairment → pain + restricted movement possible</li> <li>- R leg: pain, limited range of motion (abduction + internal rotation), + abnormal gait<sup>201</sup></li> </ul>	Normative; truncated at knee; wooden grave furniture present (55.0%) → possible coffin/charred board
SPC-1103	45+, M	Severe indentation (internal displacement) + tilting of ulnar notch of L radius creating sharp ridges; flattening of L ulnar head → traumatic injury	<ul style="list-style-type: none"> <li>- Rotation around ulnar notch probably impossible due to sharp ridges</li> <li>- Fixation in partial pronation → difficulty with some daily tasks<sup>202</sup></li> </ul>	Normative (only L side present)
SPC-1109	AD, M	Hypertrophy of distal R fibula + ovular lesion with rounded edges on lateral distal end (cloaca) → osteomyelitis <sup>203</sup>	<ul style="list-style-type: none"> <li>- Pain, tenderness, + chronic/intermittent drainage of fistulae<sup>204</sup></li> <li>- Probable abnormal gait</li> </ul>	Only R leg present; wooden grave furniture present (55.0%) → possible coffin
SPC-1268	45+, M	Diffuse PNB in R/L humeri, sacrum, lower limbs (mixture of compact + porous) → non-specific systemic infection? HOA? <sup>205</sup>	<ul style="list-style-type: none"> <li>- Secondary HOA associated with severe internal illness<sup>206</sup></li> <li>- Deep aching or burning pain in affected areas + joint swelling<sup>207</sup> → restricted movement</li> <li>- Possible cutaneous involvement<sup>208</sup></li> </ul>	Normative; wooden grave furniture present (55.0%) → coffin
SPC-1309	25–34, M	Large, smoothed out lesion on anterosuperior aspect of L femoral head + 2 smaller lesions on inferior aspect → considerable deformation of shape of femoral head; flattening of L acetabulum + macroporosity + eburation; diaphysis of L femur slimmer than R → unicameral bone cyst? <sup>209</sup> giant cell tumour? <sup>210</sup>	<ul style="list-style-type: none"> <li>- Pain, swelling, + restricted range of motion<sup>211</sup></li> <li>- Some disuse atrophy of L leg → suggests abnormality of gait + restricted use of L leg</li> </ul>	Normative; wooden grave furniture present (55.0%) → coffin
SPC-1766	AD, M	Osteophytic lipping on all present tarsals; irregularly shaped, erosive, somewhat scooped out lesions on distal + proximal ends of several R/L MTs → gout <sup>212</sup>	<ul style="list-style-type: none"> <li>- Foot pain, abnormality of gait, + periods of inability to move independently<sup>213</sup></li> </ul>	?Marginal (NW corner); normative; only skeleton below neck present
SPC-1870	25–34, M	Large, scooped-out, scalloped lesions on R/L posterior calcanei + scooped-out lesions on distal ends of R/L MTs → gout <sup>214</sup>	<ul style="list-style-type: none"> <li>- Foot pain, abnormality of gait, + periods of inability to move independently<sup>215</sup></li> </ul>	Stones included (8.8%) → stones at side of skull (6.2%); wooden grave furniture present (55.0%) → coffin
SPC-1876	16–20, F?	L tibia/fibula: hypertrophy of diaphyses + nodular PNB; same alterations but less severe on R tibia/fibula → non-specific inflammation/infection/osteitis <sup>216</sup> (lack of skull prevents investigation of leprosy or treponemal disease)	<ul style="list-style-type: none"> <li>- Pain + swelling<sup>217</sup> → possible abnormality of gait + restricted use of both legs</li> </ul>	?L side (2.3%); only skeleton below mid chest present; wooden grave furniture present (55.0%) → coffin

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
SPC-1910	45+, M	Severe hypertrophy of R tibia + grooving, eburnation, + flattening of distal articular surface; flattening of superior surface of R talus + grooving/ridging on R talar head; long exostosis from R fibula; x-ray (not available) suggested chronic osteomyelitis <sup>218</sup> → traumatic injury? non-perforating osteomyelitis? <sup>219</sup> osteitis? <sup>220</sup>	- Chronic or intermittent pain + malaise <sup>221</sup> , abnormal articulation of R ankle/foot → abnormality of gait	Contemporary horizontal multiple grave (2.6%) containing 4 other individuals with intertwined limbs (older adult male, two older children, + an adolescent)
SPC-2389	AD, M	Asymmetry in shape/size/angle of zygapophyseal joints + transverse processes of LV + ?upper TV; wedging of LV + ?upper TV bodies; R zygapophyseal joint absent on S1 → scoliosis (congenital?, idiopathic?, neuromuscular?) <sup>222</sup>	- Possible pain, restricted movement, + gait abnormality <sup>223</sup>	Normative (but R leg, L arm, upper chest + skull absent)
SPC-2427	17–25, F	Dysplasia of R femoral head, non-existent acetabulum, thinning of proximal R femoral diaphysis, + asymmetrical ankylosis of R SIJ → developmental dysplasia of the hip <sup>224</sup>	- Abnormal articulation of R hip → abnormal gait - Restricted use of R leg due to possible pain, + probably abnormality in range of motion + general functionality <sup>225</sup>	Buried on E margin; wooden grave furniture present (55.0%) → coffin
SPC-2583	45+, M	Displacement of R glenoid cavity onto anterior surface of scapula; enlargement of glenoid cavity with macroporosity; eburnated area of articulation on inferior aspect of coracoid process + eburnation on R humeral head where articulation usually would not occur → subcoracoid anterior dislocation of R humerus <sup>226</sup>	- Pain, limited use of R shoulder → reduced elevation + rotation <sup>227</sup>	Adjacent to church; wooden grave furniture present (55.0%) → coffin
SPC-2616	35–44, M	Severe OA of L elbow → flexion + partial pronation fixation (not analysed by lead author) <sup>228</sup> → primary or secondary OA <sup>229</sup>	- Pain, joint contracture/impingement, + restricted use of L forearm → difficulty performing some daily tasks <sup>230</sup>	?R side (1.8%); wooden grave furniture present (55.0%) → coffin
SPC-2799	35–44, M	Hypertrophy of R radius; hypertrophy of R tibia with occlusion of medullary cavity + extreme thinning of cortical surface → fibrous dysplasia? <sup>231</sup>	- Pain in affected areas (R forearm + lower leg) <sup>232</sup> → restricted use of R arm + R leg	Normative
SPC-2801	25–34, F	R femoral head: thick, irregular osteophytic lipping on inferior + posterior margins; eburnation, macroporosity, + furrows of bone with ridging on anterior; R acetabulum: enlargement, flattening, eburnation, macroporosity, + grooving → OA <sup>233</sup>	- When femur + acetabulum articulated → hip movement not possible in all directions - Limited range of motion, diffuse pain through groin, buttocks, knee, + shin → possible restricted use of leg <sup>234</sup>	Normative

<sup>a</sup> BLG= Black Gate; EA= Elstow Abbey; PO= Priory Orchard; RD= Raunds; SPC= St Peter's Church

<sup>b</sup> M/F (male/female); M?/F? (probable male/female); US (unsexed); AD (adult); OA (older adult)

<sup>c</sup> CV (cervical vertebrae); FNA (femoral neck angle); HOA (hypertrophic osteoarthropathy); HOE (hair-on-end); L (left); L# (lumbar vertebra #); LV (lumbar vertebrae); MC (metacarpal); MT (metatarsal); OA (osteoarthritis); PNB (periosteal new bone); R (right); RA (rheumatoid arthritis); S# (sacral vertebra #); SCFE (slipped capital femoral epiphysis); SIJ (sacroiliac joint); T# (thoracic vertebra #); TB (tuberculosis); TV (thoracic vertebrae)

<sup>d</sup> E (east); L (left); N (north); NW (northwest); R (right); S (south); SE (southeast); W (west); ? (possibly); Parenthetical percentages indicate the percent of the entire burial assemblage in which a specific funerary variable occurred.

Table 3

*Summary of the palaeopathological analysis, possible diagnoses, functional restrictions, and notable funerary treatment for the individuals with physical impairment from the Christian cemeteries (based on extant osteological analysis). NB: All diagnoses are based on previous palaeopathological analysis, but sources are included where relevant.*

SK no. <sup>a</sup>	Age/ sex <sup>b</sup>	Physical impairment + possible diagnoses <sup>c</sup>	Possible functional restrictions <sup>c</sup>	Notable funerary treatment <sup>d</sup>
<b>Cherry Hinton<sup>235</sup></b>				
CH-2012 (Grave 1)	15–25, M	Fracture of R ankle (alterations not discussed), considerable swelling of L MT1, + swelling of R MT1 + another R MT → non-suppurative osteomyelitis <sup>236</sup>	- Continuous or intermittent episodes of pain + swelling <sup>237</sup> → possible abnormality of gait	Normative body/limb positioning; feet turned inwards*; near E margin (c.3 m)
CH-2018 (Grave 3)	15–18, M	Swelling of ?R tibia/fibula + RMT1; x-ray reveals no cloacae → chronic, non-suppurative osteomyelitis <sup>238</sup>	- Continuous or intermittent episodes of pain + swelling <sup>239</sup> → possible abnormality of gait	Normative body/limb positioning; feet turned to R*; probable coffin (1.4%); near E margin (c.3.25 m)
CH-2077 (Grave 17)	45+, M	L humerus 79 mm shorter than R; flattening, dysplasia, + erosion of L humeral head + glenoid cavity → traumatic fracture of L humerus <sup>240</sup> + abnormality of L shoulder joint	- Shortening + abnormal shoulder joint → restricted use of L arm <sup>241</sup>	Normative body/limb positioning; near E margin (c.3 m)
CH-2136 (Grave 36)	45+, M	Diffuse, thick, disorganised PNB on cranial base, pelvis, distal radii, femora, tibiae, fibulae, + calcanei; focal concentrations of sclerosis in TV, LV, pelvis, femora, calcanei → metastatic carcinoma (probably of the prostate?) <sup>242</sup>	- Skull: possible bone pain, cranial nerve palsy, + headache <sup>243</sup> - Pain in lower back + legs, + functional instability <sup>244</sup> - Hypercalcemia → fatigue, deterioration of mental functioning, dysfunction of gastrointestinal, kidney, rectal, + central nervous systems <sup>245</sup> - If due to prostate → fatigue, bone/nerve pain, urinary incontinence, blood in urine, problems urinating, constipation, diarrhoea, faecal urgency/incontinence, bowel obstruction <sup>246</sup> - May have required short term external care to ensure survival <sup>247</sup>	Normative body/limb positioning; stone inclusion (3.6%); skull propped up by large stone (pillow stone= 2.9%); in SE corner (c.2.5 m from E margin of burials; c.2.25 m from probable S margin of burials)
CH-2498 (Grave 145)	45+, F	Deformation + resorption of L distal humerus + proximal ulna/radius → comminuted fracture of L elbow resulting in joint abnormality	- Abnormal L elbow joint → joint stiffness, + abnormal or restricted use of arm <sup>248</sup>	R lower arm turned inwards, R hand over pelvis*; L hand on top of pelvis* ?truncated below pelvis
CH-2506 (Grave 148)	45+, F	L femur: posterior displacement/angulation of distal end + 5 cm shortening + multiple, small cloacae within callus; considerable striated + irregular PNB on fragments of L tibia + fibula → partially healed, midshaft spiral fracture + osteomyelitis <sup>249</sup>	- Lower limb length discrepancy → abnormal gait, possibly restricted movement <sup>250</sup> - Cloacae not large (possibly mostly healed) but possibility of chronic pain + malaise <sup>251</sup> → abnormal gait	Normative body/limb positioning; c.5 m from church

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
CH-2843 (Grave 197)	45+, M	Severe deformation of R radial head with medial/posterior angulation of proximal end; abnormal articulation with distal humerus resulting in fixed pronation → fracture/dislocation of R radial head	- Abnormal R elbow joint + pronation fixation → difficulty performing everyday tasks <sup>252</sup>	Normative body/limb positioning; hand beneath pelvis*; c.5 m from church; skull, R lower leg, + feet absent
CH-3044 (Grave 229)	17–25, F	Widespread, bilateral PNB (porous + partially remodelled) in ribs, lower arms, pelvis, + legs → probable HOA <sup>253</sup> related to pulmonary or extra-pulmonary disease/condition	- Secondary HOA associated with severe internal illness (probably pulmonary) <sup>254</sup> - Deep aching or burning pain in affected areas + joint swelling <sup>255</sup> → restricted movement - Possible cutaneous involvement <sup>256</sup>	Normative body/limb positioning; lower arms turned inwards, hands crossed over pelvis*; c.2.5 m from church
CH-3208 (Grave 284)	45+, M	L tibia 60 mm shorter than R; L fibula 47 mm shorter than R → well-healed fracture of distal tibia/fibula with lateral displacement + secondary OA of ankle + patella-femoral joint	- Lower limb length discrepancy → abnormal gait (evidenced by OA of ankle) + possibly restricted movement <sup>257</sup>	c.5 m from church; R side of skeleton truncated (body/limb positioning not available)
CH-3270 (Grave 305)	35–45, M	Severe dysplasia + flattening of R/L humeral heads + glenoid fossae; considerable shortening of R/L humeri (humerus length → R: 243 mm; L: 200 mm); varus deformity of R/L femoral necks with mushroom appearance of R/L femoral heads + osteophytosis, eburnation, + porosity; extant R acetabulum is shallow, dysplastic, with eburnation + pitting; absence of kyphosis or lordosis in spine → probable multiple epiphyseal dysplasia <sup>258</sup>	- Pain <sup>259</sup> - Abnormalities of both shoulder joints + limb shortening → pain, limited joint use <sup>260</sup> , + restricted use of arms - Abnormalities of both hip joints → abnormal gait +/or restricted lower limb use <sup>261</sup>	Stone inclusion (3.6%) → classified as 'pillow grave' (2.9%), 6 stones identified as small finds but arrangement unclear; normative body/limb positioning; R arm ?extended, slightly behind pelvis*; legs classified as 'together'*; c.3.5 m from church
CH-3956 (Grave 50)	25–35, F	Collapse/destruction of L2–3 + associated ankylosis of L1–4 with >90° kyphosis → TB <sup>262</sup>	- Gibbus deformity - Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait <sup>263</sup> - General symptoms of TB: weakness, fatigue, weight loss, + fever <sup>264</sup>	c.2.25 m from church; no body or leg position available but arms extended*; legs truncated just below pelvis
CH-4195 (Grave 591)	35–45, F	Severe destruction of T11 + ankylosis of T10–11, T12–L1 with 90° kyphosis → TB <sup>265</sup>	- Gibbus deformity - Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait <sup>266</sup> - General symptoms of TB: weakness, fatigue, weight loss, + fever <sup>267</sup>	Normative body/limb positioning; c.3 m from church (exact location not shown on map)

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
CH-4307 (Grave 625)	8-10, US	Smooth, rounded cavity within L hard palate; abnormal positioning of first + second lateral maxillary incisors + socket for L canine merges with cavity; considerable asymmetry of L facial bones (maxilla, zygomatic, nasal septum) with supero-inferior shortening of L maxilla; hooked bony protrusion from L zygomatic extending inferiorly + medially → possible dentigerous cyst <sup>268</sup>	- Cyst itself probably benign but would have resulted in pain if infected + facial asymmetry <sup>269</sup> that was probably noticeable in most interactions	Normative body/limb positioning
CH-4337 (Grave 635)	10-12, US	Destruction + collapse of T11-12 + ankylosis of T10-L1 with >90° kyphosis → TB <sup>270</sup>	- Gibbus deformity - Disruption of spinal cord → possible paraparesis/paraplegia, urinary/anal incontinence, pain, sensory impairment, + abnormal gait <sup>271</sup> - General symptoms of TB: weakness, fatigue, weight loss, + fever <sup>272</sup>	Normative body/limb positioning (R leg displaced over L*)
CH-4411 (Grave 660)	45+, F	Large spherical mass attached to postero-medial surface of proximal R humerus + 2 smaller masses of dense bone with irregular 'walnut' appearance <sup>273</sup> ; postero-medial displacement of R humeral head; spiculated, reactive bone growth on proximal diaphysis → parosteal osteosarcoma <sup>274</sup>	- Probable restricted of movement of R shoulder <sup>275</sup> → abnormal or restricted arm movement - Pain associated with large mass <sup>276</sup>	Normative body/limb positioning but L arm + leg truncated
* Extra descriptions added by excavator, but percentage cannot be calculated as recording was not consistent. Most of these hand/arm/feet positions were probably normative.				
Jarrow <sup>277</sup>				
JA-69/15	55-75, M	Angulation + significant medial rotation of distal L femur; abnormal bowing of R/L ulnae, radii, tibiae, R femur, + L humerus; thickening of skull → probable Paget's Disease with pathological midshaft fracture of L femur <sup>278</sup>	- Limb abnormalities + fracture of L femur → gait/movement abnormalities <sup>279</sup> - Pain of affected elements <sup>280</sup>	Away from main burial concentration (c.3 m, c.4.5 m, c.5.75 m from nearest burials to the N, W, + S respectively), marginal status cannot be confirmed
JA-70/140	42-48, M	Extra articulation for R humeral head on anterior aspect of R scapula → chronic anterior dislocation of shoulder <sup>281</sup>	- Pain, limited use of R shoulder → reduced elevation + rotation <sup>282</sup>	Normative (no body position data); within main burial concentration
Monkwearmouth <sup>283</sup>				
MK-66/12	55-70, M	Inferior displacement of R humeral head with flattening, eburnation, + porosity + corresponding deformation of R glenoid cavity → slipped proximal epiphysis? trauma? severe OA changes?	- Abnormality of R shoulder joint → restricted use <sup>284</sup> + abnormal movement of R arm	Stone inclusion (16.5%) → stones by side; coffin nail (11.7%) = probable coffin (17.5%)
MK-66/20	20-23, M	Hypertrophy of proximal + distal L tibia; deformation + hypertrophy of distal L fibula; smooth, rounded cloaca on lateral aspect of distal L fibula → osteomyelitis <sup>285</sup>	- Pain, tenderness, + chronic/intermittent drainage of fistulae <sup>286</sup> - Probable abnormal gait	Double grave with 66/21

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
MK-66/31	50-65, M	<u>Fracture of R pelvis</u> : overall deformation in shape of ilium; severe fracture and partial dislocation (in superior direction) of lateral aspect of ilium; evidence for a sinus; deformation of GSN; callus formation inferoanterior to GSN; fracture line runs through acetabulum; possible fracture/displacement of R sacral ala <u>Fracture of L femur</u> : 38.5 mm shorter than R + posterior angulation of distal end → likely traumatic incident that resulted in fracture + healing of R pelvis + L femur	<ul style="list-style-type: none"> <li>- L side lower limb length discrepancy → abnormal gait + restricted movement<sup>287</sup></li> <li>- Due to deformation of pelvis, likely that R hip was in abnormal articulation → abnormal gait + restricted movement<sup>288</sup></li> </ul>	Coffin nails (11.7%) = probable coffin (17.5%)
MK-66/59	24-28, M	Hypertrophy of distal R tibia + small cloaca at distal end → osteomyelitis <sup>289</sup> (possibly result of fracture)	<ul style="list-style-type: none"> <li>- Pain, tenderness, + chronic/intermittent drainage of fistulae<sup>290</sup></li> <li>- Probable abnormal gait</li> </ul>	Coffin nail (11.7%) = probable coffin (17.5%)
MK-69/18	50-75, M?	Periostitis + thickening of R/L tibiae/fibulae; atrophy of distal manual phalanx + ankylosis/angulation of proximal + intermediate phalanges of first digit of R foot → probable lepromatous leprosy <sup>291</sup>	<ul style="list-style-type: none"> <li>- Possible hand deformity<sup>292</sup> → restricted use</li> <li>- Pain, loss of sensation in extremities, muscular paralysis, possible infection of foot via plantar ulcer, + difficulty with some activities involving feet<sup>293</sup></li> <li>- Possible: skin lesions, hair loss, lagophthalmos, + blindness<sup>294</sup></li> </ul>	Prone (8.1%); stone inclusion (16.5%) → feet on or below stones
North Elmham <sup>295</sup>				
NE-2	30-50, F	L humerus much thinner than R + gracility of L ulna fragment; poor preservation of distal L humerus + proximal L ulna → some form of paralysis (stroke? brachial plexus palsy? monomelic amyotrophy? direct trauma? neuromuscular disease?) <sup>296</sup> or septic arthritis <sup>297</sup>	<ul style="list-style-type: none"> <li>- Underdevelopment/weakness of the L arm + abnormality of L elbow joint → abnormal +/or restricted movement of L upper limb possible<sup>298</sup></li> </ul>	Near boundary ditch (c.1.5 m)
NE-10	Adult, M	Jagged osteophytosis + numerous sinuses within proximal end of L tibia; similar involvement of proximal L fibula, L patella, + L femoral condyles; osteitis of L tibial + fibular diaphyses → tuberculous arthritis <sup>299</sup> septic arthritis <sup>300</sup>	<ul style="list-style-type: none"> <li>- Swollen, hot, + painful knee<sup>301</sup> → abnormal gait + restricted use of L leg</li> </ul>	Beyond boundary ditch; only individual with head to the E
NE-26	Adult, M	Complete ankylosis of bodies of T5-L5 + some ankylosis through neural arches; complete ankylosis of at least seven ribs to TV → ankylosing spondylitis <sup>302</sup>	<ul style="list-style-type: none"> <li>- Stiffness, pain in back, pain radiating to lower limbs, tenderness, fatigue, restricted movement, + limited chest expansion<sup>303</sup></li> </ul>	Near boundary ditch (c.2 m)
NE-74A	35-40, F	Cloaca surrounded by periostitis on superior aspect of lateral end of R clavicle; large, single cloaca on proximal half of L fibula (apparently also present on L tibia) → osteomyelitis <sup>304</sup>	<ul style="list-style-type: none"> <li>- Pain, tenderness, + chronic/intermittent drainage of fistulae<sup>305</sup></li> <li>- Probable abnormal gait (L leg) + possibly restricted use of R arm</li> </ul>	Normative

SK no. <sup>a</sup> (continued)	Age/ sex <sup>b</sup> (continued)	Physical impairment + possible diagnoses <sup>c</sup> (continued)	Possible functional restrictions <sup>c</sup> (continued)	Notable funerary treatment <sup>d</sup> (continued)
NE-176	30-40, M	L radius is 38.7 mm shorter than R + much more gracile; proximal L ulna much more gracile than proximal R ulna → some form of paralysis (stroke? brachial plexus palsy? monomelic amyotrophy? direct trauma? neuromuscular disease?) <sup>306</sup>	- Underdevelopment/weakness of the L forearm → abnormal +/- or restricted movement of L upper limb possible	Not marginal, but not in central burial cluster
NE-197	30-35, F	L femoral circumference is 28.5 mm thicker than R → x-ray suggests chronic, non-perforating osteomyelitis? <sup>307</sup>	- Continuous or intermittent episodes of pain + swelling <sup>308</sup> → possible abnormality of gait	Not marginal, but not in central burial cluster

<sup>1</sup> CH= Cherry Hinton; JA= Jarrow; MK= Monkwearmouth; NE= North Elmham

<sup>2</sup> M/F (male/female); M?/F? (probable male/female); US (unsexed); AD (adult)

<sup>3</sup> GSN (greater sciatic notch); HOA (hypertrophic osteoarthropathy); L (left); L# (lumbar vertebra #); LV (lumbar vertebrae); MT (metatarsal); OA (osteoarthritis); PNB (periosteal new bone); R (right); T# (thoracic vertebra #); TB (tuberculosis); TV (thoracic vertebrae)

<sup>4</sup> E (east); L (left); N (north); R (right); S (south); SE (southeast); W (west); Parenthetical percentages indicate the percent of the entire burial assemblage in which a specific funerary variable occurred.

# Endnotes

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- <sup>1</sup> Down and Welch (1990)
- <sup>2</sup> Harris and Kirkaldy-Willis (1965); Lehovsky (1999); Resnick (2002); Ortner (2003, 233–4); Spekker *et al.* (2018)
- <sup>3</sup> Lehovsky (1999); Resnick (2002); Zimmerli (2010)
- <sup>4</sup> Hopewell (1994)
- <sup>5</sup> Resnick (2002)
- <sup>6</sup> AlQahtani *et al.* (2010)
- <sup>7</sup> Scheuer and Black (2000)
- <sup>8</sup> Selection of sources: Weinstein *et al.* (1952); Stallings *et al.* (1993); Ihkkan and Yalçin (2001); Morell *et al.* (2002); Resnick (2002); Sussman (2002); Rodrigues dos Santos *et al.* (2003); Shevell *et al.* (2003); Biggar (2006); Krigger (2006); Novak *et al.* (2012, e1285); Mughal (2014); Shah (2015); Armour *et al.* (2016)
- <sup>9</sup> Blanes *et al.* (2009)
- <sup>10</sup> Fink (2003); Krigger (2006); Nardes *et al.* (2012)
- <sup>11</sup> Bohling (2020, Section 10.2)
- <sup>12</sup> Waldron (2009, 33–34)
- <sup>13</sup> Lloyd-Roberts (1953); Jeffery (1975)
- <sup>14</sup> Doherty *et al.* (2005)
- <sup>15</sup> Hackett (1981); Aufderheide and Rodríguez-Martín (1998, 156, 160); Resnick (2002); Ortner (2003, 286, 274); Cole and Waldron (2010)
- <sup>16</sup> Ali *et al.* (1980); Pineda *et al.* (1987); Mays and Taylor (2002); Ortner (2003, 354–7); See the following research for examples of HOA in archaeological skeletons: Martínez-Lavín *et al.* (1994); Assis *et al.* (2011); González-Reimers *et al.* (2011); Masson *et al.* (2013); Binder and Saad (2017); Flohr *et al.* (2018)
- <sup>17</sup> Kent and Romanelli (2008, 228); Resnick (2002); Farnsworth and Rosen (2006)
- <sup>18</sup> Golding (1985); Martínez-Lavín (1997); Resnick (2002); Nahar *et al.* (2007); Yap *et al.* (2017)
- <sup>19</sup> Boyle *et al.* (1998; 2011)
- <sup>20</sup> Resnick (2002)
- <sup>21</sup> Resnick (2002); Roberts *et al.* (2014, 958)
- <sup>22</sup> Poigenfürst (1986)
- <sup>23</sup> Balle *et al.* (1982); Rončević (1983); Kovács and Ghahremani (2001)
- <sup>24</sup> DeKosky *et al.* (2010)
- <sup>25</sup> Roberts *et al.* (1998); Resnick (2002); Ortner (2003, 230–1); Canci *et al.* (2005); Waldron (2009, 95); Holloway *et al.* (2011)
- <sup>26</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)
- <sup>27</sup> Leung (1999)
- <sup>28</sup> Hopewell (1994)
- <sup>29</sup> Baxter and Wiley (1986); Steele and Graham (1992); Resnick (2002); Resnick and Goergen (2002)
- <sup>30</sup> Ingram (1991); Unger *et al.* (2008)
- <sup>31</sup> Henrikson (1969); Ingram (1991); Zyto *et al.* (1995); Unger *et al.* (2008)
- <sup>32</sup> Malim and Hines (1998)
- <sup>33</sup> Møller-Christensen (1961); Andersen and Manchester (1992); Lewis *et al.* (1995); Roberts and Manchester (2010, 197); confirmed via aDNA analysis by Pfrengle *et al.* (2021)
- <sup>34</sup> Andersen and Manchester (1992)
- <sup>35</sup> Golding (1985); Resnick (2002); Roberts and Manchester (2010, 197); Slim *et al.* (2011); Roberts (2020, Chapter 2).
- <sup>36</sup> Anon (2009); Roberts (2020, Chapter 2)
- <sup>37</sup> Highland and LaMont (1983); Golding (1985); Davidson *et al.* (2003)
- <sup>38</sup> Steinbock (1976, 385); Strouhal (1991); Duhig *et al.* (1996); Resnick (2002); Marks and Hamilton (2007); See the following research for examples of metastatic carcinoma in archaeological skeletons: Šefčáková *et al.* (2001); Assis and Codinha (2010); Binder *et al.* (2014); Lieverse *et al.* (2014); Ghabili *et al.* (2016)
- <sup>39</sup> Stark *et al.* (2003); Coleman (2006)
- <sup>40</sup> Resnick (2002); Coleman (2006)
- <sup>41</sup> Coleman (2001; 2006); Selvaggi and Scagliotti (2005)
- <sup>42</sup> Bohling (2020, Section 10.2)
- <sup>43</sup> Shanley (1995); Rajasekaran *et al.* (1998); Resnick (2002)
- <sup>44</sup> Rajasekaran *et al.* (1998)
- <sup>45</sup> Hopewell (1994)
- <sup>46</sup> Resnick (2002); Ortner (2003, 222); Waldron (2009, 33–34)
- <sup>47</sup> Simmons *et al.* (1983)
- <sup>48</sup> Hawkes and Grainger (2006)
- <sup>49</sup> Resnick (2002)
- <sup>50</sup> Simmons *et al.* (1983); Hankins *et al.* (2006)
- <sup>51</sup> Sherlock and Welch (1992)
- <sup>52</sup> Resnick (2002)
- <sup>53</sup> Khamis and Carmeli (2017)
- <sup>54</sup> Forsyth and Seaman (2015); Doherty and Greatorex (2016)
- <sup>55</sup> Barber (1929; 1934); See following research for examples of forearm amputation in archaeological skeletons: Bloom *et al.* (1995); Mays (1996)
- <sup>56</sup> Østlie *et al.* (2011)
- <sup>57</sup> Mays (1996); Kirkup (2007, 158)
- <sup>58</sup> Resnick (2002)
- <sup>59</sup> Ortner (2003, 54–5)
- <sup>60</sup> Waldron (2009, 33–4)
- <sup>61</sup> Resnick (2002)

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- <sup>62</sup> Doherty and Gretores (2016, 37)
- <sup>63</sup> Møller-Christensen (1961); Andersen and Manchester (1992); Lewis *et al.* (1995); Resnick (2002); Roberts and Manchester (2010, 197)
- <sup>64</sup> Andersen and Manchester (1992)
- <sup>65</sup> Resnick (2002); Roberts (2020, Chapter 2)
- <sup>66</sup> Golding (1985); Resnick (2002); Roberts and Manchester (2010, 197); Slim *et al.* (2011); Roberts (2020, Chapter 2)
- <sup>67</sup> Anon (2009); Roberts (2020, Chapter 2)
- <sup>68</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 95); Holloway *et al.* (2011)
- <sup>69</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)
- <sup>70</sup> Hopewell (1994)
- <sup>71</sup> Scull *et al.* (1992)
- <sup>72</sup> Baxter and Wiley (1986); Resnick (2002); Resnick and Goergen (2002)
- <sup>73</sup> Baxter and Wiley (1986); Zyto *et al.* (1995)
- <sup>74</sup> Resnick (2002); Mellema *et al.* (2016)
- <sup>75</sup> Bishop and Mordan (nd)
- <sup>76</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 95); Holloway *et al.* (2011)
- <sup>77</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)
- <sup>78</sup> Hopewell (1994)
- <sup>79</sup> Selection of sources: Weinstein *et al.* (1952); Minear (1956); Stallings *et al.* (1993); Ihkkan and Yalçin (2001); Morell *et al.* (2002); Resnick (2002); Sussman (2002); Rodrigues dos Santos *et al.* (2003); Shevell *et al.* (2003); Biggar (2006); Jan (2006); Krigger (2006); Novak *et al.* (2012, e1285); Mughal (2014); Shah (2015); Armour *et al.* (2016)
- <sup>80</sup> Blanes *et al.* (2009)
- <sup>81</sup> Fink (2003); Krigger (2006); Nardes *et al.* (2012)
- <sup>82</sup> Bohling (2020, Section 10.2)
- <sup>83</sup> Resnick (2002); Ortner (2003, 199)
- <sup>84</sup> Waldvogel *et al.* (1970); Lerner *et al.* (1993); Lew and Waldvogel (2004); Haztenbuehler and Pulling (2011); Baldan *et al.* (2014); Lima *et al.* (2014); Panteli and Giannoudis (2017)
- <sup>85</sup> Selected sources: Weinstein *et al.* (1952); Kattan and Spitz (1968); Singh *et al.* (1980); Parker *et al.* (1986); Hirayama *et al.* (1987); Waters *et al.* (1998); Broeks *et al.* (1999); Resnick (2002); Gordon *et al.* (2004); Talbot (2004); Jan (2006); Shah (2015); Armour *et al.* (2016)
- <sup>86</sup> Broeks *et al.* (1999); Gourie-Devi and Nalini (2003); Nalini *et al.* (2014)
- <sup>87</sup> Resnick (2002)
- <sup>88</sup> Simmons *et al.* (1983)
- <sup>89</sup> Simmons *et al.* (1983); Hankins *et al.* (2006)
- <sup>90</sup> Ali *et al.* (1980); Pineda *et al.* (1987); Mays and Taylor (2002); Ortner (2003, 354–7); See the following research for examples of HOA in archaeological skeletons: Martínez-Lavín *et al.* (1994); Assis *et al.* (2011); González-Reimers *et al.* (2011); Masson *et al.* (2013); Binder and Saad (2017); Flohr *et al.* (2018)
- <sup>91</sup> Martínez-Lavín (1997); Yap *et al.* (2017)
- <sup>92</sup> Golding (1985); Martínez-Lavín (1997); Resnick (2002); Nahar *et al.* (2007); Yap *et al.* (2017)
- <sup>93</sup> Yap *et al.* (2017)
- <sup>94</sup> Hawkes and Grainger (2003)
- <sup>95</sup> Denis (1983)
- <sup>96</sup> Takemitsu (1988); Roussouly and Nnadi (2010); Lee *et al.* (2017)
- <sup>97</sup> Bohling (2020, Section 7.10.4.2)
- <sup>98</sup> Resnick (2002)
- <sup>99</sup> Högstrom *et al.* (1976)
- <sup>100</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 95); Holloway *et al.* (2011)
- <sup>101</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)
- <sup>102</sup> Hopewell (1994)
- <sup>103</sup> Selected sources: Weinstein *et al.* (1952); Kattan and Spitz (1968); Singh *et al.* (1980); Parker *et al.* (1986); Hirayama *et al.* (1987); Waters *et al.* (1998); Broeks *et al.* (1999); Resnick (2002); Gordon *et al.* (2004); Talbot (2004); Jan (2006); Shah (2015); Armour *et al.* (2016)
- <sup>104</sup> Broeks *et al.* (1999); Gourie-Devi and Nalini (2003); Nalini *et al.* (2014)
- <sup>105</sup> Ashman *et al.* (2001); Boffeli *et al.* (2015)
- <sup>106</sup> Tennvall and Apelqvist (2000); Ashman *et al.* (2001); Price (2004)
- <sup>107</sup> ARCUS (1996); Nolan *et al.* (2010); Swales (2012)
- <sup>108</sup> Andersen and Manchester (1987)
- <sup>109</sup> Ortner (2003, 466–7); Waldron (2009, 216)
- <sup>110</sup> Resnick (2002)
- <sup>111</sup> Bohne and Root (1977); Achterman and Kalamachi (1979); Resnick (2002)
- <sup>112</sup> Resnick (2002); Kernbach and Blitz (2008)
- <sup>113</sup> Selected sources: Colonna and Saal (1941); Weinstein *et al.* (1952); Minear (1956); Ratliff (1959); Madigan and Wallace (1981); Zancolli *et al.* (1983); Fulford (1990); Tonkin and Gschwind (1992); Cornell (1995); Emery (2002); Ozonoff (2002); Resnick (2002); Sussman (2002); Shevell *et al.* (2003); Sees and Miller (2013); Shah (2015); Armour *et al.* (2016)
- <sup>114</sup> Zancolli *et al.* (1983); Tonkin and Gschwind (1992)
- <sup>115</sup> Giakas *et al.* (1996); Ozonoff (2002); Aebi (2005); Mahaudens *et al.* (2005); Smith *et al.* (2008); Syczewska *et al.* (2012)
- <sup>116</sup> Herd *et al.* (2004)
- <sup>117</sup> Fink (2003); Krigger (2006); Young *et al.* (2008); Nardes *et al.* (2012); Novak *et al.* (2012)
- <sup>118</sup> Cummings and Rega (2008)
- <sup>119</sup> Resnick (2002)
- <sup>120</sup> Fagg (1988); Schmidt-Rohlfing *et al.* (2001); Zebala *et al.* (2007)
- <sup>121</sup> Resnick (2002)
- <sup>122</sup> Baker (2014; 2016); unpublished archive held by David Baker
- <sup>123</sup> Resnick (2002); Ortner (2003, 199)
- <sup>124</sup> Waldvogel *et al.* (1970); Lerner *et al.* (1993); Lew and Waldvogel (2004); Haztenbuehler and Pulling (2011); Baldan *et al.* (2014); Lima *et al.* (2014); Panteli and Giannoudis (2017)

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- <sup>125</sup> Cohn (1942); Resnick (2002)
- <sup>126</sup> Soni *et al.* (2019)
- <sup>127</sup> Simmons *et al.* (1983)
- <sup>128</sup> Lehovsky (1999); Resnick (2002)
- <sup>129</sup> Takemitsu (1988); Roussouly and Nnadi (2010); Lee *et al.* (2017)
- <sup>130</sup> Lehovsky (1999); Resnick (2002); Zimmerli (2010)
- <sup>131</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 95); Holloway *et al.* (2011)
- <sup>132</sup> Ali *et al.* (1980); Pineda *et al.* (1987); Mays and Taylor (2002); Ortner (2003, 354–7); See the following research for examples of HOA in archaeological skeletons: Martínez-Lavín *et al.* (1994); Assis *et al.* (2011); González-Reimers *et al.* (2011); Masson *et al.* (2013); Binder and Saad (2017); Flohr *et al.* (2018)
- <sup>133</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)
- <sup>134</sup> Hopewell (1994)
- <sup>135</sup> Leung (1999)
- <sup>136</sup> Golding (1985); Martínez-Lavín (1997); Resnick (2002); Nahar *et al.* (2007); Yap *et al.* (2017)
- <sup>137</sup> Resnick (2002)
- <sup>138</sup> Ward (1999); Resnick (2002); Bostan *et al.* (2003)
- <sup>139</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 95); Holloway *et al.* (2011)
- <sup>140</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)
- <sup>141</sup> Hopewell (1994)
- <sup>142</sup> Randall (2014; 2016)
- <sup>143</sup> Resnick (2002); Loizou *et al.* (2010)
- <sup>144</sup> Khamis and Carmeli (2017)
- <sup>145</sup> Aufderheide and Rodríguez Martín (1998, 390–1); Resnick (2002)
- <sup>146</sup> Murphy *et al.* (1982); Cisneros *et al.* (1985); Capanna *et al.* (1986); Resnick (2002)
- <sup>147</sup> Kim *et al.* (1999); Resnick (2002); Malaviya and Kotwal (2003); Ortner (2003, 222)
- <sup>148</sup> Kim *et al.* (1999); Resnick (2002); Malaviya and Kotwal (2003); Ortner (2003, 222)
- <sup>149</sup> Klatt and Stevens (2008)
- <sup>150</sup> Kundel *et al.* (1996); Mellema *et al.* (2016)
- <sup>151</sup> Boddington (1996), Craig (2006)
- <sup>152</sup> Møller-Christensen (1961); Andersen and Manchester (1992); Lewis *et al.* (1995); Roberts and Manchester (2010, 197)
- <sup>153</sup> Ortner (2003, 54–5)
- <sup>154</sup> Andersen and Manchester (1992)
- <sup>155</sup> Golding (1985); Resnick (2002); Roberts and Manchester (2010, 197); Slim *et al.* (2011); Roberts (2020, Chapter 2)
- <sup>156</sup> Anon (2009); Roberts (2020, Chapter 2)
- <sup>157</sup> Baxter and Wiley (1986); Resnick (2002); Resnick and Goergen (2002)
- <sup>158</sup> Ortner (2003, 347); Ponce and Novellino (2014)
- <sup>159</sup> Baxter and Wiley (1986); Zyto *et al.* (1995)
- <sup>160</sup> Boyer *et al.* (1981); Ordeberg *et al.* (1984); Carney and Weinstein (1996)
- <sup>161</sup> Resnick (2002); Malaviya and Kotwal (2003); Ortner (2003, 222)
- <sup>162</sup> Resnick (2002); Malaviya and Kotwal (2003); Ortner (2003, 222)
- <sup>163</sup> Goldenberg (1998); Malaviya and Kotwal (2003)
- <sup>164</sup> Baxter and Wiley (1986); Resnick (2002); Resnick and Goergen (2002)
- <sup>165</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 93–5); Spekter *et al.* (2018)
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- <sup>167</sup> Weinstein *et al.* (1952); Ratliff (1959); Faraj (2006)
- <sup>168</sup> Kim *et al.* (1999); Resnick (2002); Malaviya and Kotwal (2003); Ortner (2003, 222)
- <sup>169</sup> Kim *et al.* (1999); Resnick (2002); Malaviya and Kotwal (2003); Ortner (2003, 222)
- <sup>170</sup> Baxter and Wiley (1986); Zyto *et al.* (1995)
- <sup>171</sup> Leung (1999)
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- <sup>173</sup> Goldenberg (1998); Malaviya and Kotwal (2003)
- <sup>174</sup> Klatt and Stevens (2008); Khamis and Carmeli (2017)
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- <sup>178</sup> Stark *et al.* (2003); Coleman (2006)
- <sup>179</sup> Resnick (2002); Coleman (2006)
- <sup>180</sup> Coleman (2001; 2006); Selvaggi and Scagliotti (2005)
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- <sup>182</sup> Resnick (2002); Ortner (2003, 571)
- <sup>183</sup> Resnick (2002)
- <sup>184</sup> Takakura *et al.* (1991); Wilde *et al.* (1994); Lemley *et al.* (2006)
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- <sup>192</sup> Bohling (2020, Section 10.2)  
<sup>193</sup> Resnick (2002); Leden *et al.* (2012)  
<sup>194</sup> Resnick (2002); Ortner (2003, 132, 222)  
<sup>195</sup> Kacki *et al.* (2013)  
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<sup>197</sup> Shichikawa *et al.* (1978); Bywaters (1981); Resnick (2002)  
<sup>198</sup> Aufderheide and Rodríguez-Martín (1998, 84); Resnick (2002); Ortner (2003, 346); Berger *et al.* (2017)  
<sup>199</sup> Ortner (2003, 347); Ponce and Novellino (2014)  
<sup>200</sup> Terzis and Barm pitsioti (2009)  
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<sup>202</sup> Simmons *et al.* (1983)  
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<sup>206</sup> Martínez-Lavín (1997); Yap *et al.* (2017)  
<sup>207</sup> Golding (1985); Martínez-Lavín (1997); Resnick (2002); Nahar *et al.* (2007); Yap *et al.* (2017)  
<sup>208</sup> Yap *et al.* (2017)  
<sup>209</sup> Aufderheide and Rodríguez-Martín (1998, 390); Resnick (2002)  
<sup>210</sup> Resnick (2002)  
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<sup>213</sup> German and Holmes (1986); Lindsay *et al.* (2011); Rome *et al.* (2012)  
<sup>214</sup> Resnick (2002); de Ávila Fernandes *et al.* (2010); Dalbeth *et al.* (2013)  
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<sup>216</sup> Ortner (2003, 54–5)  
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<sup>219</sup> Aufderheide and Rodríguez-Martín (1998, 178); Ortner (2003, 185)  
<sup>220</sup> Ortner (2003, 54–5)  
<sup>221</sup> Waldvogel *et al.* (1970); Collert and Isacson (1982); Kadish *et al.* (1982); Lerner *et al.* (1993); Lew and Waldvogel (2004); Haztenbuehler and Pulling (2011); Baldan *et al.* (2014); Lima *et al.* (2014); Panteli and Giannoudis (2017)  
<sup>222</sup> Ozonoff (2002); Giampietro *et al.* (2003)  
<sup>223</sup> Berven *et al.* (2003)  
<sup>224</sup> Dwek *et al.* (2002); Mitchell and Redfern (2008)  
<sup>225</sup> Crowe *et al.* (1979)  
<sup>226</sup> Flatow *et al.* (1993); Resnick (2002)  
<sup>227</sup> Rowe and Zairns (1982); Flatow *et al.* (1993)  
<sup>228</sup> See unpublished osteological archive provided by Tony Waldron and English Heritage Trust  
<sup>229</sup> Resnick (2002); Waldron (2009, 33–34)  
<sup>230</sup> Simmons *et al.* (1983); Adams *et al.* (2008)  
<sup>231</sup> Stewart *et al.* (1962); Kransforf *et al.* (1990); Feldman (2002); Ortner (2003, 443); Mohan *et al.* (2011)  
<sup>232</sup> Mohan *et al.* (2011)  
<sup>233</sup> Waldron (2009, 33–34)  
<sup>234</sup> Resnick (2002); Doherty *et al.* (2005); Holla *et al.* (2011)  
<sup>235</sup> McDonald and Doel (2000); Ferrante di Ruffano and Waldron (2006)  
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<sup>244</sup> Resnick (2002); Coleman (2006)  
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<sup>249</sup> Resnick (2002); Ortner (2003, 199)  
<sup>250</sup> Khamis and Carmeli (2017)  
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<sup>252</sup> Simmons *et al.* (1983); Hankins *et al.* (2006); Mellema *et al.* (2016)  
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<sup>254</sup> Martínez-Lavín (1997); Yap *et al.* (2017)  
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<sup>259</sup> Briggs *et al.* (2003 [updated 2019]); Bajuifer and Letts (2005)  
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<sup>262</sup> Resnick (2002); Ortner (2003, 230–1); Waldron (2009, 95); Holloway *et al.* (2011)  
<sup>263</sup> Turgut (2001); Resnick (2002); Roberts and Buikstra (2003, 95); Owolabi *et al.* (2010)  
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<sup>267</sup> Hopewell (1994)  
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<sup>269</sup> Neville *et al.* (2016); Önay *et al.* (2019)  
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<sup>273</sup> Ferrante di Ruffano and Waldron (2006, 123)  
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<sup>275</sup> Campanacci *et al.* (1984); Hang and Chih-Hseuh (2014)  
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<sup>277</sup> Anderson *et al.* (2006); Cramp (2005a; 2005b)  
<sup>278</sup> Wells and Woodhouse (1975); Ortner (2003, 435–43); Bone (2006); Langston *et al.* (2007)  
<sup>279</sup> Bone (2006); Wermers *et al.* (2008)  
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<sup>282</sup> Rowe and Zairns (1982); Flatow *et al.* (1993)  
<sup>283</sup> Cramp (2005a; 2005b); Anderson *et al.* (2006)  
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<sup>291</sup> Møller-Christensen (1961); Lewis *et al.* (1995); Resnick (2002)  
<sup>292</sup> Resnick (2002); Roberts (2020, Chapter 2)  
<sup>293</sup> Golding (1985); Resnick (2002); Roberts and Manchester (2010, 197); Slim *et al.* (2011); Roberts (2020, Chapter 2)  
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<sup>295</sup> Wade-Martins (1980); Wells and Clayton (1980)  
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<sup>297</sup> Resnick (2002); Ortner (2003, 132, 222)  
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