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Palaeodemography and palaeopathology of Khartoum Mesolithic skeletal remains from Jebel Sabaloka in central Sudan: first insights from the site of Sphinx

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Abstract: The site of Sphinx (SBK.W-60), located about 80 km north of Khartoum in the western part of Jebel Sabaloka, has been investigated since 2011 by the Charles University Sabaloka Expedition. Eleven trenches contained settlement deposits relating to occupation by hunter-fisher-gatherers of the Khartoum Mesolithic (or the Early Khartoum culture) dated at the site between 8750 and 4750 cal BC. In addition, five of the trenches yielded also human skeletal remains in primary and secondary deposits, with the minimal number of individuals estimated following anthropological standards at 45 individuals. The demographic structure of the burial site shows no selection based on sex, but immature individuals, especially those under the age of one year, seem to be markedly underrepresented, which is not unusual in pre-Neolithic funeral assemblages. Dental diseases, especially periapical lesions and inflammatory changes, predominate at Sphinx; however, a very low incidence of dental caries was recorded. Healed traumatic lesions or fractures possibly of accidental origin occurred in only six individuals. One identified case of perimortem trauma on the right scapula indicates an act of inter-personal violence. Nevertheless, it is possible to perceive the population buried at Sphinx as relatively healthy and peaceful.

Keywords: Africa; Sudan; Nile Valley; early Holocene; Early Khartoum culture; Mesolithic; hunter-gatherers; human burials; health state; palaeodemography; palaeopathology

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Introduction

Study of age-at-death and sex distribution within a burial site as well as health state of buried individuals provides essential data for understanding the ways and conditions of life of past populations. The further back one usually goes in time, however, the smaller is the

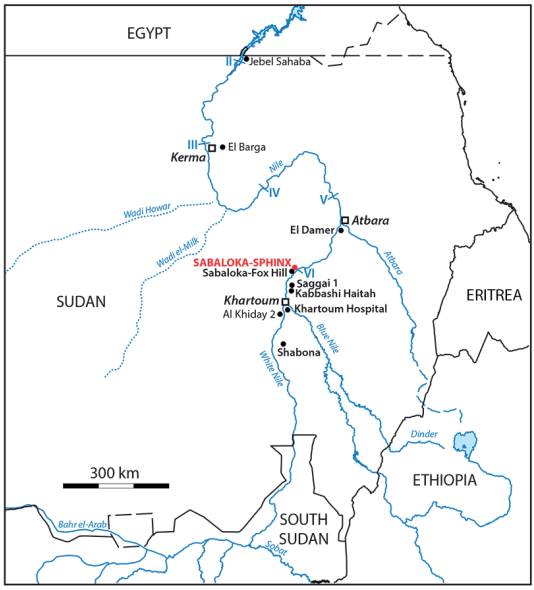

Fig. 1. Map of greater part of today's Republic of the Sudan with marked location of the site of Sphinx in Jebel Sabaloka (in red) and other locations discussed in the paper. Bold type refers to Early Khartoum sites. Roman numerals refer to the Nile cataracts. Compiled by L. Varadzinová.

number and the size of burial assemblages available for this type of study. This is also the case of the early Holocene central Sudan, where seven sites with remains of more than two individuals dated to the Khartoum Mesolithic (or the Early Khartoum culture) have been recorded since late 1940s (Fig. 1), but only rarely studied from the point of view of sex and age-at-death estimation and health state due to the state of preservation of the remains (e.g., Khartoum Hospital – Arkell 1949) or other reasons (e.g., Kabbashi Haitah – Caneva & di Lernia 1996; El Damer – Haaland 1993; Fox Hill – Varadzinová & Varadzin 2020; Varadzinová et al. 2022b). Thus, the anthropologically processed and published human skeletal assemblages from the Khartoum Mesolithic burial sites in central Sudan have included until now one from the site of Shabona on the White Nile (Clark 1989) and one from the site of Saggai 1 in the Khartoum Province (Coppa & Macchiarelli 1983), with each containing less than ten individuals. The situation is slightly better at other two recently excavated geographically or chronologically close funerary assemblages from the Nile Valley in the Sudan (Fig. 1) for which preliminary information on age-at-death and sex distribution and health state has been published: Al Khiday 2 on the Lower White Nile, where 85 individuals assigned to a pre-Mesolithic period (before 6700 cal BC; Salvatori 2012, Usai et al. 2010) have been assessed from the point of view of bioarchaeology (Jakob 2014), and El-Barga (46 individuals) dated to the Mesolithic period, but located outside the Early Khartoum province in the area of the Third Nile Cataract (Crevecoeur 2012, Honegger et al. *in preparation*).

In this paper we present the results of the first bioarchaeological assessment of a relatively robust sample of a Khartoum Mesolithic population documented at the site of Sphinx in Jebel Sabaloka at the Sixth Nile Cataract excavated between 2011 and 2015 by the Charles University Sabaloka Expedition. The study was carried out in the Anthropological Department of the National Museum in Prague where the excavated human skeletal remains had been transported for the purposes of documentation and study based on the permission of the National Corporation for Antiquities and Museums of the Sudan. This has increased the possibilities of anthropological processing and analyses and allowed for a larger-scale use of diverse imaging techniques (X-ray, CT, or micro-CT). The presented results are mainly focused on palaeodemography – sex and age-at-death distribution within the studied burial site – and description and categorisation of recorded pathological alterations. While both archaeological and anthropological study of the burial assemblages excavated in the western part of Jebel Sabaloka are still ongoing (e.g., Varadzinová et al. 2022b), the first insights presented in this study still constitute a valuable contribution from central Sudan to the understanding of the life ways and conditions of small-scale hunter-gatherer communities well before the emergence of the earliest civilizations.

Burial ground and the composition of the sample

The site of Sphinx (SBK.W-60) is located about 80 km north of Khartoum in Jebel Sabaloka, a mountain range of volcanic origin, whose western part has been investigated since 2009 by the Charles University Sabaloka Expedition (Suková & Varadzin 2012, Varadzinová & Varadzin 2017, Varadzinová et al. 2022a; Fig. 1). The site is situated on a small granite inselberg at the north-western foot of the mountain. The main area of the site (793 m^2) occupies an elevated position ~15 m above the surrounding plain and is divided by granite boulders into southern, central, and northern platforms. These are adjoined from the east by two narrow tongue-shaped areas, which we call the northern and southern shelters.

Between 2011 and 2019, 11 trenches (49.95 m^2) were excavated across the site. All the trenches contained settlement deposits relating to occupation by hunter-fisher-gatherers of the Khartoum Mesolithic, or the Early Khartoum culture, dated at the site between 8750 and 4750 cal BC (Varadzinová et al. *submitted*). Trenches 2, 5+6, and 7 in the southern platform and Trench 9 in the northern shelter (42.25 m^2 in total) yielded also human skeletal remains (Fig. 2).

A series of radiocarbon dates on enamel bioapatite of 14 individuals places the burial activity at Sphinx within the seventh and early sixth millennium cal BC (Varadzinová et al. *submitted*) and well within the Early Khartoum culture. The Early Khartoum culture constitutes the earliest known cultural entity along the Nile in central Sudan after the Middle Stone Age. These were semi-sedentary hunter-fisher-gatherers who occupied their sites over a long time, sometimes even for millennia, and relied heavily on fishing complemented by hunting of savannah and riverine animals and gathering of plant foods (Garcea 2020).

The burial assemblage from Sphinx

Altogether 50 field burial numbers (B.1–B.50) were assigned to the human remains recorded at Sphinx between 2011 and 2015 (Suková & Varadzin 2012, Varadzinová & Varadzin 2017, Varadzinová Suková et al. 2015). Many of the burials were found in dense clusters, with earlier interments often truncated and disturbed by subsequent burial or settlement activity (Fig. 3). This resulted in destruction of (parts of) some burials and redeposition of some skeletal elements into adjacent burial or settlement features or in scattering of fragments of bones and teeth through the archaeological deposit.

Where possible, removal of skeletons followed anatomical order. With 13 burials located in the walls of the trenches, the skeletal remains were left entirely (4) or partly (9) *in situ*. With human remains found outside their primary context or as part of commingled deposits, removal by groups of bones respecting the rules of stratigraphy was employed. In addition, several scattered and fragmented bones and teeth identified during dry-sieving of the excavated sediment were registered as separate assemblages according to the trench, sector, and level.

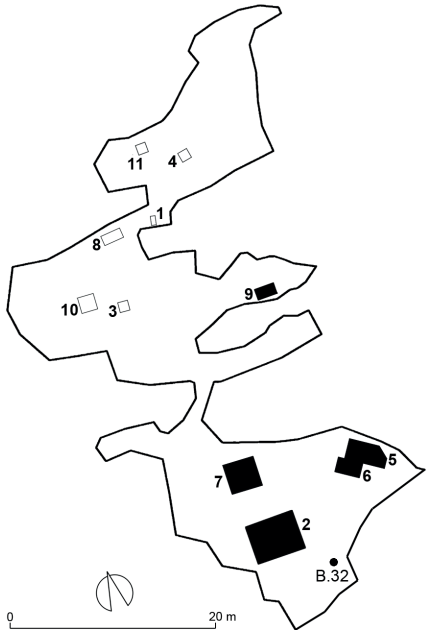

Fig. 2. Plan of the settlement platform at Sphinx showing the location of all trenches excavated between 2011 and 2019. Trenches with human burials are shown in black. B.32 indicates the position of human remains identified outside the excavated area. After Varadzinová Suková et al. 2015, fig. 4 (adapted).

Fig. 3. Dense cluster of primary and secondary depositions in Trench 6. Photo: L. Varadzin.

During subsequent study of the skeletal assemblage, seven units designated in the field as "burials" were conservatively reclassified as redeposited human remains and two units were joined as parts of the same interment. Burials that constitute secure primary depositions (Duday 2009, Knüsel & Robb 2016) were designated as PD. Redeposited human remains were reclassified and, where possible, allocated to known individuals based on archaeological and anthropological aspects. Those recorded directly in the field were designated as secondary depositions (SD).

After the critical assessment (Table 1), the burial assemblage excavated at Sphinx contains 41 more or less complete primary depositions (PD1–PD41), of which 38 were submitted to anthropological examination. In addition, there are 28 secondary depositions (SD1–SD28) consisting of single skeletal elements or scatters or clusters of bones and teeth. In some cases, one SD contains the remains of more than one individual. Some of the skeletal elements in the SDs could be allocated with more or less certainty to some of the known individuals (n=12) while other elements were found to belong to further six individuals with no archaeological correlates among the excavated PDs. These SDs increase the number of distinct individuals attested archaeologically to 44. The other unassigned skeletal remains identified among SDs or obtained through dry-sieving of the excavated deposit may derive from still other, now entirely destroyed burials and may thus potentially further increase the minimum number of individuals once buried in the excavated area.

Trench	Size (m^2)	Primary depositions (PD)		Secondary depositions (SD)				Other human fragments
		recorded	anthropologically assessed	recorded	(partly) assigned to PD	new individuals	(partly) unassigned	
2	20	22	22	4	4		1	+
5+6	11.25	14	13	23	8	6	18	+++
7	9	3	1	1			1	+
9	2	2	2					++
Total	42.25	41	38	28	12	6		

Table 1. Burial assemblage at Sphinx, with identified primary and secondary depositions and other unidentified remains (+ = present; ++ = relatively frequent; +++ = abundant). Note: one SD may contain the remains of more than one individual.

Methods

The skeletal material from Sphinx was significantly affected by different taphonomical conditions within the burial site. Most of the remains were fragmented and heavily cemented by calcareous concretions, therefore their parts had to be removed as blocks of sediment and cleaned in laboratory (Fig. 4). Calcareous concretions complicated some anthropological examination especially where the surfaces of bones need to be evaluated. The best-preserved segments were teeth which were used for anthropological determination of MNI. The biological identification of individuals relied on classical anthropological methods whose selection reflected the state of preservation of human remains.

Sex estimation was based on morphological (Brůžek 2002, Ferembach et al. 1980) and metrical (Brůžek et al. 2017, Murail et al. 2005) analysis of coxal bones and descriptive morphological features of the skull (Ferembach et al. 1980). Metrical analysis of the clavicle (Akhlaghi et al. 2012, Papaioannou et al. 2012) or mandible (Dayal et al. 2008, Giles 1964) was applied where the skull or coxal bones were missing, however, the sexual dimorphism in these bones is population specific and the sex-diagnostic formulae are based on other populations. Given the poor state of preservation especially in the case of coxal bones, all possible methods for age-at-death estimation were applied: morphoscopic evaluation of the structures of coxal bones including the auricular surface (Lovejoy et al. 1985, Schmitt 2005), pubic symphysis (Brooks & Suchey 1990, McKern & Stewart 1957), or acetabulum (Calce 2012); degenerative changes of the vertebral column (Stloukal & Vyhnánek 1976); inner architecture of the proximal femur/humerus (Szilvássy & Kritscher 1990) and dental wear evaluation (Lovejoy 1985, Miles 1963). Individuals sexed by metrical or morphological analysis of coxal bone were classified as "Male" or "Female" (M/F) whereas individuals which were sexed primarily according to morphological features of the skull were classified as "probable Male" or "probable Female" (M?/F?). Where sex estimation was more intuitive, e.g., based on only

Fig. 4. Skull of PD7 heavily coated with carbonaceous crust. Photo: L. Varadzin.

Trench	Frequency MNI		Association & exclusion	Total
	Element	Number		
2	Lower left first molar (LLM1)	19	4	23
5+6	Lower right first molar (LRM1)	10	7	17
7	Lower left second deciduous incisor (LLdi2)	2		2
9	Upper left second incisor (ULI2)	2	1	3
Total MNI				45

Table 2. Detail of the Minimal Number of Individuals (MNI) calculation at Sphinx.

one or few features in combination with robusticity of the skeleton rather than on a concrete method, the individuals were marked ?(M?)/?(F?), but should be considered as sexually undetermined.

The estimation of the age-at-death of subadult individuals was assessed using Moorrees standards of dental development (Moorrees et al. 1963a, Moorrees et al. 1963b). This method allows to include the results for deciduous and permanent teeth in a 95% confidence interval. This method was supplemented by other approaches: mineralization and eruption of the teeth (Brown 1985, Ubelaker 1978); fusion of epiphyses and apophyses (Krogman & Iscan 1986, Schwartz 1995) or age-at-death estimation based on the length of long bones' diaphysis where teeth were absent (Florkowski & Kozlowski 1994, Maresh 1970, Stloukal & Hanáková 1978).

Metrical analysis of cranial and infra-cranial dimensions of the skeleton followed the definitions of Martin and Saller (1957). Stature estimation was based on the length of the best-preserved long bone following the regressions of Trotter and Gleser (1952, 1958, 1977) or Sjøvold (1990) in the case of unknown sex of individual.

Palaeodemography

Minimal number of individuals

Given the large number of bones not assigned to the known PDs, we estimated the minimal number of individuals (MNI) of the burial ground following anthropological standards (Buikstra & Ubelaker 1994, Poplin 1976), taking into account all PDs, SDs and other human fragments (Table 1). Based on the frequency of the most common type of bone or tooth, this MNI of frequency was then refined through associations and exclusions. It was possible to add individuals that were excluded from the frequency count based on pairing elements. Exclusion by age-at-death also allowed the addition to the MNI of individuals who were not present in the category of retained bones or teeth but were represented elsewhere.

MNI was counted by trenches given their relative distance one from another, but Trenches 5 and 6 were grouped due to their contiguity. Table 2 regroups the detail of the counting for each trench. In all cases, dental remains were the most numerous elements that were selected for the MNI of frequency. Adjustments were made based on the age-at-death, the laterality, and the exclusion of some association. The final MNI was set at 45 individuals.

Age-at-death distribution

With the limited preservation of the pelvic remains, it was not possible to apply the method of Schmitt (2005) for estimation of the age-at-death of the adults on a significant number of individuals. Given the strong dependence of the senescence processes on populational, environmental and behavioral factors (Brůžek et al. 2005), the adult individuals were grouped in two age classes: [20–35] or [>35]. The immature individuals were grouped in five conven

Age groups	Individuals attested as PD or SD		MNI based on teeth	
	N	%	N	%
[0–<1]	1	2.3	2	4.4
[1–4]	2	4.5	6	13.3
[5–9]	1	2.3	1	2.2
[10–14]	0	0	0	0
[15–19]	1	2.3	1	2.2
Subadults	5	11.4	10	22.2
[20–35]	18	40.9	18	40
[>35] – IND	21	4.7	17	37.8
Adults	39	88.6	35	77.8
Total	44		45	

Table 3. Age-at-death distribution of individuals based on two approaches: individuals attested as anthropologically studied primary (PD) or secondary (SD) depositions and the Minimal Number of Individuals (MNI) based on teeth; IND = indeterminable.

tional age classes ([0–<1], [1–4], [5–9], [10–14] and [15–19]). This allows us to compare the demographic profile of the Sphinx funeral assemblage with the theoretical mortality values for a population with a life expectancy at birth between 25 and 35 years (cf. Ledermann 1969). The assignment of some immature individuals to one specific age group while they were associated to two different age classes based on the age estimate standard deviations was determined following the method of minimization of anomalies (Sellier 1996).

Among the 44 anthropologically assessed individuals that were attested archaeologically as PDs and SDs, only five immature skeletons were identified (Table 3). However, when unassigned teeth found outside the primary context were included in the calculation (MNI), the number of subadult individuals in the sample increased to ten.

The age-at-death repartition in relation to the theoretical mortality quotient was also investigated to discuss potential demographic anomalies that could reflect burial selection or mortality crises (Castex et al. 2008, Sellier 1995). If we compare the mortality quotient of Sphinx before adulthood [<20] with the theoretical values, there is a strong anomaly with the proportion of immature individuals (22.2%) that stands far below the theoretical interval of 45.5% to 54.5% (Ledermann 1969).

Some trends can nevertheless be drawn with regard to the under-representation of immature individuals. As illustrated in Figure 5, the imbalance between mature and immature individuals is mainly related to the deficit in perinates, new-born babies or children under the age of one year (age class [0–<1]). Young children (age class [1–4]) are underrepresented as well, with their mortality quotient lying in the lower limit of the theoretical value. Whatever its origin, this demographic anomaly is not unusual in pre-Neolithic funeral assemblages (Bocquet-Appel 2002, Jakob 2014, Saxe 1971). As illustrated by the mortality quotient curve from the late Pleistocene cemetery of Jebel Sahaba at the Second Nile Cataract and the Mesolithic site of El-Barga near the Third Nile Cataract, the underrepresentation of young children in hunter-gatherer funeral assemblages along the Nile is common. In the case of Sphinx, just as with Jebel Sahaba, it does not seem to be related to taphonomical processes that would have impacted immature bones differently since well-preserved immature individuals are present in both assemblages. In burial, therefore, a selection in relation to the age-at-death might have occurred at least for the youngest class.

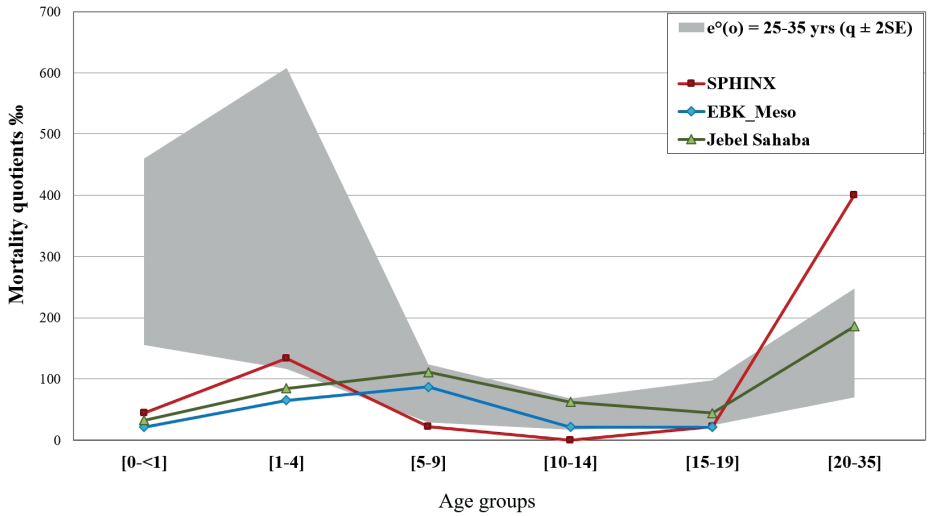

Fig. 5. Mortality quotients by age class of the Sphinx funerary assemblage compared to the values for Jebel Sahaba and El-Barga and to the theoretical mortality rates of Ledermann (1969) for populations with a life expectancy at birth between 25 and 35 years.

Sexual diagnosis

Just as in the case of age-at-death estimation, the sexual diagnosis was also complicated due to the state of preservation of the skeletal remains. Primary sex estimation based on the metrical or morphological analysis of the coxal bone was possible only in four cases (2 males and 2 females; Table 4). 13 individuals were sexed according to the morphological features of the skull (marked F?/M?). With other 13 individuals (marked ?(F?)/?(M?)), the sex estimation is more problematic as it was based on only one or few features in combination with robusticity of the skeleton rather than on a concrete method. 14 individuals remain undetermined.

Following these results, no selection based on sex was recorded and the distribution of males and females seems to be even. A similar distribution of male and female burials was recorded at the site of El-Barga near the Third Nile Cataract, where no significant difference in relation to sex representation was observed for the Mesolithic burials whereas a significant prevalence of female individuals suggests that a selection of deceased in relation to gender occurred later, during the Neolithic period (Crevecoeur 2012). At Shabona on the White Nile, only seven burials were unearthed, among which the distribution according to sex of the buried individuals was even, with three males and three females, and one individual indeterminable (Clark 1989). Males and females were present in approximately equal numbers also in the pre-Mesolithic burial assemblage from Al Khiday 2 on the west bank of the Lower White Nile of which 85 individuals have been assessed from the point of view of anthropology so far (Jakob 2014). The sex distribution seems to differ at the Khartoum Mesolithic site of Saggai 1 (Khartoum Province) where four individuals were estimated to be female and only one highly fragmentary skeleton probably belonging to a male (Coppa & Macchiarelli 1983); however, this may be influenced by the low number of unearthed skeletons at this site.

Morphological characteristics and affinities

The skeletons from Sphinx are mainly middle-robust to robust. The skulls are characterized by a thick diploe and a rather long shape, significant and asymmetrical dental wear, protruding maxillae, slight expression of the external occipital process, and strong development of

Method	Coxal bone	Skull	Other	Total	
Sex	M/F	M?/F?	?(M?)/?(F?)	N	%
Males	2	8	5	15	34.1
Females	2	5	8	15	34.1
Indeterminable				14	31.8
Total	4	13	13	44	100

Table 4. Totals of male and female skeletons according to different anthropological methods of sex estimation.

masticatory entheses at the mandible even in females. A similar appearance of female mandibles was described at Saggai 1 (Coppa & Macchiarelli 1983) where the splanchnocranium shows consistently alveolar prognathism and the mandibles show a male trend. Assessment of the body height at Sphinx was possible in only ten cases where whole long bones were preserved. The general average living stature is 168 cm. However, the statures seem to differ significantly according to sex. An average male height is 173 cm and female height 163 cm. These values fit within the trend of decreasing body height recorded at the site of Al Khiday 2, with burials from three different periods: pre-Mesolithic (before 6700 cal BC), Neolithic (4360–4250 cal BC) and Meroitic (20–140 cal AD). For both males and females, the recorded average stature was the highest in the pre-Mesolithic population (Jakob 2014). The males and females from Sphinx fall with their average body height well between the pre-Mesolithic and Neolithic periods at Al Khiday 2.

Skeletal health at Sphinx

A detailed evaluation of the skeletal remains was carried out in order to determine the overall health state of the population. Our attention was paid particularly to several main categories of pathological alterations: the diseases of teeth and jaws, fractures, traumas, degenerative joint disorders, skeletal malformations, infectious diseases, endocrine and metabolic diseases, tumours, and skeletal malformations of unknown aetiology.

A total of 15 of the 44 anthropologically assessed individuals (34%) exhibit at least one of the diverse kinds of pathological lesions, especially in the area of the jaws and teeth (9 individuals; Table 5). No case of tumours, skeletal malformations or endocrine diseases was recorded. Especially in the case of endocrine diseases, this can also be due to the preservation and character of the skeletal material, since this type of diseases manifests itself mainly in porosity, which may not have been detected under the calcareous coating of the bones (Fig. 4).

Dental diseases

Pathological alterations connected with teeth and jaws predominated among the individuals buried at Sphinx. Significant and mostly asymmetrical dental wear was recorded in almost all individuals with preserved teeth. Dental wear in itself may not pose a serious problem; however, it may lead to a periodontal (inflammatory) disease or periapical lesions, a disturbance of the skeletal tissue around the apex of the tooth that may be related to a granuloma, cyst, or an abscess (Pilloud & Fancher 2019). These lesions including also lingual tilting, chipping, antemortem tooth loss, and temporomandibular changes, may be linked to extramasticatory wear patterns (Molnar 2011). Wear exposing the dental pulp opens up a pathway for infection (Greene et al. 1967). Inflammatory changes occurred in six individuals (on 16 teeth out of 695; 2.3%) and were most often located in the area around the first molars on the mandible on the left side (five cases) and the right side (two cases). It is worth mentioning that abscesses or periapical lesions on the mandible were recorded only in the proximity of

Category	Skull	Infra-cranial	M	F	IND	Total	Deposit No.
Dental carries	3		2	1	0	3	PD14, PD16, PD19
Dental abscess/ inflammation	6		3	2	1	6	PD8, PD17, PD21, PD26, PD34, PD40
Fracture	0	4	2	1	1	4	PD8, PD15, PD19, PD20 (IMM)
Trauma	1	3	3	1	0	4	PD8, PD11, PD21
Infectious diseases	0	1	1	0	0	1	PD6
Degenerative joint diseases	0	3	2	0	1	3	PD7, PD11, PD30
Tumours	0	0				0	
Skeletal malformations	0	0				0	
Endocrine diseases	0	0				0	
Unknown aetiology	0	2	2	0	0	2	PD8, PD17
Total N of cases	10	13	15	5	3	23	

Table 5. Distribution of pathological lesions by category and sex (M = males; F = females; IND = indeterminable; IMM = immature).

the first molars (Fig. 6). The presence of inflammatory changes on the maxilla, on the other hand, was not so clearly localized; inflammations occurred more around premolars but were also noted under incisors or canines. A high number of periapical lesions or abscesses may be related to a high degree of dental wear, in combination with other periodontal diseases (Jakob 2014). The severity and irregular character of dental wear at Sphinx indicates that the teeth were used as a tool, "a third hand", for example for preparation of fibres and sinews, as is also assumed with the pre-Mesothitic individuals buried at Al Khiday 2 (Jakob 2014).

Although the rate of inflammatory changes is relatively high, the incidence of caries is low. Dental caries occurred in only three cases out of 695 preserved teeth (0.43%), all of them on molars (ULM2, LRM1, LLM3). Among five individuals from Saggai 1, no dental caries was registered (Coppa & Macchiarelli 1983). Compared to the low frequency of dental caries at the aforementioned sites, the individuals from Shabona exhibit dental caries in three out of seven individuals, specifically in 22.9% (20/87) of all observable teeth (Crosby 2013). However, after excluding one of the individuals who showed caries in 69% of the teeth, the incidence of caries is reduced to 3%. The frequency of caries in the pre-Mesolithic individuals from Al Khiday 2 was even higher, with 5% of affected teeth (Jakob 2014).

The high prevalence of dental caries in recent humans is attributed to a more frequent consumption of plant foods rich in fermentable carbohydrates in food-producing societies. Non-agricultural populations tend to be less affected by dental caries (usually about 1%) due to a low proportion of carbohydrate-rich food (Greene 1972). Nevertheless, the analysis of oral pathology of the individuals buried at Taforalt (Grotte des Pigeons) in Morocco between 15,000 and 13,700 cal BP reveals an exceptionally high prevalence of caries (51.2% of teeth in adult dentitions), comparable to modern industrialized populations with a diet high in refined sugars and processed cereals (Humphrey et al. 2014). The lower rates of caries at Sphinx may indicate a lesser reliance on foods rich in fermentable carbohydrates, or a difference in bacterial virulence or changes in the pattern and likelihood of transmission between infected and uninfected individuals (Humphrey et al. 2014).

Fig. 6. Dental abscess under the first mandibular molar on the right side (PD20). Photo: P. Brukner Havelková.

Fig. 7. Isolated fracture of the distal part of the right ulna (PD19). Photo: P. Brukner Havelková.

Fig. 8. Serious coxarthrosis of the acetabulum and the femoral head on the right side (PD11). Photo: P. Brukner Havelková.

Traumatic lesions and fractures

Among the 44 individuals examined, only six exhibit healed traumatic lesions (fracture or trauma). Individual PD15 (field number B.1) exhibits two ribs which were broken and healed. Three cases of broken forearm were noted in the skeletal assemblage. An isolated fracture of the distal part of the right ulna (Fig. 7) was recorded in PD19 (B.2), whereas the preserved fragment of the right radius appears to be intact. Individual PD20 (B.6) exhibits a healed fracture of the distal half of the left radius, however, although the left ulna is warped and partially damaged, it does not appear to be broken. It is probably also the isolated fracture of one of the forearm bones. Fractures of the distal part of the radius are commonly located near the wrist and are usually caused by a fall onto a hard surface with outstretched arms (Mays 2006). However, the fracture mentioned above is localised more proximally, closer to the bone midshaft. Radius shaft fractures are the result of a high energy trauma (e.g., falls from a height) in young individuals with age-appropriate bone quality; both bone forearm fractures that result from a low energy trauma, such as a fall from a standing height, are typically seen only in individuals with impaired bone quality (Small & Yaish 2022). The third case from PD8 (B.14) is very similar to the previous one: it is a healed fracture of the right radius, without any pathological changes in the ulna detected. Posttraumatic changes manifested by deformation and inflammatory changes were observed on hand bones, more precisely on the right first proximal phalanx in individual PD21 (B.16). The origin of these changes (fracture or another trauma) is unclear. The last case of a traumatic lesion was registered on the fragment of the left pubic bone that belonged to individual PD11 (B.21), which was deformed in shape and more robust than the opposite one. An initial stage of ankylosis of the sacroiliac joint was recorded on the same side. Although a clear cause for these changes cannot be established, it should be mentioned that the same individual also suffered from a serious coxarthrosis on the opposite (right) side (Figure 8), both in the area of the acetabulum and the femoral head. Due to the probable trauma identified on the left pubic bone, it is likely that this is a manifestation of the so-called secondary osteoarthritis caused by a compensating movement on the right side. Compensation results from restrictions in the range of plasticity or adaptive potential. Compensation comes into play when specific behavioral capacities are lost, as a result of pain, surgery, or disability, or are reduced below the standard required for adequate functioning (Rush et al. 2011).

Fig. 9. Osteoarthritis of the elbow of the right ulna (PD7). Photo: P. Brukner Havelková.

Degenerative joint diseases

Two other serious cases of degenerative joint diseases occurred in the skeletal assemblage. Individual PD30 (B.45) exhibited strong degenerative changes of feet, especially phalanges where proximal parts of several of them were deformed ("cauliflower--like"). In addition, osteoarthritic changes of the right knee were present. A severe osteoarthritis of the right elbow was recorded in *incisura trochlearis* of the right ulna (Fig. 9) of skeleton PD7 (B.9). Unfortunately, other parts of the joint were missing. Fragments of the proximal part of the left ulna seem to be affected by osteoarthritic changes as well, however it cannot be proven due to the poor preservation.

Other pathological conditions

Only one evidence of infectious (inflammatory) lesion on bones of infra--cranial skeleton was observed on the distal epiphysis of the first foot phalanx in PD6 (B.12). It is more than likely that inflammatory changes were more numerous in the studied bones of infra-cranial skeletons. Unfortunately, the detection of inflammatory changes is complicated by the state of preservation of the skeletal material, especially regarding the character of the bone surface, on which inflammatory changes, such as periostitis, are most readily recognized and which was heavily cemented by calcareous concretions in most of the studied bones (Fig. 4).

Fig. 10. Perimortem sharp force trauma caused by penetration of a heat-modified non-human bone between the right scapula and the rib cage (PD8). Photo: P. Brukner Havelková.

In the case of individual PD17 (B.4), a strange deformation of the odontoid process of the axis was registered. The process was thin, long and twisted whereas the *fovea dentis* of the atlas were large. The character of the alterations does not appear to be traumatic and even a taphonomic cause cannot be ruled out; however, the aetiology is unknown.

A polytraumatic alteration was registered in PD8 (B.14). The atlas and axis exhibit two space-occupying lesions on the transversal arch of the atlas and the anterior part of the axis body. A small depression was present above the left orbit, and the distal part of the diaphysis of the right radius was bulging probably due to a healed fracture (as mentioned above). However, this individual also exhibits signs of a perimortem trauma (Brukner Havelková et al. *submitted*). During cleaning of a cemented block containing the right clavicle, scapula and five ribs, an embedded fragment of a non-human (faunal) bone was discovered. This triangular bone fragment was wedged between the right scapula and the rib cage. The subscapular fossa was perforated and bulging posteriorly following the axis of the apex of the distal part of the bone fragment at the level of its contact with the scapula (Fig. 10). The pattern of the

recorded fractures on the scapula and adjacent bones is also consistent with descriptions of the present-day scapula fracture types (e.g., Bartoníček et al. 2018, Bartoníček et al. 2021, Südkamp et al. 2011, Tuček et al. 2017).

The distribution of pathological alterations with respect to sex of individuals is also worth mentioning. As can be seen from Table 5, except for dental diseases, the occurrence of pathological lesions predominates significantly in males. Only one case of a fracture of two ribs (PD5) and one case of a trauma/fracture of the hand bone (PD21) were recorded in females.

The chronologically and/or geographically close localities where pathological alterations were studied and published (Al Khiday 2, Shabona, El-Barga) show a similarly low number of recorded pathological changes. In Shabona, one case of a healed rib and one of osteoarthritis of the hand and foot occurred among seven individuals (Clark 1989), while at El-Barga, out of the 46 individuals, three exhibit a healed fracture of the forearm and seven crania show signs of a trauma (Crevecoeur 2012). At Al Khiday 2, only two out of the 85 studied pre-Mesolithic individuals showed evidence for healed fractures, however, a large number of individuals had suffered from temporomandibular joint disease (Jakob 2014).

The individuals at Sphinx appear to be a relatively healthy population and most of the recorded pathological alteration can be very likely considered the consequences of everyday activities. The same probably applies also to the other geographically or chronologically close burial sites assessed in this study.

Conclusion

The significance of the skeletal remains from the site of Sphinx, attributed to the Early Khartoum culture, is primarily related to the size of the burial site, which is unique in central Sudan. In terms of bioarchaeology, it provides a robust sample that allows to track the formation of one stable hunter-gatherer group with a high degree of sedentariness.

Regarding the palaeodemographic profile of the burial site, it is worth mentioning a strong anomaly with the proportion of immature individuals whose registered numbers are very low. The imbalance between mature and immature individuals is mainly related to a deficit in perinates, new-born babies or children under the age of one year. This demographic anomaly, however, is not unusual in pre-Neolithic funeral assemblages. Sex distribution within the cemetery, on the other hand, is even for male and female burials and it seems likely that at Sphinx there was no sex-based selection in burials.

As far as the health state of the population is concerned, dental diseases, especially periapical lesions and inflammatory changes, predominate at Sphinx. This is probably closely related to the high degree of dental wear and its irregular character indicating the use of teeth as a tool. In contrast, a very low incidence of dental caries (0.43%) was recorded, which is typical for non-agricultural populations. Healed traumatic lesions or fractures were recorded in only six individuals. All these injuries are most likely of an accidental origin linked to habitual activities. A unique piece of evidence of inter-personal violence at Sphinx is indicated by the perimortem sharp force trauma caused by penetration of a heat-modified non-human bone between the right scapula and the rib cage of individual PD8. Based on palaeopathological evidence, it is possible to perceive the population from Sphinx as relatively healthy and peaceful.

Nevertheless, the archaeological excavations at Sphinx as well as at sites in the western part of Jebel Sabaloka (e.g., Fox Hill; Varadzinová & Varadzin 2020, Varadzinová et al. 2022b) are still ongoing, and it is possible that the increasing number of human skeletal remains available for study will provide further and more detailed information about the late hunter-fisher-gatherers of central Sudan and their ways and conditions of life.

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