ASSESSMENT OF GROWTH PATTERNS IN JUVENILE SKELETONS FROM SAQQARA

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A number of studies have been published recently on health changes and nutritional status in past populations.[1] Juvenile skeletons have been included in these studies for developmental disturbances caused by various systemic stressors, such as malnutrition and infectious disease, thus providing general information on the relationship between a population and environment.

This paper aims to describe the pattern of growth in infants, children and adolescents, reconstructed from diaphyseal age-related changes in order to gain insight into their overall health status.

SUBJECTS OF INVESTIGATION

This paper is focused on subadult skeletal remains excavated by the Polish-Egyptian mission at Saqqara in 1996-2002. The precise dating of the burials, failing inscriptions or grave goods, was very difficult. However, since the immature burials were found in context with those of adults or close to other burials, occasional pottery finds made it possible to anchor them with fair certainty in the Late and Ptolemaic periods, possibly also slightly earlier and later.[2]

There is evidence for differential burial practices as far as method of mummification and type of burial are concerned. It was found that mummification techniques applied to children followed the same pattern as the ones applied to adults, e.g. incomplete mummification contributed to body decay. In some cases, as for example in burial 35[3] and in burial 183, a careful wrapping of the body in bandages was practiced in a similar way as it was done in adults. Sophisticated and very precise wrapping stands in contrast with the poor embalming method.[4] There were also numerous burials which did not reveal any attempts at artificial preservation of the body. The absence of any traces of mummification suggests the practice of burying the dead in shrouds.

1) Among many others: R.D. Hoppa, “Evaluating human skeletal growth: An Anglo-Saxon example”, *Int.J.Osteoarch.* 2 (1992), 275-288; S.R. Saunders, R.D. Hoppa and R. Southern, “Diaphyseal growth in a nineteenth century skeletal sample of subadults from St. Thomas' Church, Belleville, Ontario”, *Int.J.Osteoarch.* 3 (1993), 265-281; R.D. Hoppa and Ch.M. Fitz Gerald (eds.), Human growth in the past. Studies from bones and teeth, Cambridge University Press (Cambridge 1999).

2) For the dating of the necropolis, cf. K. Myśliwiec, “The Ptolemaic Period Cemetery in West Saqqara”, in: A Tribute to Excellence. Studies offered in Honour of E. Gaál, U. Luft, L. Török (ed. T.A. Bács), *Studia Aegyptiaca* XVII (Budapest 2002), 349-359.

3) Mummy of an infant not yet examined.

4) For a detailed description of mummification methods identified in the material from the Saqqara excavations, see M. Kaczmarek, “Anthropological analysis of mummified burials from Saqqara”, *PAM XI, Reports 1999* (2000), 118-124.

As for the type of burial, subadult individuals turned out to be buried either singly or in pairs or multiple burials. Those buried in twos were found together with either an adult male or female, probably the father or mother respectively, or another child (burials nos. 188 and 177). Those who were buried in multiple burials were found both with adult and young individuals, probably other members of the family (e.g. burials nos. 181 and 184).

A crucial point in the study of skeletal samples is the question of bone preservation. It is widely believed that the smallness and fragility of the bones of infants, children and young individuals make them more susceptible to decay compared to the robust adult bones. The state of the 43 subadult skeletal remains excavated at West Saqqara to date ranged from only a few fragments to complete skeletons. Dental, diaphyseal or both indicators sufficient for age estimation were preserved in all but five of the subadult skeletons.

The studied sample is presented in Table 1 on the following pages. The total number of individuals studied in the present work included two infants aged less than one year old at death, 16 children aged from 1 to 7 years at death, 13 children who died at age 7-14 and seven adolescents who died between the 14th and 18th year of their lives. In five cases skeletal remains were insufficient for a reliable assessment of the age at death.

ESTIMATING AGE AT DEATH

Estimation of age at death of subadult individuals involves establishing physiological age. The latter has been assessed from developmental changes in the tissues correlated to chronological age. The most commonly used indicators of physiological maturity in subadult skeletons are dental maturity, the appearance and union of bony epiphyses and bone (diaphyseal) size. Reference standards for age evaluation derive from data collected for living samples.

In studying skeletal remains from Saqqara I have found that teeth were frequently the only human tissues available for scientific inquiry from burial contexts where bones might not be well preserved. This remark corroborates the belief that dentition is of special importance in studies of ancient people for the accuracy of age at death estimates, dietary reconstruction, health status, disease and genetic affinity.[5] In our study each individual (except for the five incomplete skeletons, cf. above) was aged according to the sequence of formation and eruption of teeth. Standards developed by Moorrees et al., Demirjian et al. and Ubelaker were used.[6] The Moorrees and Demirjian reference standards of tooth formation for deciduous and permanent teeth demonstrated that numeric estimates of dental age should be extrapolated from the charts. Therefore, in order to maximize the reliability of dental age estimation all three methods were used simultaneously.

5) Numerous books have been published on dental anthropology since the first one edited by D.R. Brothwell, Dental Anthropology (Oxford-London-New York-Paris 1963), e.g. D.R. Brothwell, "The relationship of toothwear to aging", in: Age Markers in the Human Skeleton, ed. M.Y. Iscan (Springfield 1989); D.H. Ubelaker, Human Skeletal Remains, 2nd ed. (Washington 1989) or M.A. Kelley and C.S. Larsen (eds.), Advances in Dental Anthropology (New York 1991).

6) C.F.A. Moorrees, E.A. Fanning and E.E. Hunt, "Age variation of formation stages for ten permanent teeth", *J Dent Res* 42 (1963), 1490-1501; A. Demirjian, H. Goldstein, J.M. Tanner, "A new system of dental assessment" *Hum Biol* 45 (1973), 211-228; J.E. Buikstra and D.H. Ubelaker, Standards for data collection from human skeletal remains, *Arkansas Archeological Survey Research Series* No. 44 (1994).

Table 1. Description of subadult remains according to state of preservation and age at death

Item	Burial no.	Age category	Description
1.	46	infans I, 2-3 yrs	single burial; accurate wrapping in bandages; poor mummification; decayed body; fragmented skeleton; deciduous dentition completed
2.	49	infans I, c. 7 yrs	double burial with adult; obvious traces of mummification; remains of bandages; decomposed body; well preserved bones tinged dark brown by resin
3.	53	infans II, 8-9 yrs	single burial in wooden coffin with red inscription; poor mummification; bones well preserved
4.	73	infans I, 5-6 yrs	single burial; body mummified but totally decomposed; strong oxidation; well preserved skeleton; bones *in situ*
5.	77	infans I, c. 7 yrs	single burial; accurate wrapping in bandages; poor mummification; body totally decomposed; skeleton incompletely preserved
6.	81	child, age unknown	single burial; lying on mat; no traces of mummification; skeleton incompletely preserved; bones fragmented
7.	84	juvenis, 17-18 yrs	single burial; accurate wrapping in bandages; satisfactory mummification; well preserved bones
8.	85	infans II, 7-8 yrs	single burial; skeleton sufficiently well preserved.
9.	98	infans I, birth-6 ms	single burial; no traces of mummification; long bones well preserved; skull badly damaged
10.	99	infans I, c. 2 yrs	single burial; strongly oxidized; mummy wrapped in bandages with great care; skeleton sufficiently well preserved
11.	116	infans I, c. 1 yr	double burial with adult; no traces of mummification; bones in anatomical order; skeleton well preserved
12.	121	juvenis, 14-18 yrs	single burial; buried in wooden coffin; strongly oxidized; mummy wrapped in bandages; body decomposed; skeleton incomplete, bones well preserved
13.	126	infans II, c. 11 yrs	single burial; no traces of mummification; skeleton moderately preserved
14.	130	infans I, c. 2 yrs	double burial with adult; no traces of mummification; skeleton incomplete
15.	139	infans II, 9-10 yrs	single burial; no traces of mummification; skull destroyed; single bones preserved
16.	144	infans I, 6-7 yrs	single burial; no traces of mummification; skeleton destroyed; bones fragmented
17.	162	infans I, c. 3 yrs	single burial; no traces of mummification; bones well preserved
18.	167	infans I, 2-3 yrs	single burial; no traces of mummification; skeleton well preserved; bones in anatomical position
19.	177	juvenis, c. 18 yrs	double burial with another child (no. 188); no traces of mummification; skeleton well preserved
20.	188	infans II, 12-14 yrs	double burial with another subadult (no. 177); no traces of mummification; skeleton well preserved
21.	181	infans I, 12-18 ms	triple burial: female 35-40 yrs old, infant (No. 181) and child (No. 184); mummified; skeleton moderately preserved
22.	184	infans I, 6-7 yrs	triple burial: female 35-40 yrs old, infant (No. 181) and child (No. 184); mummified; skeleton moderately preserved

Table 1., cont.

Item	Burial no.	Age category	Description
23.	183	infans II, c. 10 yrs	single burial; mummy wrapped carefully in bandages; only skeleton preserved; head badly damaged
24.	185	infans II, c. 12 yrs	single burial; mummy wrapped with great care; skeleton well preserved
25.	189	infans I, 2-3 yrs	single burial; poor mummification; bones moderately preserved
26.	206	infans I, 4-5 yrs	single burial; poor mummification; bones well preserved; skull damaged
27.	218	juvenis, 16-18 yrs	double burial with adult; body mummified, poor state of preservation
28.	229	child, age unknown	burial damaged; skeleton destroyed; bones fragmented
29.	230	child, age unknown	no traces of mummification; skeleton destroyed; only some fragments of bones preserved
30.	244	infans II, c. 7 yrs	single burial; traces of mummification; poor preservation of skeleton; first permanent molar erupted
31.	249	child, age unknown	traces of mummification; burial completely destroyed; some fragments of bones preserved
32.	254	infans I, 5-6 yrs	single burial; body mummified; bones well preserved
33.	261	child, age unknown	burial mummified; skeleton destroyed; single bones well preserved
34.	262	infans II, c. 7 yrs	single burial; traces of mummification; skeleton destroyed; single bones preserved
35.	277	child, age unknown	single burial; traces of mummification; very poor state of preservation; only single bones preserved
36.	318	infans II, 12-14 yrs	single burial; mummy prepared and wrapped very carefully; bones well preserved
37.	320	infans I, c. 6 yrs	multiple burial with other children and adults; body mummified; bones well preserved
38.	321	child, age unknown	multiple burial with other children and adults; body mummified but decomposed; bones very poorly preserved
39.	322	infans II, 7-8 yrs	multiple burial with other children and adults; body mummified but decomposed; bones in poor state of preservation
40.	329	juvenis, c. 18 yrs	multiple burial with adults; body mummified; bones very well preserved
41.	337	juvenis, 14-18 yrs	single burial; no traces of mummification; poor state of preservation
42.	339	juvenis, c. 18 yrs	single burial; body mummified; bones very well preserved
43.	347	infans II, 9-10 yrs	single burial; body mummified with great care; bones well preserved
44.	352	infans II, c. 7 yrs	probably double burial with male adult; no traces of mummification; skeleton destroyed; only mandible with deciduous teeth and first permanent molar

PATTERN OF PHYSICAL GROWTH

The pattern of physical growth was estimated based on measurements of the diaphyseal length of long bones. Measurements were taken on 22 femora, 18 tibiae, 16 humeri, 7 ulnae, 2 radii and 2 fibulae of 43 individuals aged from 0-6 months to 18 years. The raw scores were then plotted on a graph by dental age and compared with available data for children from the Iron Age site at K2 in South Africa.[7] In the present report, skeletal growth has been illustrated by charts plotted for femur and humerus bones. This choice seems to be reasonable in view of the fact that the femur as a segment of the lower limb plays an important role in the growth of stature.

Diaphyseal growth of the femur in children from Saqqara (*Fig. 1*) may be seen as a continuous increase throughout childhood and adolescence, although it does not mean that the elongation of the lower limb bones proceeded at a constant rate. This impression may be caused by the cross-sectional design of the study and pooled sexes. One can also see that intra-size variation in the sample from Saqqara is rather small. The magnitude of standard deviation for defined ages ranges from 2.25 mm to 3.47 mm.

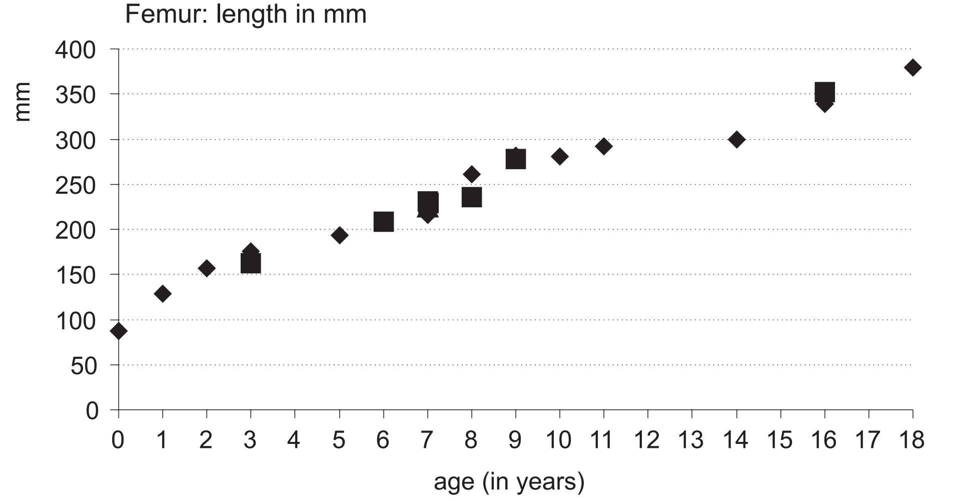

Fig. 1. Diaphyseal growth of the femur in children from Saqqara

7) Comparative data was derived from M. Steyn and M. Henneberg, “Skeletal growth of children from the Iron Age site at K2 (South Africa)”, *Am J Phys Anthrop* 100 (1996), 389-396. The Iron Age site of Mapungubwe is situated in the Northern Transvaal and is dated to 1000-1200 AD. A detailed description of the site can be found in: M. Henneberg and M. Steyn, “Preliminary report on the paleodemography of the K2 and Mapungubwe populations (South Africa)”, *Hum Biol* 66 (1994), 105-120.

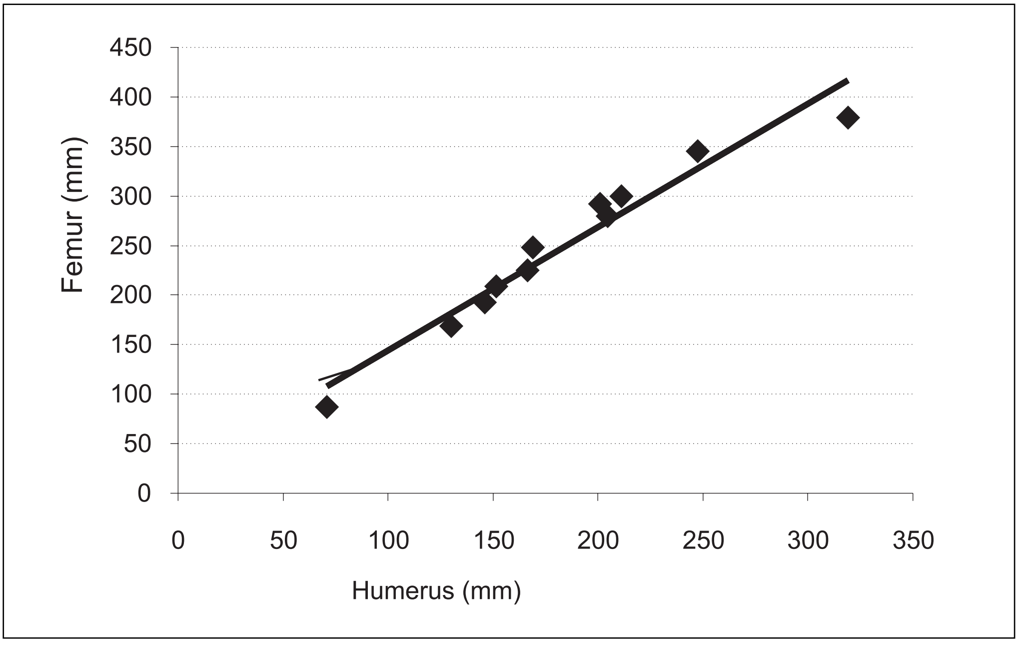

Fig. 2. Allometric growth: diaphyseal growth of the femur against diaphyseal growth of the humerus.

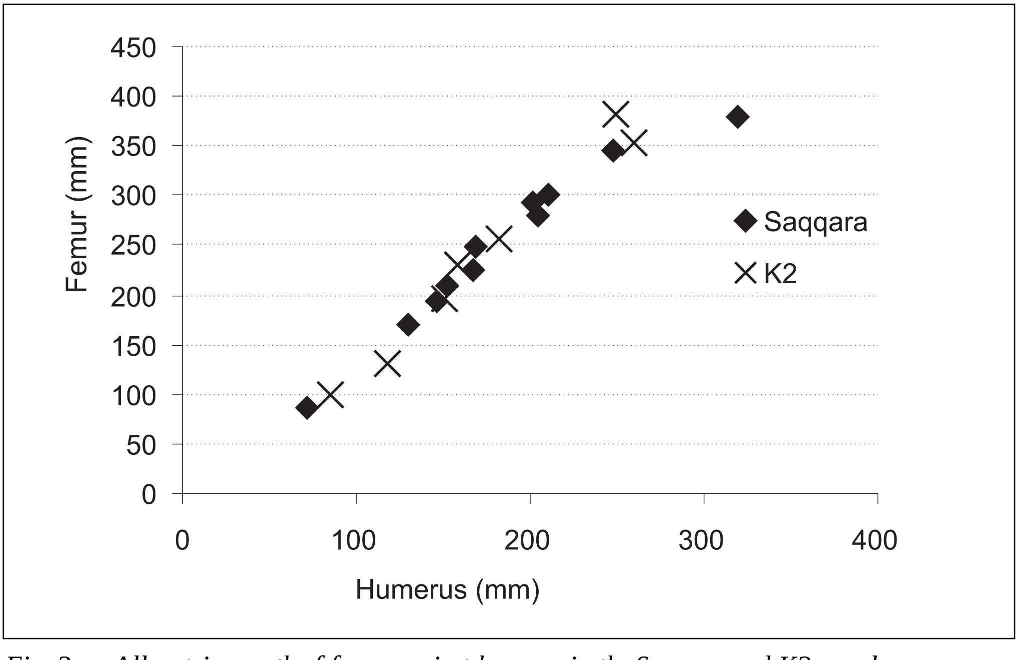

Fig. 3. Allometric growth of femur against humerus in the Saqqara and K2 samples

The next step was to analyze the allometric growth, e.g. proportional growth of one body part against the other. This method enables the age and the effect of possible erroneous ageing to be eliminated. Any disturbances in proportional growth may be assumed to be caused by environmental stressors. In our study the allometric growth is illustrated by diaphyseal length of the femur plotted against diaphyseal length of the humerus (*Fig. 2*). The chart reveals the proportional growth of lower and upper limbs. This solution can be judged by linear regression. The proportional growth pattern of children and adolescents from Saqqara is very similar to that of K2. The comparative data is shown in *Fig. 3*.

DISCUSSION

The analysis of growth-related phenomena in archaeological skeletal samples meets with some problems. Most critical to the interpretation of the results is the small sample size. The Saqqara sample is hardly representative, but this is also true of the K2 sample and in this point the two samples are comparable. Another issue is the fact that the pattern of growth reveals growth of children who had died and who had thus become part of a biased mortality sample.[8]) On the other hand, however, juvenile mortality is believed to be caused by acute diseases that need not drastically alter physiological maturation. The latter argument fits well with Lovejoy and colleagues or Sundick, who have argued that skeletal samples of juveniles compare favorably with the bones of their counterparts who had survived to adulthood.[9)]

Comparison of allometric growth indicates similarity between direction and the pattern of growth in the Saqqara and K2 samples. The same pattern of relationships between population and environment established in two compared samples indicate that the juveniles from these two samples were provided with similar conditions for development. This conclusion is well supported by the relatively low frequency of cribra orbitalia, enamel hypoplasia and other paleopathological records found in two samples. This in turn indicates that the people in the two samples were relatively healthy.

8) F.E. Johnston, "Growth of the long bones of infants and young children at Indian Knoll", *Am J Phys Anthropol* 20 (1962), 249-254.

9) C.O. Lovejoy, K.F. Russel, M.L. Harrison, "Long bone velocity in the Libben Population", *Am J Hum Biol* 2 (1990), 533-542; R.I. Sundick, "Human skeletal growth and age determination", *Homo* 29 (1978), 228-249.