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Health and demography in late 19th century Kimberley : a palaeopathological assessment

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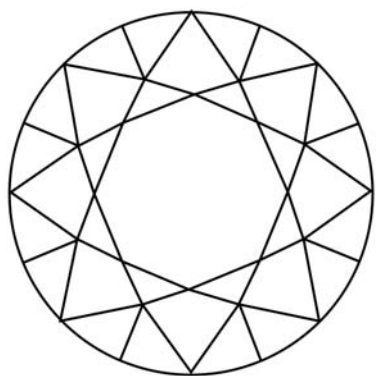
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CHAPTER 2

Materials and Methods

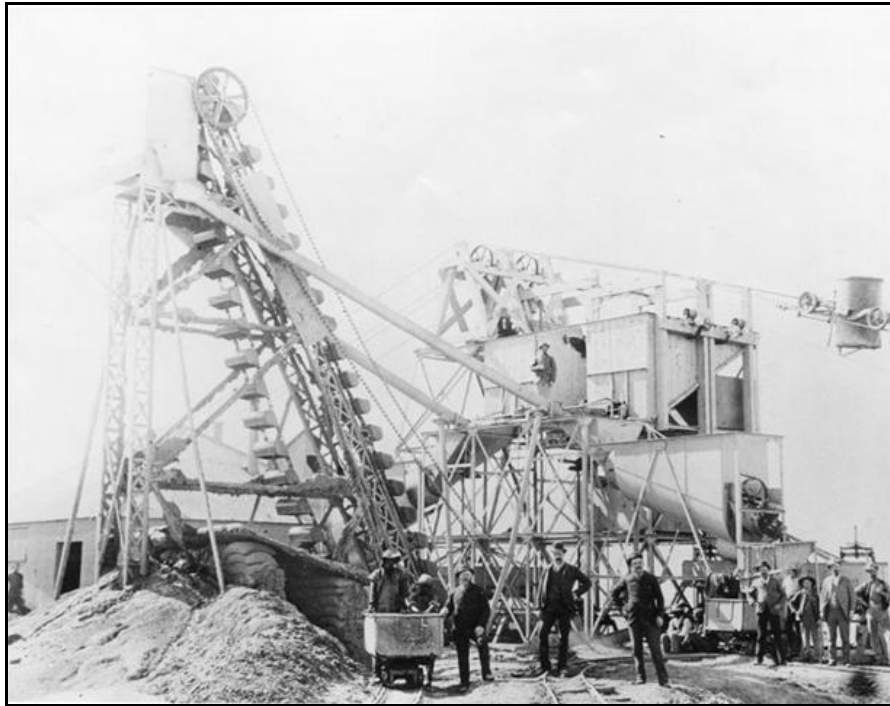
Modified from article accepted for publication as:

The history and health of a nineteenth-century migrant mine-worker population from

Kimberley, South Africa

A.E. Van der Merwe, D. Morris, M. Steyn, G.J.R. Maat

South African Archaeological Bulletin



Diamond washing machinery, 1886
(McGregor Museum Kimberley Photography nr.7617)



Jones Street, Kimberley, 1895
(McGregor Museum Kimberley Photography nr.954_002)

2.1 Excavation of the skeletal material

A permit for excavation of a sample of the damaged graves was granted to the McGregor Museum in Kimberley by the South African Heritage Resources Agency (SAHRA) (permit 80/03/04/004/51). Since the proposed storm-water drain was diverted away from its original route (continued trenching was likely to have doubled the impact), it was not necessary to exhume all of the 145 graves exposed by the trench: 15 were chosen for detailed investigation, including all instances where skeletons had been left exposed by the trenching and with a view to assessing variation along the length of the disturbance. Once the salvage was completed, the trench and excavated graves were re-filled with sand. The permit also provided for temporary storage of the human and artefact remains excavated from the site at the Museum. As was required by SAHRA, regular public meetings and press briefings were held in order to inform the community and public at large of the progress being made with the study.

Information on the disturbance and the preliminary findings were disseminated broadly via various media to the citizens of Kimberley and beyond. Responses by people claiming knowledge of the cemetery were sporadic and essentially irrelevant. Not in a single instance was any direct link with the graves in question asserted (Morris *et al.*, 2004).

Local community members claimed that the graves were those of ‘Skotse soldate’ – Scottish soldiers – until indications to the contrary were pointed out (i.e. the absence of coffins and the occurrence of glass beads, iron and copper bangles, and copper ear-rings associated with male skeletons). This underscored the crucial role of archaeology in substantiating the identity of the buried individuals, and disproved the presumption that communities would be reliable informants in all instances. An understanding emerged, however, that these graves could represent part of the collective experience of Kimberley’s underclass in the late 19th century, and a growing sense of responsibility amongst community members was palpable. Their involvement was an integral part of every stage of the ensuing investigation, with several public meetings being held to report on findings and proposals and to seek guidance or approval for successive interventions.

During the archaeological investigations, two sites were involved: firstly, the 180m-long trench itself, where the burials were disturbed, and secondly, a diamond washing plant halfway between the cemetery and Kenilworth village, where material dug out of the trench had been dumped in heaps before being bull-dozed to fill hollows or for processing in the

diamond screening operation. Exhumation of selected graves in the trench began in May 2003. It was clear that trenching had seriously damaged and displaced remains from the upper part of at least seven graves.

The dump-site was divided into ten sectors and screened accordingly (see Figure 2.1), resulting in the salvage of a large number of bones. Work there was called off in June 2003, when it was considered that most of the retrievable human remains had been recovered. Following excavation, all skeletal material and artefacts recovered were taken to the McGregor Museum for temporary storage in anticipation of further analysis. Traditional healers were given an opportunity to perform a cleansing ritual on the human remains at the museum.

All skeletal remains excavated from the trench were analyzed. In most cases the skeletons were complete and preservation was excellent. The remains recovered from the dumpsite near Kenilworth were analyzed separately using techniques specific to commingled remains as outlined by Ubelaker (2002), Byrd and Adams (2003) and L'Abbé (2005). Although some bones were damaged by the excavation machinery, the majority were well preserved and intact. All skeletal elements were counted taking left and right sides into account. Pair matching and articulation were done where possible and the minimum number of individuals represented by the remains recovered from the dump site was determined. Since these single skeletal elements may, in fact, not represent new individuals, but merely parts of incomplete skeletons excavated from the trench, they were not taken into account in the demographic and palaeopathological analyses of this study.

2.2 Accession numbers

Each grave was assigned a number and position in relation to a gap, which was probably a roadway between the graves: for example N8 (North 8), S2 (South 2), SE6 (South-East 6), etc. (see Figure 2.2). The accession numbers for the skeletons consisted of the grave designation followed by a number that corresponded to the quantity of skeletons removed from the grave, for example S2.2 would indicate the second skeleton in grave S2.

The dump was divided into eight sections (A – H), as can be seen in Figure 2.1, and skeletal elements were numbered according to the section from which they were excavated.

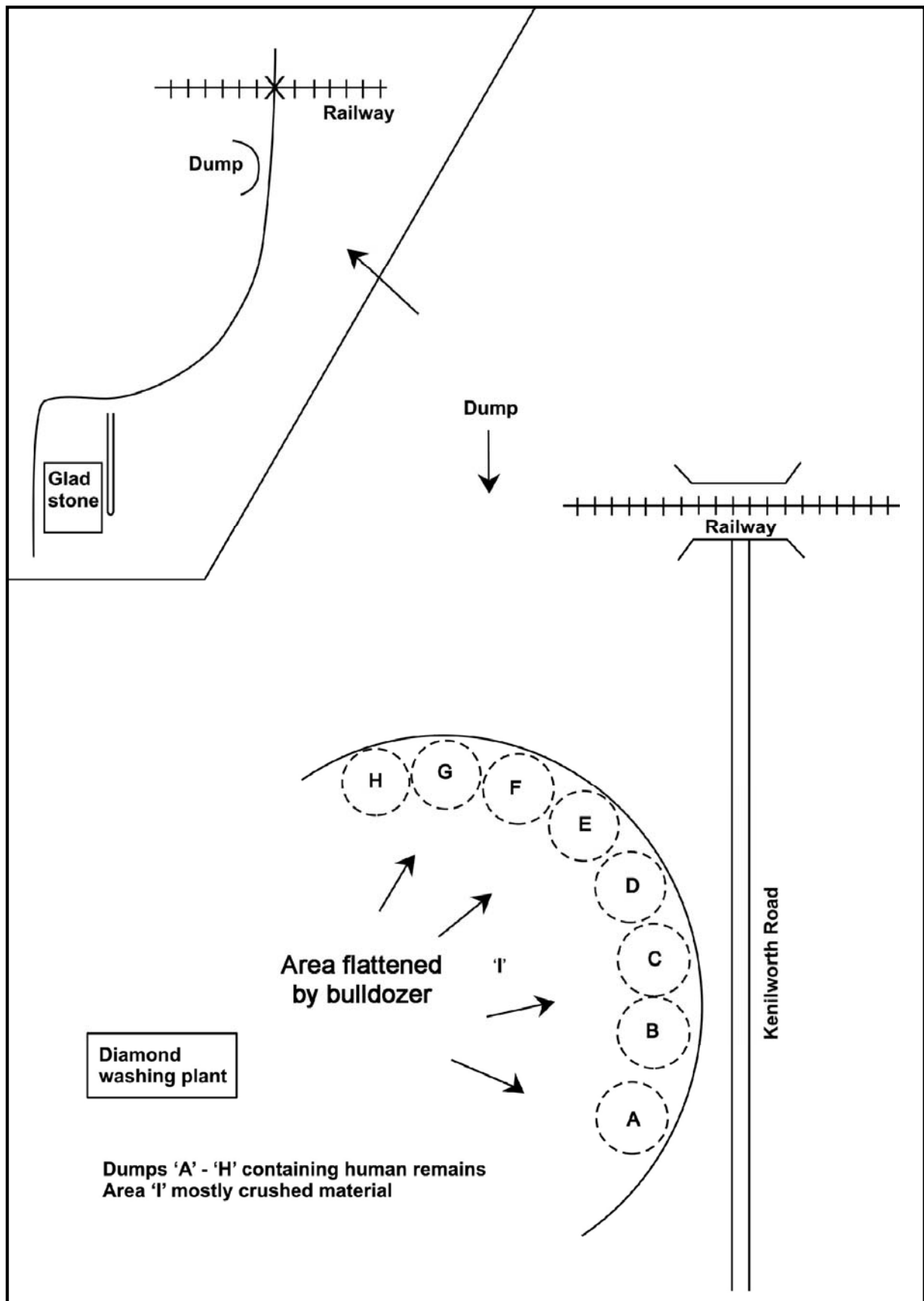


Figure 2.1 Map indicating the location of the dump site (top left corner) as well as the different areas of excavation A-H.

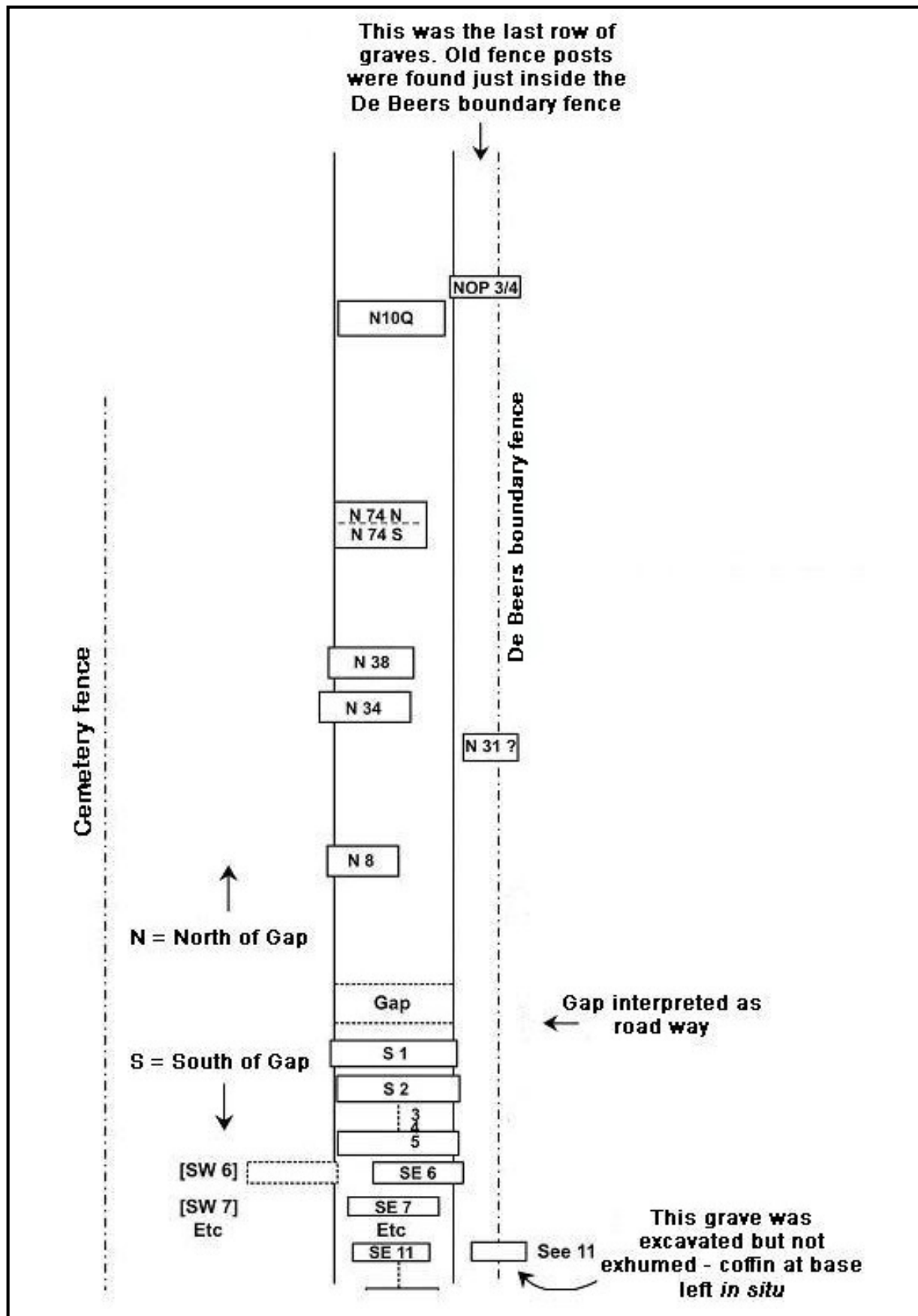


Figure 2.2 Map indicating the location of the graves in relation to the gap.

2.3 Methods*

2.3.1 Methods for sex determination

A combination of non-metric morphological skeletal characteristics, as well as several metric standards and discriminant functions derived from modern South African populations, was used to determine sex from adult skeletal remains in this study. The accuracy of sex determination of unknown skeletal material is highly dependant on the relative completeness as well as the preservation of the skeletal remains. Therefore, this multi-disciplinary approach increased the accuracy of sex determination in cases where non-metric traits could not be assessed or landmarks, from which measurements had to be taken, were damaged or missing.

It is also important to note that metric and non-metric differences between males and females are spread across a continuum, with a large amount of overlap between the sexes and only extreme cases showing exclusive male or female features (both morphologically and metrically). Thus, it is advisable to use more than one technique in order to obtain the most reliable results (Meindl *et al.*, 1985; Loth & İşcan, 2000b).

Sex determination: Morphological techniques

Non-metric morphological techniques used to determine the sex of an individual consist of the visual assessment of the morphology of a certain bony feature, which differs between sexes in shape or size. The degree of sexual dimorphism between the sexes dictates the accuracy of these features as a means of sex determination. These morphological features are more than often very effective since they are developmental in nature. For example, the expansion of the subpubic angle is a pelvic feature that develops during adolescence to accommodate childbirth (Loth & İşcan, 2000b). The only difficulty with these methods is that experience is needed in order to judge what is relatively large or small, or narrow or wide, for the specific population group being studied (Meindl *et al.*, 1985; Loth & İşcan, 2000b).

The most diagnostic elements for sex determination by non-metric means are the skull and pelvis (Berrizbeitia, 1989; Loth & İşcan, 2000b). Cranial features such as a prominent supraorbital torus, sloping forehead (when viewed laterally), prominent external occipital

* Modified from A.E. van der Merwe (2007)

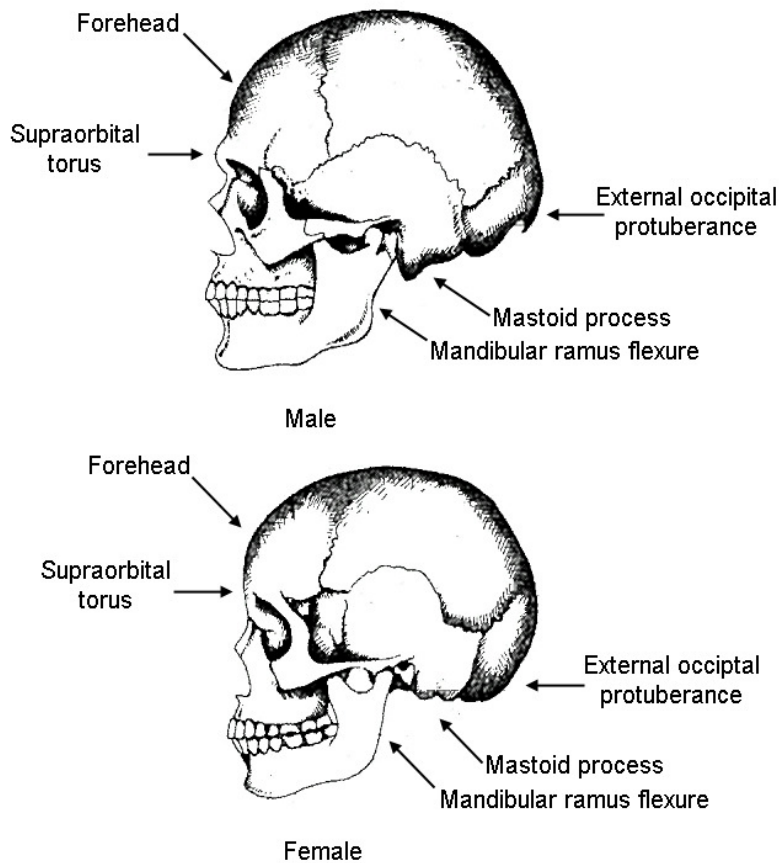


Figure 2.3 Morphological sex differences as can be observed in the skull (modified from Steyn *et al.*, 2004).

protuberance, large mastoid processes and rounded orbital margins, suggest possible masculine development (see Figure 2.3). Feminine development is indicated by a small supraorbital torus and straight forehead, a less prominent external occipital protuberance, small mastoid processes and sharp orbital margins (De Villiers, 1968; Krogman & İşcan, 1986; Loth & İşcan, 2000b). Several characteristics of the mandible, such as the size and shape of the mandibular condyles, the shape of the chin (squared or angular), degree of gonial

eversion, as well as mandibular ramus flexure, can also aid in sex determination (De Villiers, 1968; Krogman & İşcan, 1986; Kemkes-Grottenthaler *et al.*, 2002).

Some of these methods are more accurate than others and these differences are often population specific. For example, Loth and Henneberg (1996) found that mandibular ramus flexure at the level of the occlusal plane is a good indicator of sex in the South African population, with an average accuracy of 94%. On the other hand Kemkes-Grottenthaler *et al.* (2002) indicated a mere 59% overall accuracy in sex determination when mandibular ramus flexure was applied to a German forensic and archaeological sample for the purpose of sex determination. This study also indicated that the accuracy of mandibular non-metric morphological features (degree of mandibular ramus flexure and gonial eversion) is greatly influenced by antemortem tooth loss (Kemkes-Grottenthaler *et al.*, 2002). Nevertheless, mandibular ramus flexure, gonial eversion, as well as the shape and size of the mandibular condyles were assessed in situations where only the mandible was available or in conjunction with other methods and features.

In the pelvis (see Figure 2.4), non-metric features, such as a wide subpubic angle, wide sciatic notches, a round pelvic inlet, a broad and flat sacrum, elongated pubic bones, and a pre-auricular sulcus suggest possible feminine development (Day, 1975; Flander, 1978; St Hoyme & İşcan, 1989; Patriquin *et al.*, 2003). Masculine developmental characteristics include a narrow subpubic angle and sciatic notches, a heart-shaped pelvic inlet, a narrow and curved sacrum, as well as triangular pubic bones (Loth & İşcan, 2000b; Patriquin *et al.*, 2003). A study by Patriquin *et al.* (2003) indicated that the assessment of the shape of the greater sciatic notches, as well as the pubic bones, yielded the most dependable results in the black South African population.

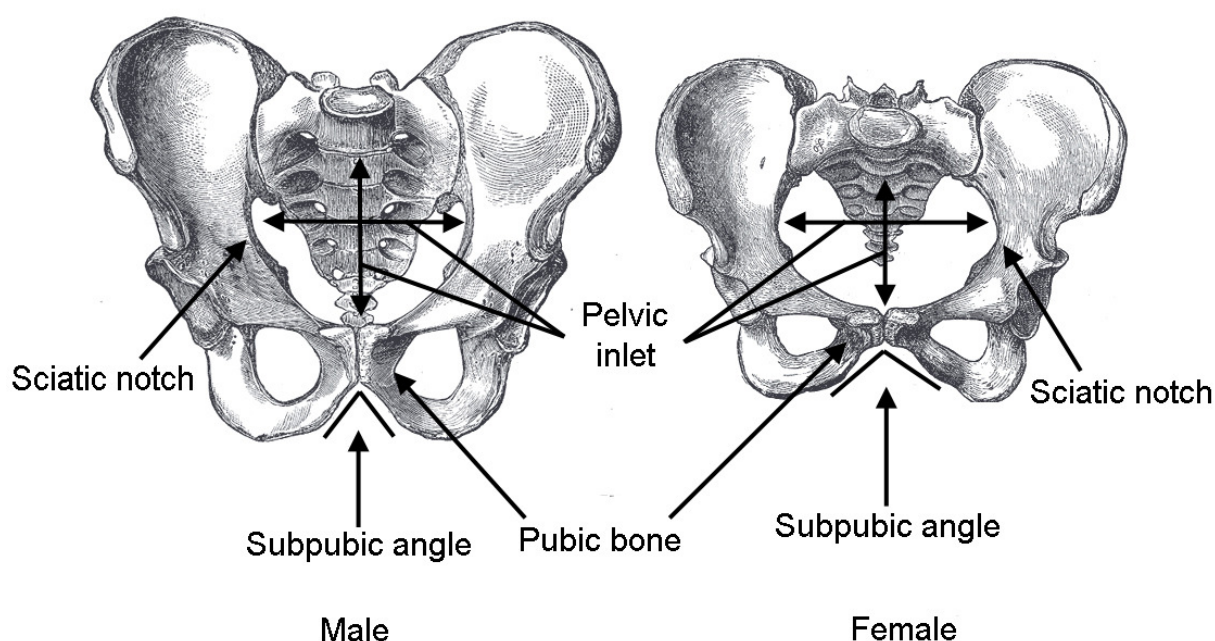


Figure 2.4 Morphological sex differences as can be observed in the pelvis.

Sex determination: osteometric techniques

Although sex differences in morphological features are clearly visible on the skull and pelvis, they are not easily visualized in other parts of the human skeleton, such as the long bones. Accordingly, metric investigation of long bones is needed to determine differences in dimensions between male and female individuals. The metric technique of sex determination is based on the fact that within various population groups, males tend to be more robust than females (Meindl *et al.*, 1985; St Hoyme & İşcan, 1989; Loth & İşcan, 2000b). Unfortunately, the drawbacks of these methods are that the formulae are population specific and the metric overlap between the sexes can be as high as 85% (Steyn

& İşcan, 1997; Loth & İşcan, 2000b; Franklin *et al.*, 2005). Additionally, all landmarks needed to make the necessary measurements should be intact.

A number of metric techniques are available for the South African Black population. Standards for sex determination of Black South Africans from single long bone measurements are available for the humerus, femur and tibia (Berrizbeitia, 1989; Loth & İşcan, 2000b; Asala *et al.*, 2004). Of these measurements, the maximum diameter of the femoral and humeral heads prove to be the most accurate (91%) (Asala, 2001). Other dimensions such as humeral epicondylar breadth, femoral midshaft circumference, femoral distal breadth, proximal tibial breadth and tibial circumference at the nutrient foramen, are between 85.3% and 88.6% accurate (Kieser *et al.*, 1992; Loth & İşcan, 2000b). Franklin *et al.* (2005) recently developed cranial multivariate discriminant functions for the Black South African population that are 75-80% accurate, with bizygomatic breadth, cranial length, and cranial height as the most sexually dimorphic.

Taking the geographical location of Kimberley into consideration, it can be expected that some of the skeletal remains within this population may belong to individuals of KhoeSan ancestry. As osteometric techniques are population specific, sex determination based on standards for South African Negroids may not prove very useful for these individuals (De Villiers, 1968; Morris, 1984; Meindl *et al.*, 1985; Patriquin *et al.*, 2003).

Sex determination: juvenile skeletal remains

Sex differences in the skeleton are hard to visualize and often ambiguous before puberty, making sex determination in young individuals extremely difficult (Krogman & İşcan, 1986; St Hoyme & İşcan, 1989; Loth & İşcan, 2000b; Schutkowski, 1993; Loth & Henneberg, 2001). Nevertheless, some features such as the shape of the mandible, depth of the greater sciatic notch and the curvature of the iliac crest can be successful in the determination of sex for individuals up to five years of age (Schutkowski, 1993; Loth & İşcan, 2000b; Loth & Henneberg, 2001). Since techniques developed for sex determination in juvenile skeletal remains tend to be unreliable, no attempts were made to determine sex from immature skeletons in this study.

2.3.2 *Methods for age determination*

The human lifespan can be divided into four distinct phases, i.e. infancy (0-3 years), childhood (4 to approximately 12 years), adolescence (13 to approximately 16 years) and adulthood (Scheuer & Black, 2004). Various techniques for age determination exist for each of these groups and they will be discussed accordingly.

Age determination: infants and childhood

Prenatal and infant age can often be metrically determined from the diaphyseal lengths of bones such as the clavicles, humeri, ulnae, radii and femora. These methods are relatively accurate, and can provide an age estimate to within a month of the infant's true age at death (Ubelaker, 1987; Kosa, 1989; Loth & İşcan, 2000a; Scheuer & Black, 2000).

Dental development and eruption is the most reliable method for estimating the age of children (Massler *et al.*, 1941; Ubelaker, 1987; Ubelaker, 1989; Johnston & Zimmer, 1989; Loth & İşcan, 2000a; Scheuer & Black, 2000; Foti *et al.*, 2003). Teeth are consistent in the sequence and rate of eruption and are therefore a very reliable indicator of age (Loth & İşcan, 2000a; Foti *et al.*, 2003). Deciduous lower central incisors start erupting between six and seven months of age, and a full set of deciduous teeth is visible around three years of age (Ubelaker, 1987; Ubelaker, 1989; Scheuer & Black, 2000). A chart developed by Ubelaker (1987) was used to estimate age at death in cases where deciduous tooth eruption had commenced. Ubelaker's (1987) eruption chart is of great value, especially when estimating the age of individuals between five months in utero and four years, since it can estimate age with relative accuracy, based on dental development and eruption of deciduous teeth. After four years of age, the age estimations based on the dental eruption of permanent teeth gets wider and it is therefore suggested that this method is used in association with other aging methods in the older age groups.

Other aging methods include fusion of the various bones of the skull and mandible. For example, union of the mandible at the mandibular symphysis occurs between six and nine months, while development of the tympanic ring and its eventual fusion with the temporal bone, closure of the fontanelles, and fusion of the metopic suture all normally occur around two to three years of age (Weaver, 1979; Becker, 1986; Johnston & Zimmer, 1989; Scheuer & Black, 2000). Development of the vertebral column is also a valuable indicator of age. Fusion of the two segments of the neural arch normally occurs during the

first year of life and fusion of the vertebral arch to the vertebral body (neurocentral fusion) usually takes place between the ages of two and three years (Scheuer & Black, 2000).

The diaphyseal lengths of long bones were used as an indicator of juvenile age in conjunction with estimates given by tooth eruption charts and stages of bone epiphyseal fusion (Scheuer & Black, 2000). No x-rays were used in the study of dental eruption; all investigations were done through macroscopic visual assessment only. Methods, such as the assessment of fontanelle closure, could not be used due to the young age of the individuals in this study and the fragmentary condition of the remains.

Age determination: adolescence

Two methods were used for the estimation of age at death for adolescents: the eruption of permanent teeth and epiphyseal closure (Scheuer & Black, 2000; Foti *et al.*, 2003). Although the majority of permanent teeth erupt before the age of 11 years, canine and second molar eruption, which occurs around 11 to 12 years of age, can aid in classifying a non-adult as an adolescent (Massler *et al.*, 1941; Hillson, 1998; Loth & İşcan, 2000a).

Epiphyseal union is the most important feature to investigate during age determination in adolescents. Bone formation from ossification centres proceeds in an organized manner, with a specific sequence and timing, to form diaphyses and epiphyses. During adolescence, the cartilage structure of the metaphyses is gradually ossified, eventually leading to fusion between the diaphysis and epiphysis. When considering the major long bones, epiphyseal union starts at the elbow (distal humerus and proximal radius and ulna) between 11 and 17 years of age. It then proceeds throughout the skeleton in an orderly fashion, with the medial clavicle being the last epiphysis to unite between the ages of 16 and 30 years (Krogman & İşcan, 1986; Ubelaker, 1989; Loth & İşcan, 2000a, Scheuer & Black, 2000).

Union of other bones and epiphyses, such as the union of the primary elements of the os coxa (ilium, ischium and pubis), occurring between 11 and 17 years of age and fusion of the iliac crest and ischial tuberosity, between 17 and 23 years and 16 and 18 years of age respectively, can also be investigated. Fusion of epiphyseal ends of the metacarpals and phalanges occur between 14 and 16 years of age; the lesser trochanter of the femur between the ages of 16 and 17 years; the medial epicondyle of the humerus unite between 12 and 17 years of age; and the auricular surface of the sacrum between 12 and 14 years of age, to name but a few (Krogman & İşcan, 1986; Scheuer & Black, 2000).

Although the ossification of epiphyses proceeds in a predictable sequence, the rate at which it proceeds can be influenced by factors such as nutritional status, climate and sex (Scheuer & Black, 2000). Therefore, more than one method was utilized to estimate age at death wherever possible.

Age determination: adulthood

Once adulthood has been reached and growth and development had ceased, skeletal structures continue to be maintained and modified in a process referred to as bone remodeling. The rate of remodeling is highly variable, since it is greatly influenced by the environment, genetics and human behaviour (Loth & İşcan, 2000a). This variability makes the estimation of age from adult skeletal material extremely challenging. Therefore, it is suggested that more than one method of age determination should be employed whenever possible in order to increase accuracy.

Several relatively accurate methods are available to estimate the age of young adults, including epiphyseal fusion of the sternal end of the clavicle, ossification of the vertebral epiphyseal rings, as well as unity between the various parts of the scapula (Krogman & İşcan, 1986; Scheuer & Black, 2000). The epiphyses of the sternal ends of the clavicles fuse between 16 and 30 years of age (Krogman & İşcan, 1986; Scheuer & Black, 2000). In the vertebral column, vertebral epiphyseal rings unite with the vertebral body in individuals older than 18 years. The various parts of the scapula, including the acromion, vertebral margin and inferior angle, unite between the ages of 18 and 23 years (Krogman & İşcan, 1986).

Estimation of age from the sternal ends of the ribs is currently the most reliable, non-intrusive technique available for age estimation of older adult skeletal remains (Loth & İşcan, 1994; Oetl  & Steyn, 2000). The ribs of the remains excavated from the trench were very well preserved and therefore the investigation of sternal rib ends was the method of choice in this study (Loth & İşcan, 2000a). The sternal ends of the ribs are not affected by physical activity or environmental conditions and therefore remodeling in this region proceeds at a relatively constant rate as age increases, provided that no pathological conditions such as DISH are present in those being investigated (İşcan & Loth, 1986; Loth & İşcan, 1989; Oetl  & Steyn, 2000). This method was first developed by Loth and İşcan (1989) and includes assessment of pit depth, shape, rim and wall configuration of the sternal end of the 4th rib (İşcan & Loth, 1986; Loth & İşcan, 1989; Loth & İşcan, 1994;

Oettlé & Steyn, 2000). Oettlé and Steyn (2000) developed standards for determining age at death from sternal rib ends of the South African Negroid population. They obtained the same reliable result as was seen by Loth and İşcan (1989). Ribs depicting the different stages, as well as written descriptions of bone changes as described by Oettlé and Steyn (2000), were used in this study.

Other techniques employed to estimate the age of adults in this study included the assessment of changes present on the pubic symphysis, the closure of ectocranial sutures, and dental wear on the first, second and third molars (Lovejoy *et al.*, 1985; Brothwell, 1989; Masset, 1989; Brooks & Suchey, 1990; Loth & İşcan, 1994; Loth & İşcan, 2000a).

Other methods available for the estimation of age from adult skeletal material, such as bone histology and dental microscopy, were not used in this study due to limited funds, time restrictions and the intrusive nature of some of these methods.

2.3.3 Methods for the estimation of antemortem stature

The estimation of antemortem stature provides a factor of individualization for each skeleton investigated. The estimation of antemortem stature is based on the relationships between skeletal elements and total body length (Sjøvold, 2000). Thus, it can be assumed that the larger the skeletal elements are, the taller the individual.

For the purpose of this study, regression formulae and soft tissue correction factors for the estimation of antemortem stature for South African males and females, developed by Lundy and Feldesman (1987), were used. Long bones, which add to the body length (tibia, fibula, and femur), have been reported to yield more accurate estimations than those of the arm. Of single bone measurements, bicondylar length of the femur is the most reliable (Lundy & Feldesman, 1987; Wilson & Lundy, 1994). Accordingly, femoral measurements were used to estimate antemortem stature in this study.

2.3.4 Macroscopic evaluation of palaeopathology

All bones, regardless of their preservation, were visually assessed for any macroscopic indication of pathological bone alterations. Diagnoses were based on the bony characteristics of the defects as well as the distribution of the lesions across the skeleton. All lesions were compared to standard palaeopathological texts and photographs and illustrations found in the publications of Steinbock (1976), Roberts and Manchester (1995),

Mann and Murphy (1990), Larsen (1997), Aufderheide and Rodríguez-Martín (1998) and Ortner (2003).

Where possible, Chi-square tests were performed to determine if significant differences existed between the Gladstone sample and comparative populations in terms of pathological lesion prevalence and the prevalence of lesions between males and females.

Methods used to assess the dental health of individuals in the Gladstone skeletal sample as well as craniometric techniques employed to determine the possible ancestry of these unknown individuals will be discussed in Chapters seven and nine, respectively.

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