Trauma and amputations in 19th century miners from Kimberley, South Africa

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Abstract

Trauma is the result of violent, accidental or therapeutic events that cause physical or psychological injury. The frequencies and types of trauma within a population can give important information regarding their lifestyle as well as the quantity and quality of medical care available to them. The purpose of this study was to assess the incidence of trauma in the Gladstone sample population with regards to the presence of interpersonal violence, a hazardous working environment, strenuous working requirements and the availability of medical care. The individuals studied here were diamond miners from Kimberley, dating to the late 19th century. A total of 107 well preserved skeletons were excavated from unmarked graves after accidental discovery. This sample included 86 males, 15 females and 6 individuals of unknown sex. The majority of individuals (71%) were between 19 and 45 years of age. The remains were most likely those of migrant mine workers of low socio-economic status who had passed away at the local hospitals. All bones were visually assessed for macroscopic indications of traumatic bone alterations and compared to standard palaeopathological texts and photographs. A total of 27% (n = 28) of the individuals in the sample presented with well-healed, healing or perimortem fractures. Fractures to the skull encompassed 49% (n=20) of all the fractures that were observed. A total of six (6%) amputations were noted. Spondylolysis was observed in 7% (n = 7) of the individuals within the sample and longstanding subluxation was noted in two individuals. The high incidences of cranial fractures within this population are suggestive of high levels of interpersonal violence, while long bone fractures, spondylolysis and evidence of longstanding subluxations are indicative of the strenuous work requirements and the high-risk environment to which these individuals were exposed. When considering the presence of well-reduced fractures and healed amputations, it seems that adequate medical care was available to at least some members of this community.

Keywords: Skeletal trauma, fractures, amputations, spondylolysis, Kimberley, Palaeopathology

Introduction

Diamonds were first discovered on the Colesberg Kopje (today known as the “big hole”in Kimberley, South Africa) in 1871. By August that year approximately 800 claims had been cut out of Colesberg Kopje and between 2 000 and 3 000 men were working there (Roberts, 1976). Colesberg Kopje was soon to become Kimberley, the first large inland settlement in South Africa to be developed away from a natural water source. Kimberley was the first town in South Africa to be completely dependant on mineral wealth, the first to experience a strike, and the first town to have its streets lit by electricity (Roberts, 1976).

During the late 19th century, historical documents indicate that "Native" individuals flooded into Kimberley from surrounding areas and neighbouring countries in search of work on the mines (Stoney, 1900). A census was held in 1898 and it was established that there were approximately 14 500 Europeans and 26 500 Black labourers living and working in Kimberley (Stoney, 1900). The number of Black labourers in Kimberley were extremely changeable and dependant on the demand for labour in the mines (Stoney, 1900; McNish, 1970; Jochelson, 2001). Black labourers "from almost every tribe south of the Zambezi" (Roberts, 1976: 15) were brought to Kimberley to work, and when their contract expired, returned to their "kraals" (McNish, 1970; Leary, 1891; Roberts, 1976:294).

Mining was a labour- intensive task, fresh fruit and vegetables were scarce, comfortable accommodation was restricted and medical care limited. All of these factors contributed to the high incidence of disease and injury described in archival documents from Kimberley Hospital (Cape of Good Hope Votes and Proceedings of Parliament, 1899; Stoney, 1900; Roberts, 1976; Van der Merwe, 2007).

Labourers received medical attention from the Kimberley and compound hospitals. In the case of death, the patient was wrapped in blankets and received a pauper’s burial, without a coffin at the Gladstone or other surrounding cemeteries (Swanepoel, 2003).

The Gladstone cemetery was officially opened on the 24th of March 1883 in which half of the ground was devoted to African burials. Nearly 5000 African individuals were buried at the Gladstone cemetery between June 24, 1887 and November 28, 1892. Unfortunately, no registers were available for the period between 1892 and 1900. However, some documents indicate that a total of 611 pauper burials took place between February and June 1900 (Swanepoel, 2003).

In 1897, Gladstone cemetery was enlarged with an extra strip of land, given by the De Beers mining company, on the eastern side (Figure 1) of the cemetery. The cemetery was closed in mid-1900, and opened again in April 1902 for European internments only. In 2003, the Sol Plaatjie municipality uncovered several unmarked graves in the above-mentioned eastern area, these remains became the focus point of this research in which traumatic injuries of diamond mine workers was assessed.

Trauma is the result of intentional or accidental encounters with animals, humans, and cultural hazards found in and around the home and working place, or therapeutic procedures that cause injury to a person (psychologically or physically) (Merbs, 1989; Lovell, 1997;Walker, 2001; Neri & Lancellotti, 2004). The assessment of the prevalence of trauma in an archaeological population is difficult to interpret, since the investigation of dry bone poses several limitations. Determining trauma frequency rates is often hindered by poor preservation and fragmentation of skeletal remains. Perimortem trauma often mimics post depositional damage and consequently passes undetected. This is also the case in well remodelled fractures (Grauer & Roberts, 1996).

Notwithstanding the limitations, the assessment of trauma within a population can still yield considerable information (Ortner, 2003). The prevalence and location of traumatic lesions are influenced by intrinsic factors such as age and sex, as well as extrinsic factors relating to culture (Glencross & Stuart-Macadam, 2000; Lovell, 1997; Ortner, 2003). Different environmental conditions and cultural practices expose individuals to specific traumatic hazards. Therefore, the study of the prevalence of trauma within a population can aid in reconstructing the occupational and environmental stresses the sample was exposed to, as well as various aspects of cultural behaviour (Steinbock, 1976; Jurmain & Bellifemine, 1997; Kilgore *et al*., 1997; Lovell, 1997; Ortner, 2003). By determining whether the fracture is healed, unhealed or infected, conclusions can be made regarding the availability of medical care and the accommodation of injured individuals within the community (Steinbock, 1976; Kilgore *et al*., 1997; Neri & Lancellotti, 2004).

The purpose of this study was to assess the incidence of trauma in the skeletal population exhumed from the Gladstone cemetery. The prevalence, nature and location of fractures, amputations and longstanding subluxations will be interpreted and discussed with regard to the availability of medical care at the close of the 19th century, levels of interpersonal violence and exposure to a hazardous working environment (i.e. mining).

Materials and Methods

In April 2003, numerous unmarked graves were disturbed outside the fenced Gladstone cemetery. The McGregor Museum in Kimberley was given permission by the South African Heritage Resources Agency (SAHRA) to exhume and investigate the human remains.

The remains are believed to be those of migrant mine workers who passed away at the surrounding hospitals in Kimberley between 1897 and 1900 (Van der Merwe, 2007). These individuals were of low socio-economic status, malnourished, and exposed to a high pathogen load (Van der Merwe, 2007). The low socio-economic status of these individuals was clearly illustrated by their burial positions with the majority of persons being laid to rest without coffins and in graves containing more than one individual.

Standard anthropometric techniques such as morphological changes of the sternal ends of the ribs, changes to the pubic symphysis, cranial suture closure as well as cranial and pelvic morphology and discriminant functions were used to determine the age and sex of all individuals exhumed from the trench (e.g., De Villiers, 1968; Krogman & İşcan, 1986; Hillson, 1998; Oettlé & Steyn, 2000; Asala, 2001; Franklin *et al*., 2005).

A total of 86 males, 15 females and 6 individuals of unknown sex were excavated from the trench. The majority of these individuals (71%) were between 19 and 45 years of age, while the rest comprised of one premature baby, two infants (both younger than one year of age), eight juveniles (11 - 19 years) and 10 individuals older than 45 years of age. Due to the fragmentary condition of some of the remains investigated in this study, eight individuals could only be described as being adult and two were of unknown age. With the exception of the last mentioned 10 skeletons, all others were remarkably well preserved and complete.

All bones were visually assessed for macroscopic indications of traumatic bone alterations and diagnoses were made based on the bony characteristics of these defects. All lesions were compared to standard palaeopathological texts and photographs as can be found in Steinbock (1976), Roberts and Manchester (1995), Mann and Murphy (1996), Larsen (1997), Aufderheide and Rodríguez-Martin (1998) and Ortner (2003). X-rays were not part of the routine investigation due to time and financial constraints.

Special attention was also given to distinguish between perimortem trauma and damage caused to the remains by the trenching machinery. Perimortem fractures were identified by the absence of signs of healing. Fracture lines are generally sharp and smooth and associated with radiating lines (hairline fractures) at the site of trauma. The fractured ends are also as discoloured and weathered as the adjacent bone, and it could thus be determined whether unhealed fractures were the result of damage by the trenching machinery or perimortem trauma (Steinbock 1976; Roberts and Manchester, 1995; Mann and Murphy, 1996; Ortner, 2003).

The prevalence of skeletal lesions indicative of trauma was determined in relation to the number of individuals within the sample population, as well as the number of bony elements investigated. These frequencies were compared to other studies conducted in South-Africa and Northern Chile. (Eisenstein, 1978; Standen & Arriaza, 2000). Chi-squared tests were carried out in order to compare the prevalence of traumatic lesions between these comparative groups and the Gladstone sample. Chi-squared tests were also performed in order to test for significant differences in the frequency of lesions between males and females, where possible.

Results

Fractures

A total of 27% (n = 28) of the individuals excavated from the trench (Table 1) presented with well-healed, healing or perimortem fractures. Twenty-four of these were male and four female. No significant difference could be found in the frequency of fractures between the sexes (χ^2 = 0.006, p-value >0.2).

A total of 36 fractured bones were observed (Table 2). These included 15 fractured crania, five femoral fractures, four fractured ribs, two fractured fibulae, radii, ulnae and claviculae as well as one fractured tibia, os coxa, humerus and vertebra. It is clear that the majority of fractures occurred on the skulls, with 18% of crania presenting with a lesion (s).

Single fractures were noted in 19 individuals, while six people had two fractures, two had three fractures each, and one male had a total of four fractures. A summary of this information can be seen in Table 3.

Eight perimortem fractures were observed in five skeletons. Several well-healed and remodelled fractures were also noted. These included a parry fracture (Figure 2), also known as a defence fracture since it is usually the consequence of a blow to the ulna when lifting the arm in a defence position (Mann & Murphy, 1990; Smith, 1996). A radial fracture (Figure 3) and a Pott's fracture (Figure 4) were also noted. A sprinter's fracture was recorded in a male between 15 and 18 years of age (Figure 5). This is an avulsion fracture of the anterior inferior iliac spine caused by sudden strain on the rectus femoris muscle (Merbs, 1989).

Fractures to the skull comprised 49% (n=20) of observed traumatic injuries and were by far were the most frequently found in the sample. These included six healed fractures of the nasal bone, one of the orbital margin, four fractures of the zygomatic bone, four depressed fractures of the frontal bone (Figures 6 and 7) and five of the parietal bone. These lesions were all of relatively similar size and shape and are suggestive of blunt force trauma.

The limbs were the second most affected bone to present with fractures, particularly femoral fractures (n =5, 3%). Only one (1%) tibial and two (1%) fibular fractures were observed. The upper limbs were less affected than the lower limbs with the humerus (n=1, 1%), radius (n=2, 1%) and ulna (n=2, 1%) demonstrating 5 (1% of investigated bones) fractures in total. No significant difference were observed between fractured bones of the upper or lower limbs (χ^2 = 0.502, p-value>0.2). Furthermore four rib fractures, two fractured clavicles and one vertebral fracture was also observed.

Spondylolysis and subluxation

Spondylolysis, which refers to fracture of the vertebral arch resulting in bilateral separation of the pars interarticularis, was observed in 6% (n = 7) of the sample (Table 4). There was no significant difference in the occurrence of this lesion between the sexes (χ^2 = 0.001, p-value>0.2). All of the lesions showed bilateral separation of the neural arch (Figure 8) and occurred on L4 (n = 3) and L5 (n = 4). Spondylolysis associated with spondylolisthesis was seen in one individual (GLD NOP 3/4.1). These injuries are often associated with strenuous physical labour, and therefore were expected to be present among these diamond miners.

Another injury indicative of heavy, repetitive labour with little medical intervention would be longstanding subluxation of joints, which was noted in two individuals (Table 5). The first was in the right sternoclavicular joint of individual GLD S2.6, resulting in remodelling and the formation of an articulation facet on the inferior surface of the sternal end of the clavicle. The second was found in a 40 to 55 year old male (GLD N74.5). A fracture of the left humerus was most likely the cause for this subluxation. The non-reduced fracture caused shortening of the humeral shaft as well as lateral rotation of the distal end of the humerus. In order to attain some functionality of the arm, subluxation of the shoulder joint occurred (Figure 9). The subluxation caused a false articulation facet to develop between the acromion and the posterior surface of the humeral head. This most probably led to an unstable shoulder joint, with the humerus in a position of hyperextension and posterolateral rotation.

Amputations

While the dislocation of joints may have not received immediate care, evidence of medical intervention was noted in this sample with 6 individuals exhibiting healed and unhealed amputations. This included one amputation through the femur, two through the tibia and fibula, one of the foot at the ankle, one through the humerus and one through the proximal radius and ulna (Table 5).

A 30 - 35 year old male (GLD N38.2) presented with an amputation of the right femur, about 106 mm from the proximal end (Figure 10). This person did not survive the procedure, as the amputated limb was buried with the individual and the amputation showed no indication of healing. The reason for the amputation had most likely been a compound fracture of the distal femur (as observed during analyses of the remains) that had become severely infected, as indicated by the infectious new bone growth present around the fracture.

Examples of well-healed amputations included an amputation of the left tibia, fibula and foot (GLD N34.3) just distal to the proximal end of the left tibia and fibula (Figure 11), as well as an amputation of the left foot (GLD S2.6). These amputations developed into the very characteristic peg shape associated with healed amputations, accompanied by closure of the medullary cavity (Mann & Murphy, 1990). Ankylosis of the distal ends of the left tibia and fibula occurred, following amputation of the foot.

Apart from the above-mentioned individuals who showed signs of amputations, three amputated limbs were excavated. These amputations were of great interest, since some yielded information regarding the reason for the procedure.

The first amputated limb was composed of a left tibia, fibula and foot amputated just distal to the knee (GLD N1.8(b)). The limb was found in a coffin with the complete skeleton of a 15 to 19 year old female. The cause for this amputation was severe infection of the lower leg, which had most likely commenced at the foot. Serious signs of infection with extensive remodelling and new bone formation of the left talus and calcaneus were observed along with signs of infectious new bone formation on the tibia and fibula. A radius and ulna, amputated just distal to the elbow (GLD S2.7c), was also recorded. Signs of infectious new bone formation were present on the proximal half of the bones. The last amputated element was a humerus (GLD S2.7b). This fragment of bone was amputated at both the distal and proximal ends, as can be seen in Figure 12. The initial distal amputation had most likely become infected shortly after the procedure was done and the amputation was accordingly extended proximally.

Discussion

Evidence of interpersonal violence and strenuous activity among 19th century migrant labourers

The sample comprised of individuals who passed away at the surrounding hospitals in Kimberley and a high prevalence of pathologies, in general, can accordingly be expected. The frequency of disease in this sample should therefore be interpreted with caution, since it is not representative of a "healthy" group.

The assessment of healed trauma, such as the fractures observed in this study, on the other hand, can give a more accurate view into the lives of the people from which the sample came, since these lesions were not the reason for hospitalization. The frequency and various types of fractures within a population can yield important information regarding their lifestyle, their interaction with the environment as well as the nature of medical attention that was available at the time (Steinbock, 1976; Kilgore *et al*., 1997). Parry fractures of the ulna, blunt trauma to the skull and evidence of cut marks by a sharp object are all indicative of interpersonal violence (Smith, 1996; Jurmain & Bellifemine, 1997; Kilgore *et al*., 1997; Lovell, 1997; Jurmain, 2001; Ortner, 2003; Judd, 2004). Femoral, tibial and humeral fractures, on the other hand, are usually related to accidental incidents such as falls (Kilgore *et al*., 1997).

The high prevalence of cranial fractures within this population (24%) is suggestive of interpersonal violence, as was also suggested in a samples from Chile, where 24.6% (n=17) of individuals presented with cranial fractures (Standen & Arriaza, 2000). Most of the fractures observed on the cranial vaults were circular in shape, relatively similar in size and seemed to have been caused by a weapon such as a knobkerrie, although this cannot be said with any certainty. A knobkerrie is a traditional South African weapon in the form of a club or stick with a rounded end at one side. All cranial fractures were due to blunt-force trauma and several other weapons or even rocks can produce the same skeletal results (Jurmain & Bellifemine, 1997). Therefore, it should also be considered that the high prevalence of cranial fractures may be partly related to mining accidents such as rock falls, which were recorded in archival documents, and can not be exclusively attributed to interpersonal violence.

The incidence of lesions suggesting interpersonal violence concurred with historical documentation of violence amongst the black labourers in Kimberley. The notion of violence as a symbol of masculinity and group affiliation was very strong in this population, leading to fights between various groups. These fights were a means by which leaders were selected and justice was served. An Anglican clergymen reported that "tribal fights and murders occurred every weekend" (Harries, 1994: 58). According to records, weapons such as knobkeries, fighting sticks and pick handles were used (Harries, 1994).

Levels of interpersonal violence have been shown to increase when periods of environmental deterioration, sudden population growth and an increase in competition for resources are present within the population (e.g., Torres-Rouff & Costa Junqueira, 2006). The discovery of diamonds in Kimberley was a catalyst for the creation of these conditions. Numerous individuals went to Kimberley to seek their fortune, or employment, causing a dramatic growth in population numbers (Roberts, 1976; Harries, 1994). When considering that the study sample was most likely migrant labourers from various parts of the country, aggressive behaviour may have also been spurred by cultural differences (Harries, 1994). Furthermore, the increase in population numbers would inevitably have caused competition for resources, especially among the labourers of lower socio-economic status. The high incidence of scurvy reported in archival documents for this population supports a state of limited nutritional resources (Van der Merwe, 2007). Few women were present in Kimberley, as suggested by the few female skeletons excavated as well as the archival records, and this fact may have increased the level of social conflict and competition. Other factors such as the regular over-indulgence in liquor, labour disputes and skirmishes over the theft and illegal selling of diamonds, all led to various violent confrontations between labourers and their employers or overseers (Turrell, 1987; Harries, 1994).

According to Lovell (1997), high fracture risks are associated with occupations generally restricted to men, such as agriculture, mining and forestry while domestic activities in developing countries (such as carrying water and firewood) also pose a high risk of fractures to females. Mining accidents occurred frequently in Kimberley. These included individuals falling down mine shafts, getting killed in rock falls, drowning in mud rushes and being run over with wagons, carts or trams, to name but a few (Cape of Good Hope Votes and Proceedings of Parliament 1901; Knight, 1978; Turrell, 1987; Harries, 1994). Thus the prevalence of long bone fractures, spondylolysis, longstanding subluxations as well as some of the cranial fractures within the Gladstone population are a reflection of the high-risk environment to which these individuals were subjected.

Separation of the neural arch or spondylolysis is a condition mostly recognized by the bilateral fracture of the pars articularis of L4 or L5 (Merbs, 1989; Arriaza, 1997). Lane (1893) noted that spondylolysis is associated with strenuous physical activity and stated that it occurs frequently in "people doing heavy labour".

An investigation into the incidence of this condition among 372 Black South Africans skeletons from the Raymond Dart collection was conducted by Eisenstein (1978), who found that 3% of the sample population presented with spondylolysis (Eisenstein, 1978). Unfortunately the exact number of individuals presenting with the condition, as was observed by Eisenstein (1978), was not stated in the literature making statistical comparison difficult. The observed prevalence of the condition in the Gladstone sample (6.5%) does, however, seem higher than what would be expected in the South African black population.

Spondylolysis is caused by increased compression of the posterior elements of the vertebrae due to hyperextension of the back, or increased shearing forces due to repeated flexion. During hyperextension of the back, the joints of adjacent vertebrae become locked together, causing an increase in stress exerted on the bone (Arriaza, 1997). The reason for the high prevalence of spondylolysis in this population is clear. Activities associated with open mining will include a higher-than-average incidence of hyperflexion and hyperextension of the back. This will inevitably increase the likelihood of spondylolysis in individuals who are susceptible (Earl, 2002; Lovell, 1997). The relatively high incidence of spondylolysis within this sample is thus suggestive of participation in the strenuous physical activities most likely associated with mining. While the prevalence of spondylolysis is stated to be higher in males than females (Arriaza, 1997; Lovell, 1997), no significant inter-sex difference was found in this study. However, this may be partly or wholly due to sample size and/or distribution.

It can therefore be concluded that the individuals within this sample was exposed to high levels of interpersonal violence, a hazardous working environment as well as strenuous labour requirements.

Medical care in at the close of the 19th century in Kimberley

The clear evidence of saw marks perpendicular to the long axis of the bone observed on the amputated limbs supports the assertions made in historical documents that the Gladstone cemetery was used as a burial ground by Kimberley and other surrounding Hospitals. Several archival documentations of amputations are available from the Kimberley Hospital (Cape of Good Hope Votes and Proceedings of Parliament, 1885). According to these records, up to 35 amputations were done a year, which amounted to approximately 50% of all operations performed in Kimberley Hospital (Cape of Good Hope Votes and Proceedings of Parliament, 1885). The operations were most likely done under general anaesthesia. Anaesthesia with ether was first performed in Grahamstown (South Africa) in June 1847, and by the 1850’s chloroform was being used (Laider & Gelfand, 1971). Unfortunately, no documentation suggesting the possible reasons for these amputations was available. However, two therapeutic reasons for the amputation of a limb can be suggested: the first is amputation after injury, resulting from such severe crushing of the limb that had no chances of healing. When considering the types of mine accidents reviewed earlier, crushing and compound fractures such as these may have been frequently encountered in Kimberley. The second reason for amputation is severe infection of a part of a limb. The evidence of infectious lesions found on amputated limbs (such as GLD N38.2, GLD N8.1b, GLD S2.7b and GLD S2.7c) suggests that some amputations were a result of severe infections. This is plausible in light of the fact that antibiotics were not yet available for the treatment of infectious conditions (Quetel, 1990). The amputation of the infected body part was thus the only way to prevent spreading of the infection.

The presence of some well healed and remodelled fractures within this population also indicates that medical care, although sometimes limited, was available in the situation of a fracture. This has been confirmed historically, since hospital records refer to the treatment of injuries, which most likely would have included fractures (Cape of Good Hope Votes and Proceedings of Parliament, 1899; Cape of Good Hope Votes and Proceedings of Parliament, 1900).

In summary, the high prevalence of cranial fractures within this population is suggestive of high levels of interpersonal violence (Jurmain & Bellifemine, 1997; Standen & Arriaza, 2000). Cultural differences amongst migrant workers, competition for resources, few females, regular overindulgence in alcohol, and labour issues all most likely contributed to the occurrence of violent events within and amongst labourers and their employers (Harries, 1994; Turrell, 1987).

The incidence of fractures of long bones and possibly some of the cranial fractures, as well as the presence of spondylolysis and longstanding subluxations are indicative of the strenuous work and high-risk environment these individuals were exposed to. Medical treatment was available to these individuals, bearing in mind the presence of well reduced fractures and evidence of amputation for medical purposes.

This study has provided a valuable glimpse into the working environment, social situation and medical facilities in Kimberley at the close of the 19th century. More than 14 million carats of diamonds were extracted from a hole with an outside diameter of 1200 m, approximately 800 m deep, which used to be Colesberg Kopje. This research offers recognition to those unnamed labourers who unknowingly played a crucial role, not only in the history, but also in the economic growth of South Africa.

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Table 1. Number of individuals with fractured bones observed in the Gladstone skeletal sample

	N	Nf	%
Males	86	24	27,9
Females	15	4	26,7
Total	101	28	27,7

N - number of individuals examined

Nf - number of individuals who presented with one or more fractures

Table 2. The number of skeletal elements fractured in the Gladstone skeletal sample

	S	Fe	Ti	Fi	Oc	Ra	Ul	Hu	Cl	Ri	Vb	Total
N	84	181	173	166	161	164	164	169	159	**	**	
Males	12	4	1	2	1	2	2	1	1	4	1	31
Females	3	1	0	0	0	0	0	0	1	0	0	5
Total	15	5	1	2	1	2	2	1	2	4	1	36
%	17,9	2,8	0,6	1,2	0,6	1,2	1,2	0,6	1,3	**	**	

N - Number of skeletal elements investigated

** Due to the fragmentary condition of ribs and vertebrae, the total number of elements could not determined.

S - Skull; Fe - femur; Ti - tibia; Fi - fibula; Oc - Os coxa; Ra - radius; Ul - Ulna; Hu - humerus; Cl - clavicle; Vb - vertebra; Ri – rib.

Table 3 The prevalence of fractures in the Gladstone sample

Number	Sex	Age (years)	Fractures*	S	Fe	Ti	Fi	Oc	Ra	Ul	Hu	Cl	Ri	Vb
GLD N31.E.1	Male	30-40	3	3										
GLD N74.2	Male	18-21	1	1										
GLD N74.5	Male	40-55	1								1			
GLD N100.2	Male	28-38	1									1		
GLD S1.2	Male	25-35	1	1										
GLD N100.1	Male	40-55	1	1										
GLD N34.3	Male	30-35	2	2										
GLD N34.5	Male	15-18	1					1						
GLD N34.6	Male	22-28	1	1										
GLD N34.9	Male	22-30	1	1										
GLD N34.12	Male	22-30	1	1										
GLD N38.1	Male	23-30	1										1	
GLD N38.2	Male	25-29	4	1	1	1	1							
GLD N38.3	Male	30-40	2				1		1					
GLD N74.6	Male	30-45	3	2									1	
GLD N74.4	Male	30-40	1							1				
GLD N8.2	Male	25-30	1											1
GLD N8.10	Male	20-25	1	1										
GLD S2.3	Male	20-25	2		1				1					
GLD S2.9	Male	35-45	2		1								1	
GLD S3.2	Male	30-40	1										1	
GLD S3.5	Male	25-30	1		1									
GLD S5.1	Male	28-34	2	2										
GLD SE7.9	Male	35-45	1							1				
Total number of fractures in males			36	17	4	1	2	1	2	2	1	1	4	1
GLD SE11.6	Female	30-37	1		1									
GLD N74.1	Female	40-50	1	1										
GLD S2.4	Female	33-43	2	1								1		
GLD SE7.5	Female	30-43	1	1										
Total number of fractures in females			5	3	1	0	0	0	0	0	0	1	0	0
Total number of fractures in sample			41	20	5	1	2	1	2	2	1	2	4	1

*The number of fractures observed per individual;
S - Skull; Fe - femur; Ti - tibia; Fi - fibula; Oc - Os coxa; Ra - radius; Ul - Ulna; Hu - humerus; Cl - clavicle; Vb - vertebra; Ri – rib.

Table 4. The prevalence of spondylolysis and subluxation in the Gladstone population

Number	sex	age(years)	Spondylolysis	Subluxation
GLD N31.E.1	male	30-40	1	
GLD N74.3	male	17-22	1	
GLD N74.8	male	16-20	1	
GLD N74.5	male	40-55	1	1
GLD N34.8	female	20-23	1	
GLD N34.4	male	18-21		
GLD N34.6	male	22-28		
GLD N38.3	male	30-40		
GLD N74.7	male	35-50	1	
GLD NOP 3/4.1	male	25-35	1	
GLD S2.6	male	35-45		1
Total n = 107			7	2
%			6.5	1.8

n - total number of individuals investigated

Table 5 The incidence and location of amputations

Number	Sex	Age(years)	Femur	Tibia & Fibula	Foot	Humerus	Ulna & Radius	Total	%
GLD N34.3	Male	30-35		1					
GLD N38.2	Male	25-29	1						
GLD N8.1amp	Male	Adult		1					
GLD S2.6	Male	35-45			1				
GLD S2.7b	Unknown	Unknown				1			
GLD S2.7c	Unknown	Unknown					1		
Total n = 107			1	2	1	1	1	6	5.6