DETERMINING AGE AND SEX IN PHYSICAL ANTHROPOLOGY*

J.F.W. Koens

INTRODUCTION

The collection of the Allard Pierson Museum (APM), the archaeological museum of the University of Amsterdam, stores an entirely wrapped mummy, five heads, two left feet and a right hand. In September 1998, in co-operation with the Academisch Medisch Centrum (AMC) in Amsterdam, thorough research of these human remains, using the latest technology, was decided upon. Not only the archaeologists and Egyptologists of the APM, but also the X-ray technicians and many medical specialists of the AMC warmly received the initiative. The variety of interests and questions of the interdisciplinary research called for a 'list of preferences' to set the limits of research, to select the appropriate methods and to invite the right specialists. The questions varied from how to visualize the inscriptions on the back of the scarab between the bandages of the mummy to how to establish any diseases once suffered from.

Two 'preferences' held pride of place:

1. What are the sexes of the mummy and mummy parts?
2. What were their ages at death?

This article will discuss the methods used and the results of the research.

---

* This article summarizes the lecture given by Dr. T.S. Constandse-Westermann during the congress. Unfortunately, owing to interfering obligations, she could not deliver her written version in good time. I would like to thank her for her clear and scientific argument.

Many people cooperate in the present research. I would like to especially mention X-ray technicians Mr. R. Jansen and Miss S. van den Berg, radiologists Dr. P. Dijkstra, Dr. M. Maas and Dr. S. Phoa, oral surgeons Dr. H. van den Akker and Drs. R. Valkenburg, and pathologist Dr. S. Troost. All of us were in the good care and company of the manager of the radio-diagnostic department, Mr. Th. Kroon. Special thanks are also due to Prof. Dr. G. den Heetern and Prof. Dr. H. Laméris, who kindly allowed us to do the research. Finally, I would like to thank Mr. J.J.M. Schepers and Reinier Schröder, dentist, for their version of the English text.

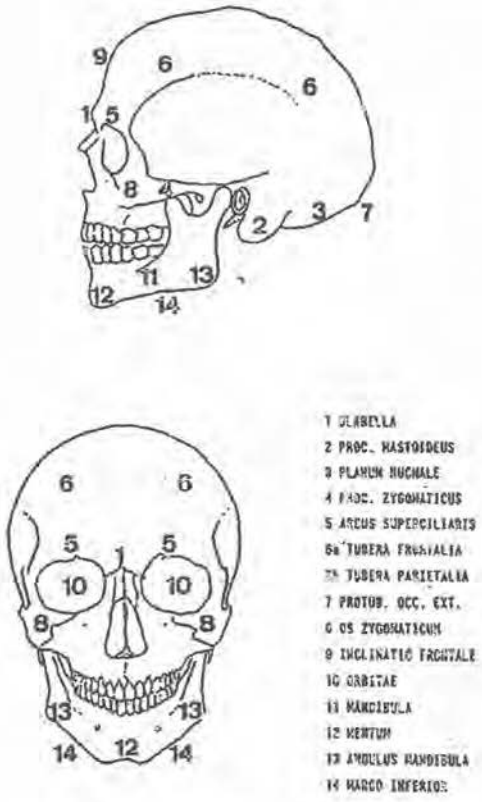


Fig. 1. Scheme: secondary sexual characteristics of skull (after Arbeitsgruppe Europäischer Anthropologen 1979, 27).

Method to determine sex

For the diagnosis of sex, we used the morphological method recommended by the "Arbeitsgruppe Europaïscher Anthropologen" (1979). The method, adapted by Dr. T. S. Constandse-Westermann and Drs. W. Bouts[1] to suit our purpose, proceeds from a number of characteristics of pelvis and skull. To these characteristics, weighing values are attached. Upon measuring the characteristics and calculating their averages, a statement of sex can be given, varying from 'extremely female' (-2) via 'indifferent' (0) to 'extremely male' (+2). No complete, undamaged

[1] Constandse-Westermann/Smits/Bouts 1995, 21.

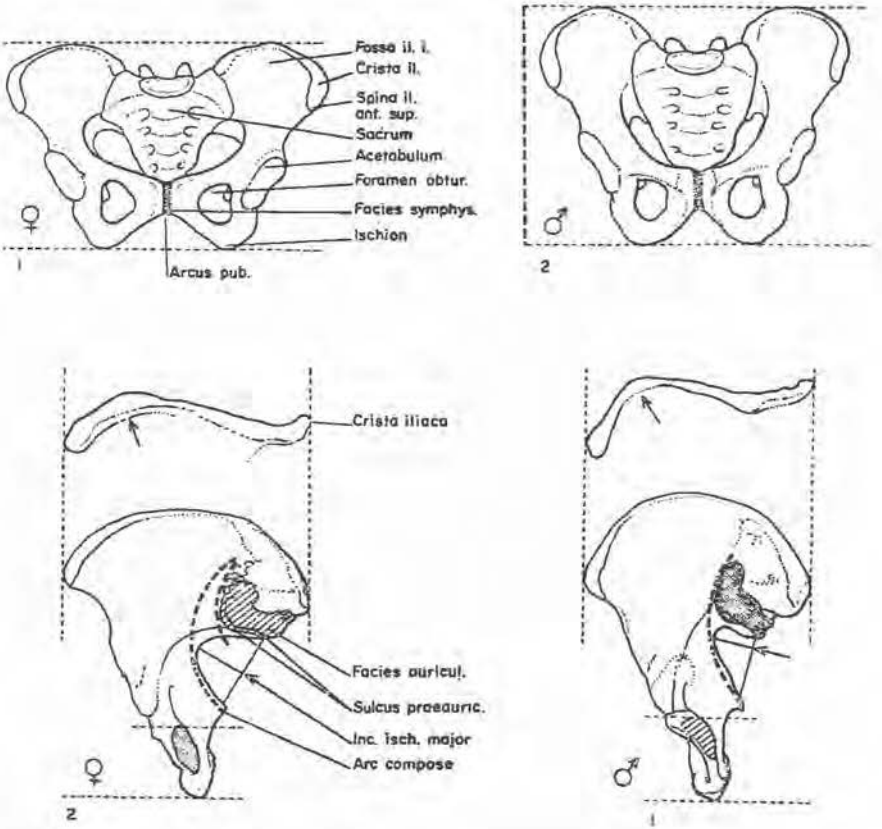


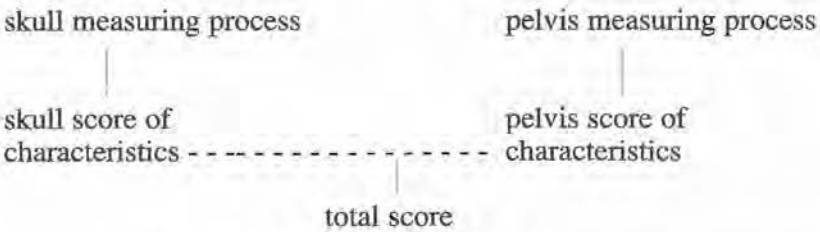
Fig. 2. Scheme: secondary sexual characteristics of pelvis (after Arbeitsgruppe Europäischer Anthropologen 1979, 26).

skeletons being required, the method comes in very useful for research of archaeological material. Its reliability, however, depends on the age at death of the individual examined. Thus, a child's morphological sexual characteristics not having fully developed, it is virtually impossible to determine the sex of its skeleton.

Determining sex

To determine the sex of complete or nearly complete skeletons, it takes three steps. First, subject to a number of criteria, the secondary sexual characteristics of pelvis and skull are scored (Figs. 1-2). Each criterium (18 in skull; 15 in pelvis) has its specific weight affecting the score of its body-part. Then, the score of each body-part is calculated as the

weighed average of its criterium scores. Following this, the body's total score is calculated as the weighed average of the scores of its parts. The resultant total score is the indicator of an individual's sex.
The above steps to determine sex can be graphically represented as follows:



Due to its many criteria, the method allows of a reliable diagnosis of sex even when either skull or pelvis is missing. In either case, the score of the other part is used as indicator of sex.

METHODS TO DETERMINE AGE[2]

An individual's age at death can be estimated by a variety of methods, four of which were used in this research.
The four methods are based on:
1. Eruption and development of teeth.
2. Fusing of epiphyses and diaphyses.
3. Gradual closure of cranial sutures.
4. Attrition of teeth and molars.

Criteria 1, 2 and 3 come in with adolescents and younger people, criteria 3 and 4 with adults.

1. Eruption and development of teeth
Being highly stable, human dentition will remain relatively well preserved after death. Consequently, ages can often be estimated by means of eruption and development of teeth. In the development of teeth, 21 stages are distinguished, ranging from the foetal stage via the eruption of temporary dentition to the permanent stage. The method to estimate ages by means of the development and eruption of teeth is described by e.g. Ubelaker (1984, 46-47, 115). It can be used with individuals up to about 18 years old. Usually, at that age, all teeth and molars will have erupted and be in occlusion. Each tooth or molar erupting at a more or less specific time, the dentitions of individuals of an age will generally show the same stage of development.

[2] See a.o. Ubelaker 1984, 45-67; Bass 1984, 12-20; Brothwell 1972, 57-70.

2. Fusing of epiphyses and diaphyses[3]

In the age group 13-25, ages can be estimated by means of epiphyseal union. The method takes into account to what extent epiphyses and diaphyses have grown together. As many bones allow of this analysis, no problems arise should one or more be missing or otherwise beyond examination. The extent to which epiphysis and diaphysis have grown together is established for each criterium. Here, four statements can be made, ranging from O (open) to C (closed). Concerning the method, it should be noted that age-intervals between the criteria of men diverge from those of women. Barring the proximal extremities of radius and ulna, women's epiphyses and diaphyses start growing together at an earlier age and finish faster. If and when possible, this phenomenon is to be taken into account estimating ages.

3. Growing together of cranial sutures[4]

With not fully-grown individuals, the gradual closing of the cranial sutures is a suitable criterium to estimate ages. With adults, the obliteration of these sutures is a criterium. Four statements cover the facts, from O (open, no narrowing at all) to C (completely grown together, no trace of suture left). The method, requiring complete skulls, will yield no more than rough, not quite reliable estimations of age (d'Hollosy 1992, 30; Brothwell 1972, 57-58). It is, therefore, hardly used but has to be used in the absence of other age indicators.

4. Attrition of teeth and molars

The attrition of teeth and molars, an age criterium developed and described by Pot (1988, 125-149) on the basis of a method published by Brothwell (1972, 81-83), is used to estimate ages of about 18 years and older. At the age of 18 years, it is normal for all teeth and molars to have erupted and be in occlusion. Its time of use determines the attrition of a tooth or molar. As their shapes and measures yield the best observable attrition patterns, the method focuses on the first, third, and, especially, second molars. In the absence of any molars or in the presence of molars with unreliable criteria, age is to be estimated by the teeth, if any. Applying this method, it should be noted that dentrition variations, infections and teeth or molars rising above occlusal level (failing their antagonists) could change mastication habits and, therefore, affect the attrition patterns. Thus, a molar having lost its antagonist ante-mortem will stop being worn off and end up as an indicator of too early an age.

---

[3] Ubelaker 1984, 52-53; Brothwell 1972, 60-63; Bass 1984, 15-18.

[4] Bass 1984, 33-39; Brothwell 1972, 57-58.

The eruption stage and the dental development are used to estimate ages up to 18 years (Fig. 3). If possible, for the age group 13-18, the extents to which epiphyses and diaphyses have grown together are also taken into account (Fig. 4). For the age group 18-25, the attrition of teeth and molars (Fig. 5) is scored, and, if possible, also the growing together of epiphyses and diaphyses. For ages over 25 years, solely attrition is considered. The obliteration of the cranial sutures (Fig. 6) is not applied as an age criterium unless all teeth and molars are missing.

DIFFICULTIES IN ESTIMATING AGES BY MEANS OF ATTRITION

Estimating ages over 18 years involves attrition. The underlying idea is for the functional live of a tooth or molar with known moment of eruption to condition its degree of attrition. Relating the degree of attrition to the moment of eruption, an individual's age at death can be calculated. Especially the molars are useful to estimating ages by means of attrition. The first (M1), second (M2) and third (M3) molars erupt at the ages of about 6, 12 and 18 years respectively. Not much later, they will be in occlusion and therefore ready for use. Moreover, being the chief tools of mastication, the molars, their shapes and measures yield the best interpretable attrition patterns (Pot 1988, 131-133).
Between populations, the rates of attrition can greatly differ, depending on collective diets and the use of teeth for different purposes.[5] Here, also activities determined by sex come in, causing men and women to use their teeth in different ways. Thus, in certain cultures, women chew their families' boots to keep or render the leather supple, in other cultures, men chew fibrous stimulants.
Many researchers use the 'general' attrition scheme by Brothwell (1972, 86). The approach, however, cannot be fully relied upon. Generally, M2 will reach occlusion six years later than M1. Reckoning with the attrition differences between M1 and M2, a more appropriate method[6] calculates the average of a 'closed' population's rate of attrition. The result is compared with that of Brothwell's method. If there are any differences, the interpretation of the scale has to be adjusted.
For example, to estimate their ages, the attrition differences between M1 and M2 of the mummies examined are to be established. Having averaged these data, the resultant rate of attrition can be compared with that by Brothwell's method, which, if necessary, has to be adjusted. The adjusted scheme, then, can be used to estimate the ages of the mummies to best accuracy.

[5] Bass 1984, 238-239; Brothwell 1972, 68-70; Bouts 1992, 109.
[6] Pot 1988, 125-149; Constandse-Westermann in press.

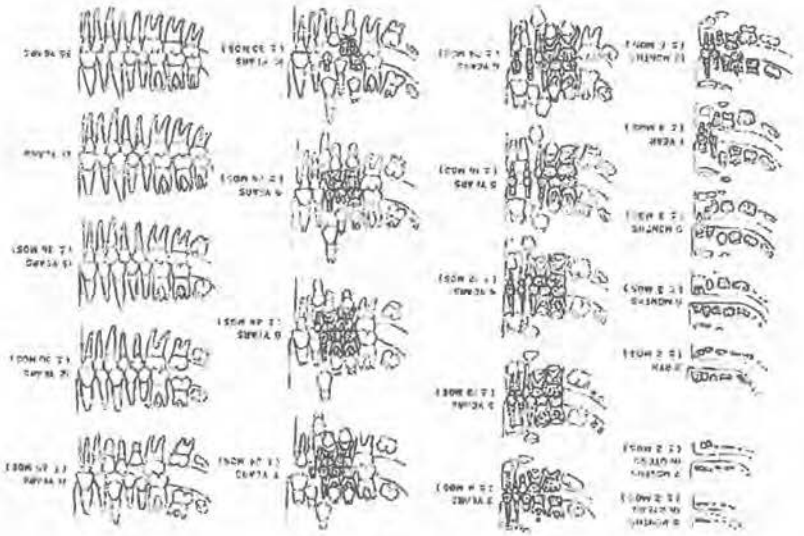


Fig. 3. Scheme: eruption stages of teeth and dental development (after Ubelaker 1984).

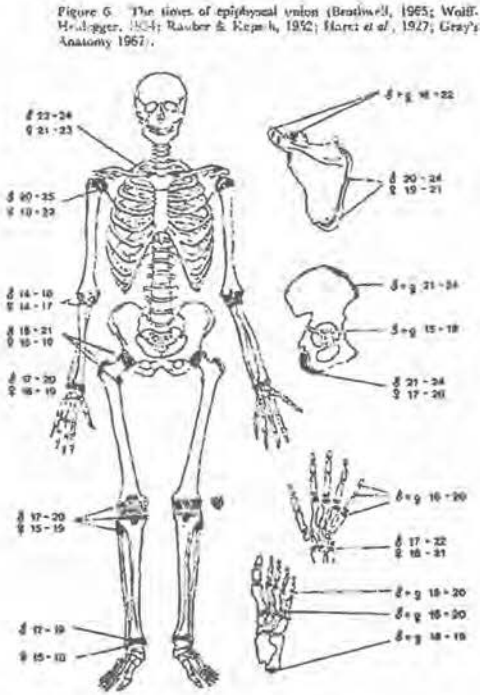


Fig. 4. Scheme: measure of fusion of epiphyses and diaphyses.

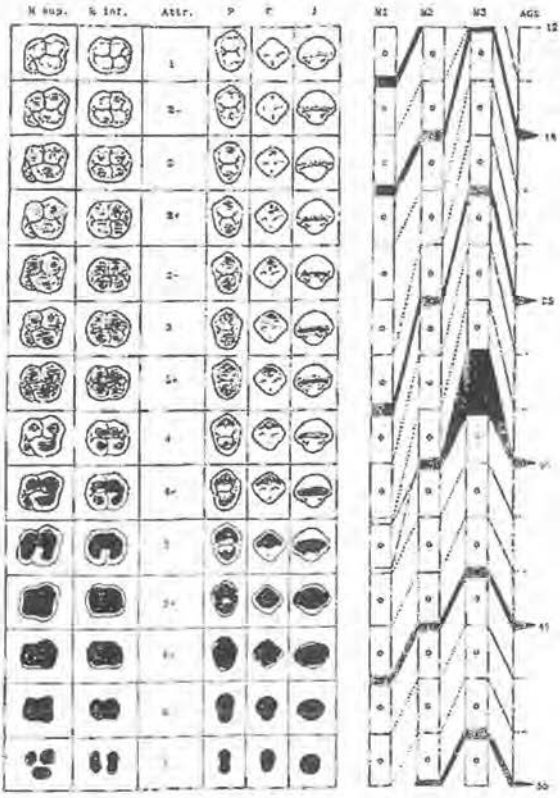


Fig. 5. Scheme: attrition of teeth and molars (after Pot 1988, 128).

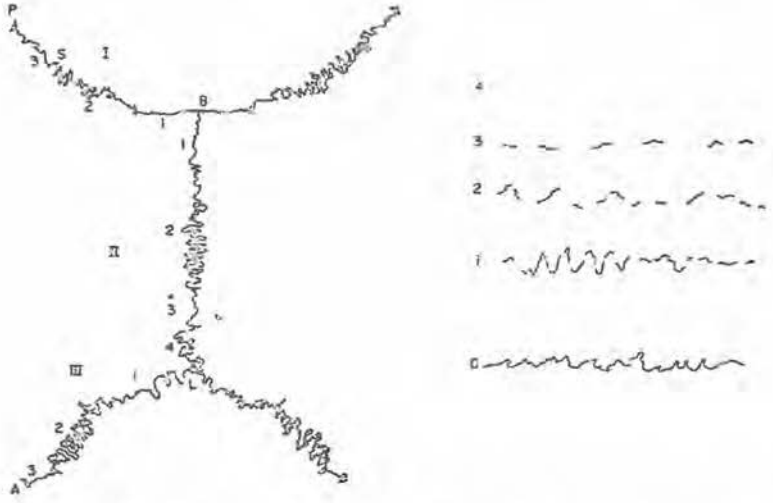


Fig. 6. Scheme: The obliteration of the cranial sutures (after Bass 1984, 33).

Head inv. no. Allard Pierson Museum 13.009 (Fig. 7)
The head, donated by the Tropenmuseum in Amsterdam, has been in the collection since 1992. Unfortunately, neither date nor provenances are known.
The head was rudely severed from the body: all cervical vertebrae are missing. The temporary dentition has fully erupted, but no tooth or molar has been shed. This state of dentition corresponds to an age of four years. The cranial sutures are open, confirming the age estimated by means of the teeth.
Owing to the youthful age, the sex cannot be ascertained.

Head inv. no. Allard Pierson Museum 10.841 (Fig. 8)
In 1984, an old lady delivered the head to the porter of the Allard Pierson Museum, saying: "It spreads a smell at home". Neither date nor provenance can be ascertained.
The head was violently severed from the body too. The cervical vertebrae are missing.
The temporary dentition has partially been shed. The X-ray photographs clearly show the M1's, the first four permanent molars. The state of dentition points to an age of seven years.
Here too, the sex cannot be ascertained.

Head inv. no. Allard Pierson Museum 10.842 (Fig. 9)
The head was delivered together with the previous one by the same old lady on the same recommendation. The head, of unknown provenance, is datable by the way its bandages are wrapped. It belongs to someone who lived in the Late Period, that is, between 525 B.C. and 332 B.C.
The upper part of the skull is missing.
The permanent dentition has fully erupted. Being agnatic, the four wisdom teeth are missing. They are said to be congenitally absent. There are no signs of caries or of periodontal bone losses. Teeth and molars show little attrition. All this points to an age at death of 18 or 19 years.
The clearly negative score of the morphological determination of sex shows the head to be a woman's.

Head inv. no. Allard Pierson Museum 13.011 (Fig. 10)
The head, donated by the Tropenmuseum, has been in the collection since 1992. Its date and provenance are unknown. Though it was somewhat rudely severed from the body, all cervical vertebrae are preserved.
The permanent dentition, including the four wisdom teeth, is entirely in occlusion. Here too, there are no signs of caries or of periodontal bone

Fig. 7. Head inv. no. Allard Pierson Museum 13.009.

Fig. 8. Head inv. no. Allard Pierson Museum 10.841.

Fig. 9. Head inv. no. Allard Pierson Museum 10.842.

Fig. 10. Head inv. no. Allard Pierson Museum 13.011.

Fig. 11. Head inv. no. Allard Pierson Museum 13.010.

losses. The occlusal faces have moderate attrition patterns. Therefore, the age at death must be between 20 and 25 years.
The positive result of morphological research of the skull shows the head to be a man's.

Head inv. no. Allard Pierson Museum 13.010 (Fig. 11)
The head was granted by the Tropenmuseum too. It has been on exhibition since 1992. Neither its date nor provenance can be ascertained. The cervical vertebrae are preserved.
All teeth and molars were lost long before death. The alveoli are completely closed. The cranial sutures have entirely grown together: C. Although the age at death is hard to estimate, the label 'old man' would seem to be near the mark. In ancient Egypt, this would refer to a man about 40 years old.
The skull has every characteristic of the male sex.

Fig. 12. Hand inv. no. Allard Pierson Museum 8.418a.

Hand inv. no. Allard Pierson Museum 8.418a (Fig. 12)
The small hand, donated by the Zoölogisch Museum, has been in the collection since 1969. It is undated and of unknown provenance. A picture of flawless mummification, it is excellently preserved. The nails are still on the fingers and even the lines on the palm and inside of fingers are clearly visible. The epiphyses have not fully fused. The X-ray photographs show the epiphyseal lines to have nearly disappeared.
The age at death must be around 15 years.

Fig. 13. Two left feet inv. no. Allard Pierson Museum 8.418b.

Two left feet inv. no. Allard Pierson Museum 8.418b (Fig. 13)
The feet were granted by the Zoölogisch Museum too. They are also undated and of unknown provenance. On each, the nails are partly preserved. All epiphyses have fully fused.
Their ages at death must be over 22 years.

Mummy inv. no. Allard Pierson Museum B 12.983 (= Leiden RMO L.XII.1) (Fig. 14)
In 1976, the collection was enriched by an entirely enwrapped mummy of unknown provenance, on permanent loan from the Rijksmuseum van Oudheden in Leiden. The style of enwrapping points to a date in the 20th or 21st dynasty, that is, somewhere in the 11th or 10th century B.C. Except for a few worn spots and local restorations of the bandages, its outside is undamaged. The shapes of the body-parts show clearly.
Excepting the right-lower wisdom tooth, the permanent dentition has

Fig. 14. Mummy inv. no. Allard Pierson Museum B 12.983.

fully erupted. The missing wisdom tooth is congenitally absent. The dentition has no caries. All teeth and molars have pronounced attrition spots on the occlusal faces, betraying an age at death between 25 and 30 years.
One of the X-ray photographs clearly shows a penis. The morphologies of skull and pelvis confirm the male sex.

Arbeitsgruppe Europäischer Anthropologen 1979, Empfehlungen für die Alters- und Geschlechtsdiagnose am Skelett, *Homo* 30, 1-32.

Bass, W.H. 1984, *Human Osteology*, Columbia.

Bouts, W.H.M./T.S. Constandse-Westermann/T. Pot/N. Verhoeven 1992, De gebitsresten uit de Broerenkerk, Zwolle, ca. 1800 AD, in: H. Clevis/T.S. Constandse-Westermann (eds.), *De doden vertellen*, Kampen.

Brothwell, D.R. 1972, *Digging up bones*, London.

Constandse-Westermann, T.S./L. Smits/W.H.M. Bouts 1995, *Syllabus Fysische Anthropologie*, Amsterdam.

Constandse-Westermann, T.S. in press, *Age estimation by dental attrition in an independently controlled early 19th century sample from Zwolle*, The Netherlands.

d'Hollosy, T. 1992, *De Doodgraver* (unpublished doctoral thesis, Albert Egges van Giffen Instituut voor pre- en protohistorische archeologie), Amsterdam.

Pot, T.J. 1988, Een gebitsonderzoek van het 18e-eeuwse grafveld St. Janskerkhof 1984, *Kroniek Bouwhistorisch en Archeologisch Onderzoek 's-Hertogenbosch* 1, 125-149.

Ubelaker, D.H. 1984, *Human skeletal remains*, Washington D.C.

J.F.W. Koens, Allard Pierson Museum, Oude Turfmarkt 127, NL-1012 GC Amsterdam, The Netherlands