DEGENERATIVE JOINT DISEASE: WHAT CAN IT TELL US ABOUT THE EARLY HISTORIC MAYA AT LAMANAI?

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ABSTRACT

The Lamanai site in Belize was excavated by the Royal Ontario Museum under the direction of Dr. Pendergast over a thirteen year period (1974-1987). The site was occupied continuously from Preclassic times on; however, this research focussed on the artifacts and human remains (from the chapel floor) from the early Historic (A.D. 1544-1641) period.

This thesis is an attempt to explore linkages between the presence of osteoarthritis and the activity patterns of the early Historic Maya. In an effort to reach this objective, a population profile was established, and all pathological conditions documented enabling the determination and /or classification of the types of arthritis present, patterns of involvement, and assessment of their severity. Once this information was obtained, the site, its history, and the material remains available in the archaeological records were examined to provide the necessary background information which enables links to be made. A multifaceted approach was necessary in order for any meaningful conclusions to be reached; a processual methodology was utilized to provide a comprehensive analysis.

This study provides an understanding of the overall health of an ancient population, a record of a prominent pathology that still occurs today, a basis for comparison to other Maya populations, and adds to the understanding of the quality of life that existed during the early Historic era. It can safely be stated that the results of this research project support previous archaeological and osteological research that found greater stress and deterioration of the quality of life during this period. This thesis was able to answer the critical question posed, that yes, some links can be made between the presence of osteoarthritis and the activities carried out by the early Historic Maya at Lamanai.

I wish to dedicate this thesis to my Mom and
(in loving memory) to my Dad.

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Thanks to our current and past department secretaries, Virginia Keating, Janice Ecclestone, and Sandi Carr for always greeting me with their warm smiles and words of wisdom. I would like to extend my gratitude to the many readers, who saw numerous versions of this thesis and challenged me along the way.

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Chapter 1- Introduction

It can safely be stated that most of the analysis of ancient Maya populations has dealt with reconstructing events and life during the Preclassic (300 B.C. or earlier), Classic(300-900 A.D.), and Postclassic periods (900-1520 A.D.), but that little overall research has dealt with the Historic period (1520-1670 A.D.) Maya. The main reason for the scarcity of exploration and literature regarding Historic Maya, is the collapse of their society after the 9th century and, therefore, interruption in the occupation of most sites during this period. Few researchers realized that not all sites collapsed after 9th century, until the discovery of a handful of sites that contained evidence of Maya material remains from Postclassic and Historic periods. Lamanai does provide a unique opportunity for researchers because it is one of the few sites known to have been continuously occupied from Preclassic to early Historic times (Pendergast 1981).

The Lamanai site is in Belize, which is located on the east coast of Central America, bordered by Mexico to the north, Guatemala to the west, and the Carribean Sea to the east (Figure 1). The actual site is located on the western shore of the New River Lagoon in northern Belize approximately 70 km from the Carribean coast (Pendergast 1981). The lagoon is fed by the New River (Dzuluinicob) to the north of the Lamanai site (Pendergast 1986b). Dr. Stanley Loten , from Carleton University, mapped the site which stretches 4.5 square kilometers, it consists of 718 structures. This probably reflects a conservative estimate of the boundaries (Loten, in Pendergast 1981:32). Over the course of occupation, the Maya moved from the north to the south end of the site. For example, the Historic church and chapel are 700 m south of the Terminal Postclassic community (Pendergast 1986a:1). In a

1981 article, Pendergast indicates that the areas adjacent to the church may be the location of residential settlement, south of the Postclassic occupation. It is the Historic area of the site that will become the primary focus of this research.

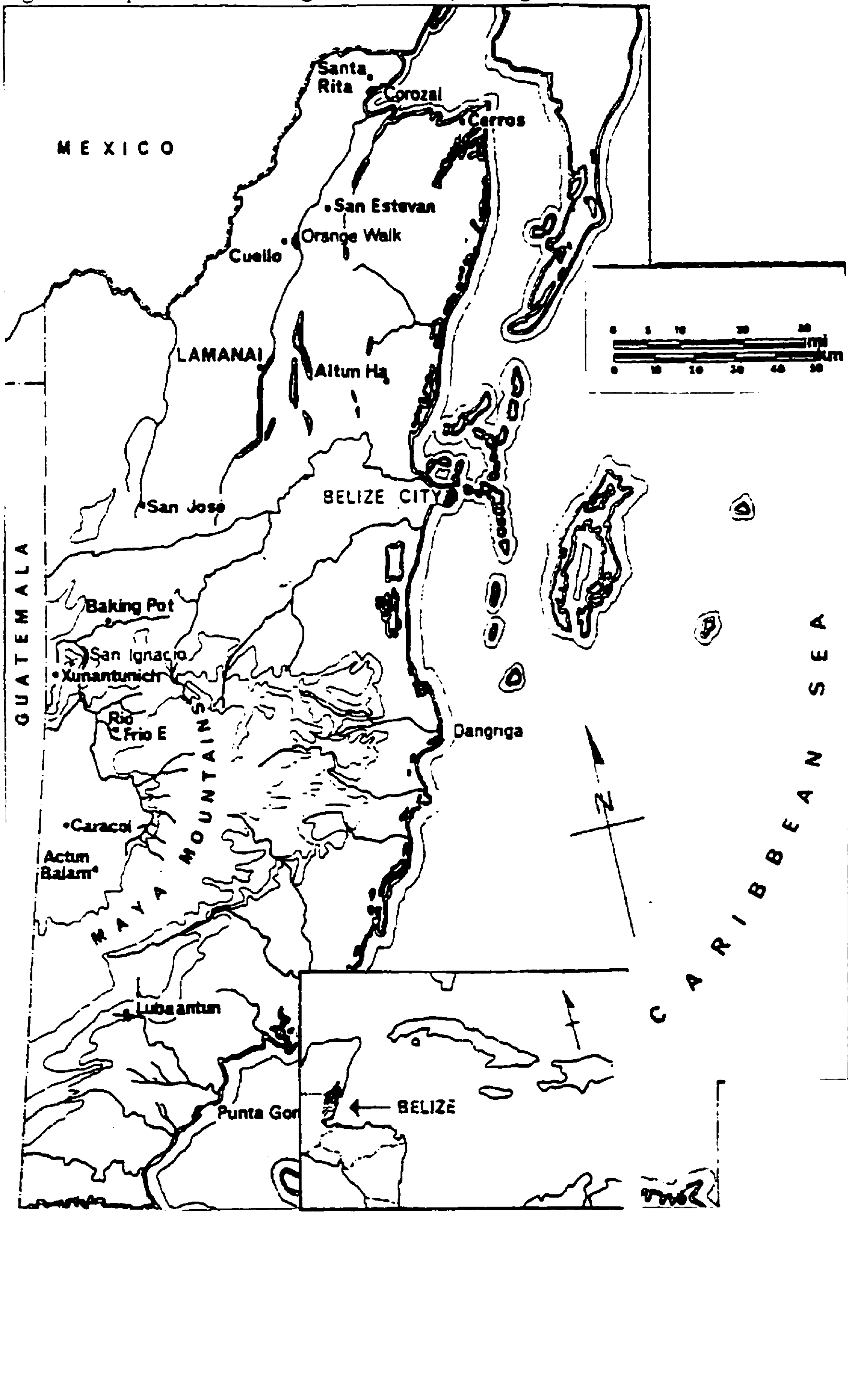
While anthropologists have documented architecture, ceramics, nutrition, subsistence activities, the dental health, and other pathological conditions of the Lamanai population, no study appears to have documented degenerative joint disease (DJD) in the early Historic sample (from the floor of the chapel). Therefore, this research project will document and discuss what degenerative joint disease can tell researchers about the life and health of the people of Lamanai.

More specifically this study may contribute to our current understanding of degenerative joint disease. An extensive literature search yielded no previous study of DJD in Maya populations of this nature. Thus, this research may provide a basis of comparison to other populations. Furthermore, information acquired concerning the incidence and severity of DJD will contribute to our knowledge regarding what is presently known about the health of the Maya from Lamanai.

Specifically, this thesis will determine if degenerative joint disease and activity patterns can be linked directly or indirectly. Examination of the connection between types of arthritis, age, sex, severity, and patterns of joint involvement enables a positive correlation to be drawn between DJD and subsistence activities. These links will be made through the aid of scientific analysis in conjunction with current medical information, historical documents, archaeological knowledge, and ethnographic information.

Before a link between subsistence activities and degenerative joint disease can even be attempted, the foundation must be laid. Chapters 2 and 3 provide background information on the site history, the archaeological and written history of the site, the environmental factors, the subsistence activities, and the physiological forces at Lamanai. Chapter 4 contains the background information on degenerative joint disease. Chapter 5 summarizes the materials and methodology used in this research. With the building blocks in place, Chapter 6 contains the research results from the early Historic period sample at Lamanai. Chapter 7 discusses what the results can tell us about the sample population's health and stress level. The final chapter (8) outlines the importance of the findings and the potential for future research on this topic.

Figure 1: Map of Belize showing Lamanai Site (Pendergast 1980/81:30).



Chapter 2- Maya and Lamanai Archaeology

Until the 1970's and the seminal research of Dr. J.R. Bullard, the importance of the Lamanai site remained largely buried with its Maya inhabitants. The site and its significance began to be unearthed twenty-seven years ago, and proves to be one of the most unique and revealing Maya sites to be excavated in recent years (Pendergast 1981). Most of the past research concerning Maya sites has dealt with the Preclassic, Classic, and Postclassic periods and initially this was the case for the Lamanai site in Belize. However, the focus switched to the historic period during the last four years of the Royal Ontario Museum (ROM) excavation project (Pendergast 1986a:2). The historic period (1520-1670 A.D.) has been reconstructed with the aid of archaeological evidence, written documents, ethnographical data, and osteological analysis.

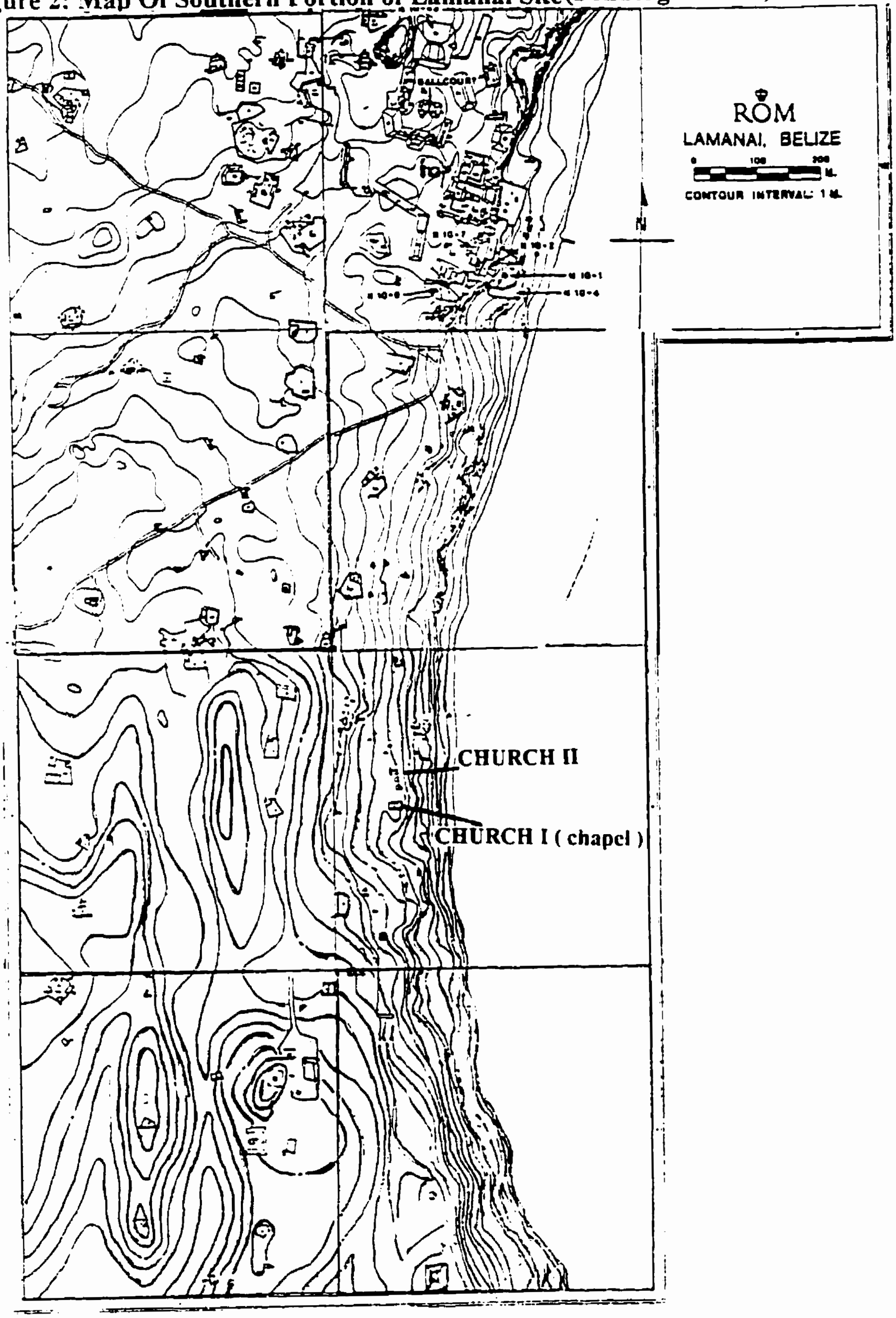
An overview of the archaeological history at Lamanai reveals that the initial interpretation of its history and its people has been altered over the course of the excavation project. A summary of the site's history follows, which allows researchers to not only understand the progression of life at Lamanai, but also the degree of occupational continuity present at the site.

2.1 Archaeological History At Lamanai and Importance of the Site

Fascination with Maya culture has a long history. Historic records indicate that Thomas Gann (1896-1936) explored the Lamanai site including " Indian Church" in 1917 (McKillop and Awe 1983:1). According to Pendergast (1986a:5) a Maya-erected stela stood on the north part of the sanctuary and a second monument stood in the nave area until sometime after 1917 when it was observed by Gann. Prior to any major period of excavation, W.R. Bullard Jr. visited Lamanai between 1917 and the1970's to conduct a surface collection; his last visit was followed by looters between the years 1971 to1974 (Pendergast 1981:32). Regardless of previous surveys and looting, the deposition context of the Lamanai site had been virtually untouched until the 1970's, making it easier to draw more accurate conclusions about the people and their history at the site (Pendergast, in Bray, 1993:111).

Guided by David Pendergast, and funded by the ROM, excavation of the Lamanai site began in 1974. The field work operated six months out of each year for the next 13 years (White 1988:3). In 1981, Pendergast provides the following summary of the archaeological field seasons at Lamanai. During the first two seasons, the main area of focus was on the southern portion of the site center which contained Postclassic (900-1520 A.D.) remains (Figure 2). At that same time, excavations recovered clear evidence of material remains from the Preclassic (1250 B.C.-300 A.D.) and the Classic (300-900A.D.) Periods. Dr. H.S. Loten also made valuable contributions during the 1974-76 field seasons by mapping many of the structures. According to Pendergast (1981), the researchers in the1977-79 seasons looked at ceremonial construction. It was also during this period that a raised field system was discovered north of the mapping that had already taken place. It was not until 1980 that investigation of the Historic 16th and 17th century community was begun by an anthropology graduate student, Olivier de Montmollin. Pendergast adds that in the 1981 field season the choice was made to intensify investigation of a 16thC church, for evidence of continuous habitation of Lamanai into early Historical times.

Figure 2: Map Of Southern Portion of Lamanai Site(Pendergast 1981)



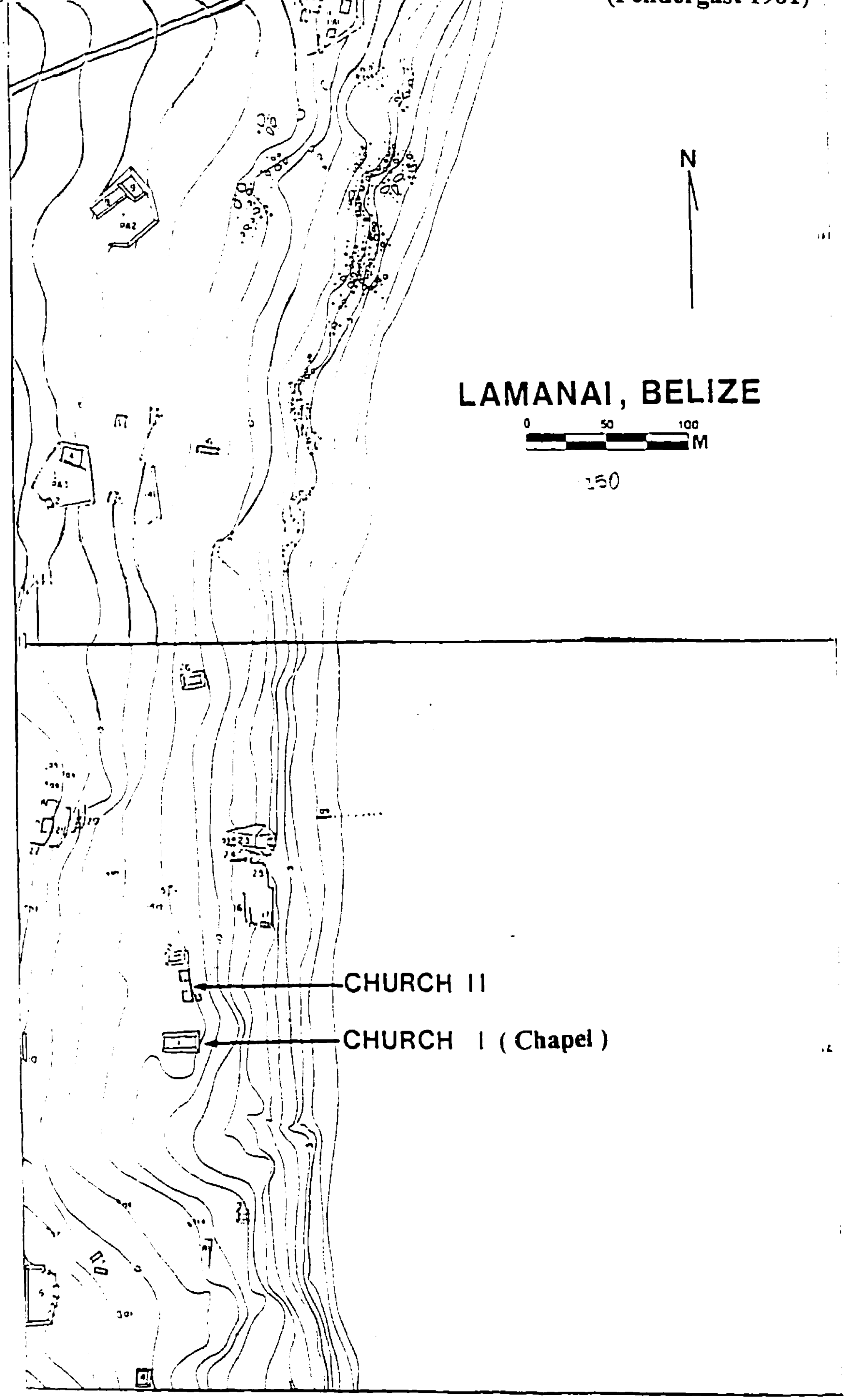
In a later article Pendergast (1985: 101) indicates that excavations in 1982 and 1983 revealed the possible existence of not one but two Spanish churches (Figure 3).

In 1983, excavations were extended to an adjacent structure north of the church and to the church floor (Pendergast 1986a: 1-2). In this small structure, excavation teams found a tomb from the Pre-Historic period. Up to this point, excavation of the Historic occupation was limited to areas not being occupied by squatters. In 1984 excavation moved northward into the middle of the squatter settlement, where work focused on a series of small structures. According to Pendergast (1986a:2) nearly all work completed in this area revealed evidence of 16th and 17th century artifacts, as well as many structures that existed just prior to the arrival of the Spanish. The 1984-5 seasons revealed evidence of pottery, other manufactured goods (e.g., beads) and housing, suggesting Spanish contact (Pendergast 1986a:2).

Until the end of the 1984 field season, archaeologists thought that the church they had excavated had served the needs of Lamanai throughout the Spanish presence. However, the burials associated with the church seemed to be too few to be representative of the population. In 1985, Dr. Pendergast (1986a:3) and other excavators present at Lamanai discovered an earlier chapel which was made of perishable material and was quite a bit smaller. This chapel's platform was in the foreground with the chancel of the later church in the background. The chapel nave was only 6 meters wide by 9 meters long (Pendergast 1990:342).

Near the end of the 12th field season, excavation of the floor of the chapel revealed a large number of Historic period burials (White et al. 1994: 137). The burials are from 1544-1641 and are considered to be a representative sample of community deaths.

Figure 3: Map of Lamanai Site Showing Early Historic Chapel and Church (Pendergast 1981)



The bulk of the burials from Lamanai come from the early Historic and Postclassic period, and although all periods have skeletal material associated with them (White 1997; White et al. 1994), the focus will be on those burials deposited during Spanish influence. The early Historic period burials, in addition to those found from all earlier periods, make up one of the largest group of burials ever found at a Maya site. Lamanai is also considered to be very unique because this site was continuously occupied for over two thousand years and did not collapse as many sites did at the end of the Classic Period. The fact that the site was continuously occupied meant that while some technology changed, much of the subsistence activities remained virtually unchanged even to more recent times. Finally, Lamanai provides a good basis to which other sites can be compared in the future because of the amount of material and human remains that have been recovered. These skeletal remains can be used to gauge levels of pathology at other sites.

2.2 Site History: Preclassic to Precontact

A brief summary of the history of the site prior to the period being examined in this thesis will allow the reader to gain an understanding of the degree of continuity in habitation and subsistence activities. The exact date that the Lamanai site was first inhabited remains unknown but, based on archaeological excavation of cultural remains, archaeologists have concluded that Lamanai was inhabited continuously by the Maya for at least 2000 years (Pendergast 1981:23). This date has been secured by two principal pieces of evidence; the first is a Preclassic structure. According to David Pendergast (1981) and Stanley Loten (1985), the Preclassic period was highly productive, as demonstrated by the presence of a 30 m high structure, one of the largest in the Maya area securely dated to the Preclassic period. The second piece of evidence is the presence of skeletal remains that were found during excavations of the site and that dated from 250 A.D. The transition from hunting and gathering to primarily agriculture had taken place by this time (Pendergast 1981). Knowing this information is crucial for this research project because the researcher has to know the type of activities that may lead to the development of DJD. Nigel Bolland (1977:14) indicates that the transition from seed gathering to planting took place around 1500 BC, and that by 1400 BC maize, squash, and beans were being planted with the aid of wooden digging sticks and the use of fire.

The Preclassic Period was followed by an equally productive Classic period (300-900 A.D.). The uniformity of the structures in the Classic period has been interpreted by Pendergast (1986b:226) as evidence that there was rigid control over the populace by the ruling class, a control which continued until the 10th century. Evidence for the conclusion that an elite ruling class was present during the Classic period was based partly on the finding of a royal burial that was dated to 500-550 A.D. (Helmuth and Pendergast 1987). Excavation at the site also revealed that Lamanai went through another growth period during the late 9th century to the early 10th century, which meant that there was still a class distinction present which enabled the organization of labour necessary to build these structures (Pendergast 1986b). Pendergast has suggested that because of this growth and organized ruling class, the Lamanai society did not collapse in the late 9th century but was able to survive. In fact, the Maya built the only ball court that is present at the Lamanai site during the Terminal Classic period (Pendergast 1986b:229). Therefore, after 900 A.D., when most Maya societies were collapsing and decreasing in numbers, Lamanai was still a strong and active center, and its population was able to make an undisrupted transition to the Postclassic period (Pendergast 1986b).

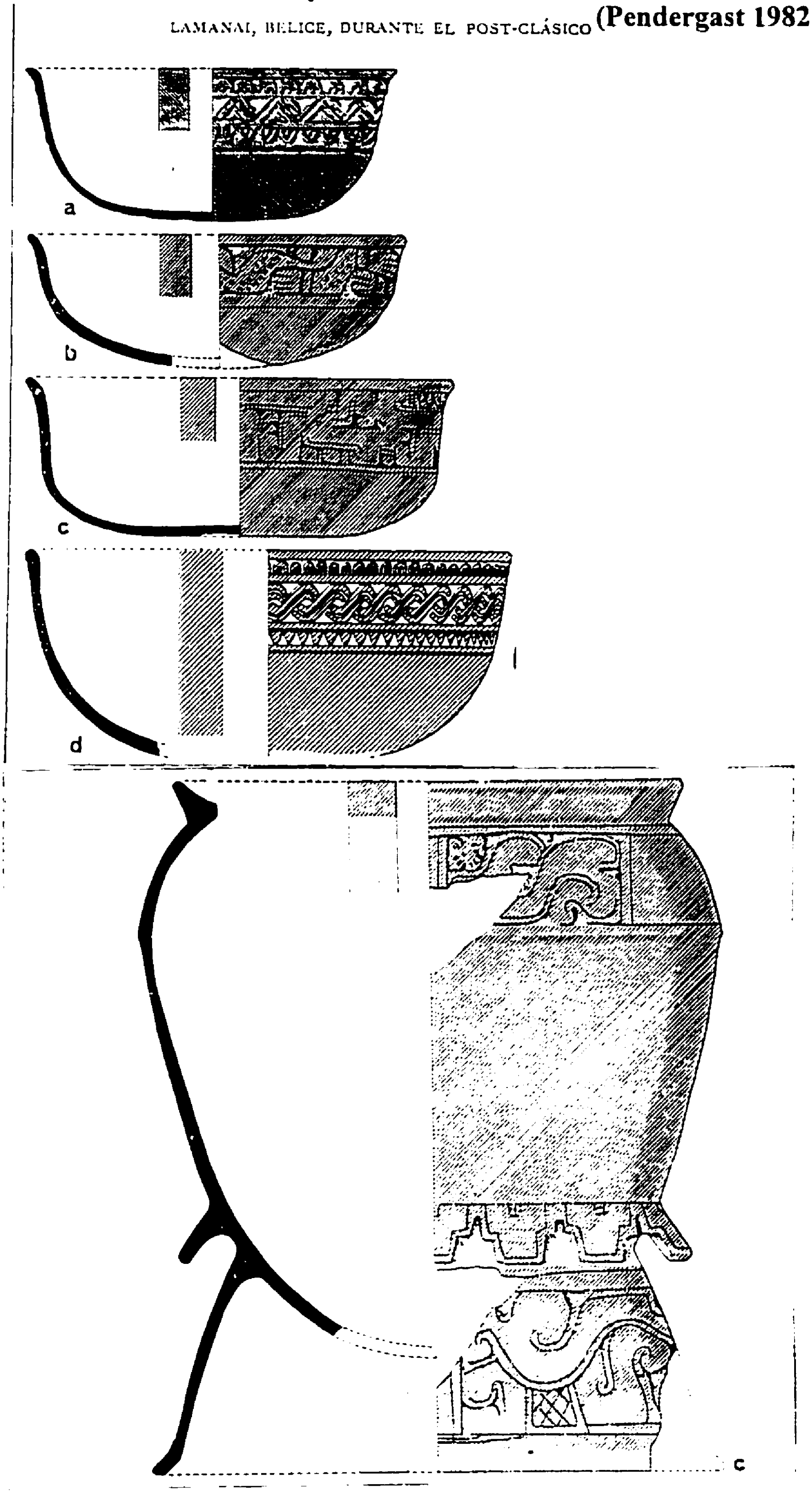
This conclusion is supported by archaeological evidence that the Postclassic rulers had enough of a labor pool for one final reconstruction of the classic period buildings in the 10th century and that this building type continued until the 12th century (Pendergast 1981:43), after which the Maya stopped temple renewal. The courtyard was one of the last major structures built in the 12th century or later which demonstrated the continued presence of an elite class, based on labor required for its construction. Afterward, several Classic structures were superimposed by Postclassic structures rather than being torn down or repaired. For example, according to Loten (1985:87), a Postclassic structure was built on top of one of the Classic period buildings causing disturbance to a burial in the process and revealing Mayapan and Tulum style pottery. The discovery of this Postclassic, Northern Yucatan style of pottery indicates that the Lamanai Maya traded articles over long distances.

By, or before, the 12th century, the focus of ceremonial acts had shifted to the area of N 10-1, B 10-2, and B 10-4, where it remained until the late Postclassic (Pendergast 1985:98). The first two structures were constructed with wattle-and-daub style walls, and the third structure served as a graveyard until the end of the Postclassic period (Pendergast 1986b:234). The Maya switched their focus to the area east of structure N 10-9 which was built in the mid-12th to the beginning of the 13th century (Pendergast 1986b). Pendergast's theory that the focus had switched to the east is supported by the archaeological discovery of an extensive midden which contains material dated to the early Postclassic period (in the 14th century). According to Pendergast (1985:98), the midden was 50 cm deep and even contained randomly placed burials. By the mid-to-late 15th century, the center of domestic life had shifted to the south end of the central precinct, south of structure N 10-1 (Pendergast 1985:98). Minor modification continued to take place at the base of the stairs of N 10-9 until the late 15th or early16th century (Pendergast 1985:98). By the early 16th century the settlement pattern had shifted to the southern third of the site (Pendergast 1990).

Even during the terminal Postclassic (16th century), when site occupation had decreased, wealth and power were still present. Excavation at Lamanai unearthed what was thought to be the last pre-Hispanic noble ruler at the site. His remains have been dated to 1525 A.D. (White and Schwarcz 1989: 468). From the Preclassic to the Postclassic period, the Maya economy was largely based on agriculture although the Lamanai Maya would trade with people from other sites to meet their needs (White and Schwarcz 1989:468). Evidence of this trade at Lamanai actually can be found at surrounding sites. According to David Pendergast and Elizabeth Graham (1987:38) Lamanai pottery styles were found at Altun Ha, Tipu, Mayflower, and Marco Gonzalez (Figure 4). Because of its diverse surroundings, Lamanai was very self sufficient and would not have required much from surrounding sites. Consequently, its people would most likely be trading for desired goods rather than out of necessity.

Having briefly summarized the major events prior to Spanish contact, it is possible to see that while shifts in occupation areas and architecture occurred, the daily lives which focused on subsistence activities changed very little to this point. As will be seen, considerable change occurred after first contact with the Spanish.

Figure 4: Postclassic Buk Pottery: links Lamanai to Mayflower and Marco Gonzalez (Pendergast 1982:41 and 51)



To document these changes, one must detail the chain of events that took place just prior to Spanish arrival at Lamanai, describe the history once contact took place, and summarize the Historical events that followed the 1638 rebellion to present day.

2.3 Site History: Contact To Present Day

In 1502, Christopher Columbus and his exploration party were the first Spaniards to make contact with the Maya in southern Mesoamerica and Central America via the Gulf of Honduras. Nine years later, in 1511, the Maya from the Yucatan region encountered Spanish sailors who were shipwrecked. Word of this latest encounter likely spread because Belize was governed by the Yucatan region until the mid 1600's (Jones and Pendergast 1989:166-7). Inhabitants in the northern lowland areas were not as easily accessible and were aware of conquest attempts; therefore, it took several decades before Spanish conquest was successful in this region. For example, in 1517, Francisco Hernandez de Cordoba led an exploration mission from Cuba and was attacked by Maya. When this incident occurred, many Maya were fearful of future encounters and therefore fled to more remote areas in the interior (Bolland 1977:17). According to Graham et al. (1989:1255), Spanish explorers made contact with the Maya inhabitants of Chetumal in 1528. The precise date that the Spanish arrived at Lamanai remains unknown. However, in 1544 A.D. the Spanish made their first real effort at Lamanai, by demolishing a fresco Tulum-style temple that was still being used by the Maya upon the arrival of the Spanish. In its place, an earthen platform was molded around the base, which provided support for a structure that was partly masonry and partly perishable material. This chapel became the first Spanish structure (Pendergast 1986a:1; 1990:341). It is also thought that Lamanai may have been established as an encomienda in

1544 (Pendergast 1991:332). Jones and Pendergast do agree that Lamanai was an encomienda by 1568. As with any attempt to reconstruct Historic events, exact dates are difficult to establish. In 1546, rumors of cruelties spread from Valladolid to Belize, and the Maya rose up in rebellion, but were quelled by the Spanish. Pendergast (1986a) indicates that in 1546 Lamanai inhabitants were sent by the Spanish to apprehend murderers from Chanlacan. Some Maya responded in fear, and fled to the interior (Jones and Pendergast 1989:167). According to Jones (1989:79), a Spanish party traveling to Bacalar passed through Lamanai on December 13th in 1568 and, while at the site, drafted an order requiring the upcoming election be held according to law, threatening to impose a thirty peso fine against anyone who refused to participate.

The precise date of the erection of the permanent church is still debated. McKillop and Awe (1983:1) have identified 1582 as the date when the Spanish Franciscans erected the " Indian Church" at Lamanai, so named from a Spanish church list. Pendergast argues that there is no way of knowing whether the construction of the church followed that of the chapel by a decade or half a century (Pendergast 1986a:3). It is difficult to say whether the Lamanai church listed in 1582 is the chapel or church. However, the general consensus seems to be that a church was built by the end of the 16th century (McKillop and Awe 1983; Pendergast 1985, 1986a, 1986b). This church was located north of the chapel, and proved to be much larger. According to Pendergast (1986a:3), this church is four times larger than the chapel, and was constructed with masonry in the sanctuary. Again, its construction was a blend of Maya and Spanish techniques, and may well have been the largest and most permanent structure of its time at Lamanai. Andrews (1991) classifies the church as an open-air-ramada church. However, this classification is debatable. According to Graham (personal communication Feb/ 2000) it is difficult to say whether the church was an open-air or closed-air-ramada church. According to Andrews (in Thomas 1991:368) an open-air-church does not have a masonry wall enclosing the nave and the walls do not meet the roof. A closed ramada church has a nave enclosed by masonry and the walls reach the roof.

In 1618, Father Bartolome de Fuensalida and Father Juan de Orbita, who supervised the erection of the chapel and church, passed through Lamanai in their travels from Merida to Bacalar and up the New River (Pendergast 1981:19). At this time, there was no indication of trouble at Lamanai; however, this changed as conflict between these two distinct cultures escalated. In 1637 Lamanai was identified by the Spanish as an encomienda vacancy that was composed of runaway Indians who had already been moved to Tamalcab (Jones 1989:117). As a result of the conflict between Maya and Spanish cultures, Jones (1989) indicates that the Lamanai Maya were being forced to pay a fine of 53 pesos and 5 tomies.

Spanish attempts to control the Maya people would not last. Beginning in 1638 a rebellion erupted, which ended in 1641. The two friars returned to the site and found the church burnt to the ground and the site largely abandoned (Graham et al. 1989; Jones 1989; Loten 1985; Pendergast 1981; Pendergast, in Bray, 1993). This rebellion was a joint effort between the people of the Lamanai and Tipu sites, and it was deemed to be successful in that it expelled the Spanish from most of Belize until 1695 (Graham et al.1989:1256). There is evidence of a number of Historic period offerings and at least one burial and shrine, that postdate the burning of the church, suggesting that the church and surrounding area continued to be occupied as a residence after the rebellion and perhaps until the end of the 17th century

(Pendergast 1985:102; Pendergast 1986a:5). After this date, documentation ends, as does knowledge of the immediate events that follow.

By 1761, European influence had returned, and the focus of the Spanish switched from religion to concentrate on commercial cash crops, and increased construction of sugar plants throughout the Maya territory (Farriss 1992:386). A sugar mill was established near the site and ran until 1880, when the site was abandoned as a permanent settlement. While the sugar mill was operational, parts of the Lamanai site were still being used. According to Pendergast (1986a:5), the church was used as a smithy by those who worked in the mill. Currently, parts of the site are occupied by refugees from El Salvador (Loten 1985:85). These refugees occupy regions that house most of the Historical evidence, therefore limiting further excavation and contaminating the context of the Maya material remains. It is important to recognize that what is known about the Historical period just scratches the surface and future excavations may shed even more light on the Lamanai site. The preceding summary of the archaeological and site history, provides an understanding of the events that shaped the type and manner in which activities were carried out during early historic times.

Chapter 3- External Forces and Living Conditions

Having considered the history at the site (Chapter 2), this chapter assesses what factors influenced the development of DJD, in the sample taken from the floor of the Spanish chapel at Lamanai. In order to reconstruct what life was like during the early Historic period, a discussion of the external and internal forces follows. Before this discussion takes place, it is important to explain what is meant by the terms external and internal forces.

External Forces: indirect factors, outside the control (e.g. climate and environment) of the Lamanai Maya or that were common to other Maya in Belize region (e.g., types of subsistence practiced) but would impact the daily activities.

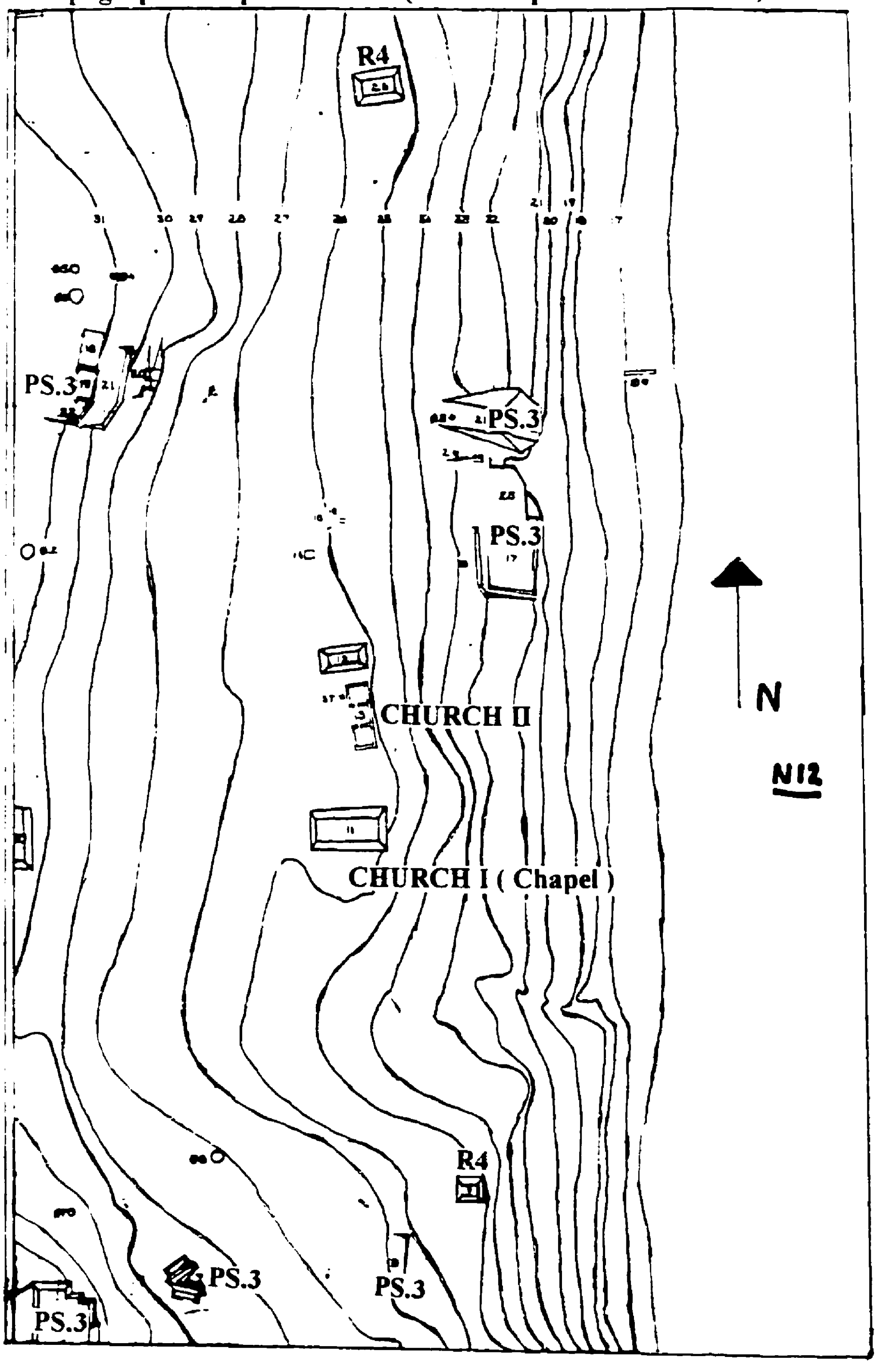
Internal Forces: direct factors, that were unique (e.g., diet) to the Lamanai site, or specific activities that were carried out at the site (e.g.,manufacturing pottery), as well as how the Spanish influenced these activities; and that may have contributed to the early onset of degenerative joint disease.

External Forces

3.1 Terrain and Topography

The layout of the structures in the southern end of the site were modified to accommodate the challenging terrain (Figure 5). The terrain had a major impact on the Maya settlement pattern in the southern end of the Lamanai site. According to David Pendergast (in Bray 1993:125), the layout of the southern end of the site was dictated by the presence of the lake and by the uneven rocky character of the ground. As a result of the bedrock outcrops at Lamanai, the Maya also had to use innovative architectural techniques. Pendergast (1981) gives the example of the Historic church which was built on dense limestone. He also states that the area surrounding the church did not have enough soil as a result of the bedrock, and therefore burials were placed to the north, near the southern limit

Figure 5: Topographic Map of Lamanai (Loten: unpublished material)



of Postclassic structures. While the terrain of the Lamanai site provided some challenge, the Maya adapted easily.

Within Belize, the topography is diverse from north to south and east to west. For example, the southern region of Belize contains low range mountains formed by limestone which arose from the sea over a long period of time, creating a rugged terrain (Coe 1993:15). Lamanai, on the other hand, is considered part of the lowlands which are devoid of the major contrasting topographical features seen in southern Belize (Farriss 1992:118). Some of the most important topographic features in the northern area are the lagoons, rivers and creeks, which served as important sources of water, food, and means of transportation (Bolland 1977:2). While most of these topographical features have changed very slowly over time, one major body of water, the Caribbean ocean, has altered the landscape. Since the Late Classic period the sea levels have risen, resulting in raised fields being buried and thus altering the amount of land present (Bolland 1977). This conclusion is supported by the geological work of S.J. Mazzullo and A. Reid (in Pendergast and Graham 1987:34), who found that sea levels rose 60 cm over the past 2000 years. However, no archaeological evidence exists that Lamanai itself was altered by the rise in the sea level (White and Schwarcz 1989).

3.2 Climate and Environment

The tropical climate in Belize is as diverse as the topography allowing for an enormous variety of natural resources. The coastal temperature ranges from 12 to 38 degrees Celsius during the year, and Belize has a monthly average temperature in January of 24 and of 27 in July (Bolland 1977). Bolland indicates that interior temperatures sometimes exceed

38°C with a humidity level average of 88%. Lamanai, which is located in northern Belize, has as annual rain fall 100-125mm (Bolland 1977: 1). Most of this precipitation occurs during the rainy season from May to October. The rainy season is the period in which planting takes place and, therefore, males would have to work in the fields during the most humid days. The humidity would have taken a toll, causing stress to the population as they performed their subsistence activities (Smith 1982: University of California).

According to Jones and Pendergast (1989: 162), Lamanai forms part of the Caribbean lowlands and has endlessly diverse vegetation, rainfall, and natural resources. The Lamanai site is considered to be an environmental microcosm for the entire Maya lowlands (White and Schwarcz 1989:453). In addition to being close to the lagoon and New River, Lamanai is surrounded by several distinct vegetational zones. According to Pendergast and Graham (1987:34), these terrestrial ecozones are comprised of swamp, cohune pine ridge, savanna grasses, and rainforest. In addition to these terrestrial ecozones, the Maya had access to a variety of aquatic ecozones in addition to the New River and lagoon, such as alluvial shoreline, estuarine, coastal reef, and ocean (Pendergast 1986b). The enormous diversity present at the Lamanai site makes it unique in this regard from many other Maya sites in Mesoamerica, and no doubt played an important role in the site's history and the history of its inhabitants.

Subsistence Activities

Repetitive physical activities cause wear and tear to all joints involved and tend to cause the greatest stress to the weight-bearing joints. If the stress is severe or continuous over time, damage to the joints commonly results in the development of degenerative joint disease. Therefore, the following discussion will attempt to outline the various types of regular stresses that the Maya from Lamanai placed on their bodies.

During the early Historic period, most activities centered around subsistence. According to the " Oxford Universal Dictionary" (1981:709), the term subsistence is defined as "to exist, to keep oneself alive" and subsistence as " subsisting, a means of doing this". For example, subsistence activities include work such as agriculture, hunting, fishing, trade, gathering firewood and water, food preparation and cooking, and child rearing, to name a few.

3.3 Agricultural Techniques

According to Pohl and Miksicek (in Pohl 1987:16), during the Pre-Historic period, four major types of agriculture would have been used by the Maya in the Belize region, including upland swiddens, wetland fields, terraces, and dooryard gardens.

Swidden or Milpa

The swidden/milpa system, which relies on tools such as digging sticks and stone axes, was initially thought to be the only type of agriculture practiced by Maya throughout history. This assumption was based on two pieces of evidence. The first was Spanish Historical records, which in many cases observed or documented only this system of agriculture, and the second was that swidden agriculture is the only technique used today (Bolland 1977). Based on her work at Lamanai, Wright (1990) concluded that swidden agriculture was responsible for most of the food production during the Postclassic and early Historic period.

According to Farriss (1992:125), except for the transition to iron materials, the swidden system has continued largely unmodified to the present day. A summary of the requirements and a description of the technique of swidden agriculture have been provided by Farriss (1992:125-129) and appears below. The swidden technique requires a large amount of land to sustain a population. The precise amount of land required varies depending on the region, soil type, rainfall, and the skill and energy of the individual. The first task of swidden agriculture is to clear the land of trees and undergrowth, which at Lamanai was very dense and required intensive labor. According to Graham et al.(1989:1258) and Pendergast (1991:352), clearing the land of trees and undergrowth would have been facilitated by the use of stone axes, which were made out of chert, and continued to be used during the Spanish period. The second task is dragging brush into piles to be dried and then burned. The resultant ashes are mixed into the soil which requires stooping. In the third stage, crops such as maize, beans, and squash are planted using a digging stick, and these are harvested when ripe. Both planting and harvesting require repetitive motion and strain on the back and shoulders. The fourth and last portion of this technique involves allowing the cleared area to revert back to bush after several year of successive planting, thus allowing the soil to recover from the nutrient depletion, and beginning the process over again in a new location. Ethnographic video of swidden horticulture among the Maya indicates the technique has changed very little since the early Historic period, except for the material of tools being used. However, inferences made by researchers about whom and how activities were carried out appear to be accurate (McGee 1986: University of Utah and 1988: University of Utah).

Labour did not cease during the period between planting and harvesting. Pohl (1987:39) argues that because of the warm environment, rapid intrusions by weeds and infestations by pests, the plot of land had to be continuously monitored and maintained. For example in Part 2 of the film " Living Maya" men had to weed their crop(s) continuously for at least three weeks to maintain the maximum yield (Smith 1982: University of California). Although the environment was challenging, there was also a positive aspect; the soil was rich enough to allow more than one crop to be planted in one season. According to Pohl (1987:36), the Maya plant the primary crop at the beginning of the wet season, followed by the second planting in November and harvest the food in May.

Researchers such as Farriss (1992: 129) have speculated that swidden agriculture may have been the only technique used prior to the arrival of the Spanish because at this time the population had declined, which was in fact the case at Lamanai. This decline meant that less intensive production was needed to feed the population. Farriss (1992) suggests that other techniques of intensive food production like raised fields and terracing were only developed when the population exceeded the maximum production of swidden agriculture. Consideration of all types of agriculture is necessary in order to ascertain the types of repetitive motions that may have led to the development of osteoarthritis. However, a decline in population in Postclassic times meant the other techniques were not necessary.

Wetland Fields

The wetland field system was a common technique thought to have been used during the Preclassic and Classic period at Lamanai (White and Schwarcz 1989:453), and it was more labour intensive than swidden agriculture. As was mentioned in the archaeological history section, a wetland field was discovered in 1978 (Pendergast 1981). Therefore, the wetland technique must be considered as a possible technique used at Lamanai which would have caused accelerated degeneration of the major joints. According to Pohl (1987:36)

Historic records written by Spanish eyewitnesses indicate that wetland fields were still being used in the Maya lowlands. Pohl includes the following quotation: " The meeting place of the two armies was cultivated land, cut up by many ditches and deep streams, difficult to cross among which our men became confused and disorganized." (Lopey de Gomara, in Simpson, 1964:45-56, as quoted in Pohl, 1987). The above statement suggests that wetland fields existed at the time of conquest. Whether wetland fields were still being used at Lamanai just prior to contact and during the early Historic period has yet to be confirmed. Though White and Schwarcz (1989:452) indicate that this system of agriculture has not been used in the Lamanai region for the past 400 years, both Wright (1990) and Pendergast (1990) indicate that wetland fields may have also contributed to the production of food.

Regardless of the terminology (e.g., wetland field, raised field etc.) used to describe this method, the wetland technique involves the exploitation of wetland areas, and it is very labor intensive. Farmers had to create large mounds of soil in rows on which to plant their multi-crops (Pohl and Miksicek, in Pohl, 1987: 12). These mounds were surrounded by water on either side, in order to ensure a continuous water supply. The creation of mounds would produce tremendous amounts of stress to the upper body and back, therefore creating stress to many of the same joints affected by swidden agriculture. If there was not enough soil in the immediate vicinity, increased labor would be needed to transport the required material. In fact, soil had to be brought into a wetland field at the Pulltrouser Swamp site due to the poor and inadequate soil (Amy 1981: Public Broadcasting Association). The Pulltrouser Swamp site is located close to Lamanai. Lack of soil may have been a factor at Lamanai since most of the site had underlying bedrock with very shallow soil. Carrying loads of soil to the desired location would have increased the stress being placed on the spine and weight bearing joints.

Terraces

Terrace agriculture is just as labor intensive as farming using wetland fields. Terraces found at Lamanai, once thought to be widely used for agriculture in ancient times (White and Schwarcz 1989:452), are thought to have been architectural in nature (White 2000:personal communication). The men had to build support walls to hold in the soil (White and Schwarcz 1989:452). The construction of terrace walls would no doubt cause stress to the lower back and shoulders of these men. As with the construction of wetland fields, terrace builders would have had to bring in soil from other locations if it was sparse (Pohl and Miksicek, in Pohl, 1987:11). Pohl and Miksicek add that one of the most significant roles of terracing was the prevention of erosion. It is difficult to say whether terracing was still being maintained at Lamanai during the Terminal Classic and Contact periods. However, it does not appear to have been in use at Lamanai in the terminal Postclassic and early Historic period, as the use of terraces is not mentioned in any of the archaeological literature consulted thus far. Therefore, this form of labour does not warrant any further discussion as an activity stressor at this time.

Arboriculture

According to Pohl and Miksicek (in Pohl, 1987:14), the presence of arboriculture is well documented in the early Historic period and involves planting around the residential structures, for example, tree crops would provide shade and bear fruit, which was especially important during times of food shortage. They also indicate that orchards (e.g., cacao) were planted for commercial use by the elite.

However, Pohl and Miksicek (in Pohl, 1987:14) do acknowledge that systematic examination at the Lamanai site reveals that the present distribution of trees does not necessarily imply the presence of orchards during the early Historic period. Rather, the present distribution of trees is more likely the result of colonization after the Maya inhabitants had abandoned the site. This is not to say that the Maya were not consuming the fruit from trees at Lamanai, but rather that there was no organized planting of trees and, therefore, that gathering was sporadic. This sort of activity should, consequently, be considered the least stressful form of food acquisition. Even if this technique was being used, it was unlikely to have been a factor in the development of osteoarthritis.

3.4 Hunting and Fishing

Hunting, as with agricultural activities, was another activity that placed an increased amount of stress on the body that might cause an accelerated rate of deterioration to the joints. Males were responsible for hunting, and game provided a complete protein that was a necessary component of the Maya diet. Prior to a major shift in technology, the Maya hunters used spears to hunt for forest animals such as white tailed deer, brocket deer, peccary, dogs, and tapir (Emery 1999). Based on faunal assemblages from early Historic middens, Lamanai inhabitants utilized fewer and less diverse species as a food source (Emery 1999:72). Emery's research shows that species richness in this region continued to increase despite increasing dominance of a small number of species. According to Pendergast (1990:175), this hunting technique began to change in the Postclassic period when the lithic technology shifted from the use of large projectile points (spears) to small ones (arrow heads). This change in technology may explain why Emery's findings indicate that there was a tremendous increase in the consumption of birds such as wild turkey and curassous, and a decreased consumption of large mammals. The transitional phase continued until the early Historic period. Using the spear and shooting an arrow require two different techniques and may cause different levels of stress to the body, affect different joints, and produce different wear patterns on the joints. The use of the bow and arrows meant that there was an increased frequency in the number of tools being made when bows broke and arrows were lost, and less time was spent in the manufacture stage (Pendergast 1990:175). Bows and arrows for hunting were eventually replaced with firearms (Farriss 1992:135), but, firearms were absent at Lamanai during the early Historic period because they were initially prohibited (Graham et al. 1989:1258).

According to Graham et al.(1989), evidence of pre-Columbian manufacture traditions of ceramics, tools, and weapons continued, unchanged in some cases, at Lamanai and Tipu throughout the Spanish period. Pendergast (1991) has suggested that hunting would have been more difficult after the arrival of the Spanish because of the increased noise level. If increased noise level was a factor at Lamanai, the hunters would have had to travel greater distances over rough terrain, and would have been forced to carry their catch longer distances, and would have experienced more stress to the major large joints. Emery (1999:73) discovered another trend from her analysis of the middens that suggested that the number of resources from cultivated land and rivers increased over time.

Unlike hunting, fishing would not have been disrupted by the arrival of the Spanish, although the Maya inhabitants' per capita protein intake may have lessened (Pendergast

1991:344). Pendergast's conclusion is supported by Emery's (1999:72) recent work at Lamanai, indicating riverine resources were overwhelmingly abundant and that consumption of fish was dominant during the colonial period. There was also evidence in many of the middens of turtle consumption. In addition to eating fish and turtles, Maya inhabitants at Lamanai were also eating jute snails from ancient times to the present day (Emery 1989). Emery's findings of increased use of aquatic species support the research of Schwarcz and White (1989) that analyzed isotopes in the bone. Emery (1999:73) concludes that there is clear evidence for continuity of animal-use practices between the Postclassic and Colonial period and that changes were not the result of direct Spanish contact but are instead related to Postclassic patterns.

3.5 Trade

Trade was critical to the Maya from Lamanai and may have given its inhabitants a better chance of survival into the Postclassic period. Unlike coastal trade, which was interrupted by the Spanish arrival, Lamanai remained active in the trade of important resources. According to Emery (1999), Lamanai had several attributes enabling trade to continue: its protected inland location, and the intensification of Postclassic patterns of fish use in diet and trade. Lamanai is also located in an area that was considered to be a transitional zone, and was influenced by Chetumal and Dzuluincob provinces (Graham et al. 1989:1255). According to Pendergast (1990:171), the riverine highway provided Lamanai with an ideal means of travel to other Maya sites and to the outside world. The Maya from Lamanai are known to have traded, whether by land or water, for desired goods with Maya sites such as Altun Ha, Tipu and Marco Gonzalez (Pendergast 1986; Pendergast and Graham

1987; and Graham et al. 1989). Whether travel to the local sites was done by foot or canoe, evidence suggests that Lamanai was providing pottery in exchange for perishable items such as salt, wax, and honey (Pendergast 1990:173). If travel was carried out by canoe, stress would be placed on the shoulder joint, thus increasing the potential development of DJD.

Pendergast and Graham (1987) also confirmed that some raw materials came from as far away as the northern highlands of Guatemala (e.g. grey obsidian) and the valley of Mexico (e.g., green obsidian). In the 12th century, copper objects were reaching Lamanai from western and central Mexico (Pendergast 1990:173; Emery 1999:75). Also, during the Postclassic period, turtles played an important role in religion and economy as part of state tribute. Therefore importation from both Maya and non-Maya sites was very important to the people at Lamanai by the end of the pre-Historic period (Pendergast 1991:338). The act of trading meant that loads of material had to be carried over rugged terrain causing strain predominantly to the lower limb weight bearing joints and/or predominately to the upper limbs if trade travel was done by canoe.

By the 15th century, lithic sources diminished, which caused Lamanai inhabitants to become more resourceful by re-using or re-shaping earlier pieces (Pendergast 1990). The re-use of earlier pieces also indicates that local resources were not being abandoned in favor of European materials. The types of lithic materials used provide important information on the type of subsistence activities and how they were carried out.

The arrival of the Spanish only meant that the objects being traded for were altered from time to time. At Lamanai, due to its distance from the ocean coast, most European items found at the site from the early Historic period had been gifts offered to the Maya in exchange for religious complacency (Bray 1993:117). Brays' conclusion that they were gifts rather than trade items stems from the scarcity of European items at Lamanai, which include glass beads, steel axes, two knife blades, earrings and necklaces, and a few dishes. All of these items are greatly outnumbered by their native counterparts. Although all trade goods are of interest, the tools provide an idea of how activities were carried out. Regardless of items being traded, commerce was a crucial element to continued survival throughout the Maya history at Lamanai, and therefore travel to obtain such items, whether required or desired, was very much a part of the regular activities carried out.

3.6 Food Preparation and Cooking

Food preparation and cooking, unlike the activities described above, were done by Maya women. One of the major activities carried out on a regular basis was grinding of corn. The repetitive task of grinding would increase the likelihood of developing osteoarthritis in the shoulders, the elbows, the wrists and the hands. White (1988:5) documents the presence of lime lined ceramic colanders at Lamanai and reveals the existence of ethnohistorical removal of maize pericarp. Pendergast (1981) also notes the presence of a chile grinding bowl at Lamanai. Other preparation equipment commonly found in the kitchen includes manos, metates, and lime lined pots (Pendergast 1981). The design of manos and metates design has not changed since the early Historic period. The National Film board of Canada released a film in 1993 (National Film Board) which showed Maya in rural areas still using the same technique to grind food for consumption. Most food preparation and cooking activities involve highest amount of stress on their knees and the upper limbs.

3.7 Water and Firewood Collection

Both food preparation and cooking meant women had to gather water and firewood. At Lamanai, water was readily accessible, although the lagoon was located approximately 1/4 of a mile downhill from the principal residential zone during the early Historic period (Graham; personal communication Feb. 2000). Therefore, loads of water had to be carried uphill to the residential zone, which would cause stress to the neck, shoulder, and head if the large pottery vessels were carried on the head. Evidence for this method of load bearing can be found in ethnographic videos (Feldmar 1987c: Penn State University; Ojo Video 1985; National Geographic Society 1993; Smith 1982: University of California). In all of these videos females were responsible for the manufacture of pottery, therefore, it is likely that women would experience greatest stress to their wrists and hands while performing this task. Note, this assumption is based on the available visual record and it should be stated that there is a chance that males performed this task.

Based on video evidence listed above firewood would also have been carried with the help of a tump-line, and would also cause stress to women's neck and head region. The distance covered would depend on the size of the population and how far away women had to travel to get wood. The distance traveled would increase over the years, as inhabitants at Lamanai exhausted the wood supply close to the site. The added distance traveled with heavy loads of wood would create definite stress to the back. Once Lamanai became an encomienda, the increasing population would force the collectors to travel further distances and therefore increase the burden to the body, accelerating the wear and tear on joints in the spine and other weight-bearing joints.

3.8 Child Rearing

Child rearing is another regular activity carried out by women during all periods including the Historic. However, it is not an activity that can be easily associated to the presence of degenerative joint disease. Each mother may have had a different approach regarding how to raise her children, but most women would likely carry young children in the same manner. According to Claudia Feldmar's film " Chichicastenango"(Feldmar 1987a and b:Penn State University) there seem to be two common methods of carrying children depending on the manner that loads are carried. If the load is carried on the head then children were carried on the back. However, if a tump-line was used across the head, children would be carried on the front.

From the above descriptions of subsistence activities it is possible to conclude that men and women in Maya culture performed very different tasks in their daily lives during early Historic times. However, all tasks were equally important to ensure the functioning of the household and the survival of the inhabitants. Even with the support of an extended family the ability to carry out all of the activities was founded on the geology, the climate, and the flora and fauna. The ability to carry out subsistence activities was also dependent on the quality and quantity of the diet, the technology being used, the overall health, and the impact of the Spanish conquerors' colonization activities.

3.9 Technology

Technology may alter the way a certain activity is performed. The type of technology used often dictates how tasks are performed, which may increase or decrease the development of DJD or alter its pattern. One subsistence activity that was drastically altered by technological change was hunting. The transition from the use of a spear to a bow and arrow changed the way hunting was carried out. Technological changes occurred throughout the occupation of the Lamanai site. One of the greatest changes took place during the 12th century when large monumental buildings made of limestone blocks were replaced by smaller structures made of wattle and daub (Bolland1977; Pendergast1981). These new constructions would have demanded a smaller labor pool and less stress to the weight-bearing joints. However, because wattle and daub is made out of perishable material, there would be increased maintenance required. The first Spanish structure was constructed from wattle and daub and was not easily found by archaeologists, as a result of its perishable construction. The last major structure to be built was the church, and this would have required a reasonably large labor pool. However, construction was not occurring on a regular basis and, therefore, could not be linked to the presence of degenerative joint disease.

Internal Forces

3.10 Manufacturing of Pottery at Lamanai

The Maya also developed new ways to mold raw materials. In the early 16th century, the Maya developed the Yglesia phase of ceramics and began to work with copper. (Pendergast1986;1989;1993). The Yglesia ceramics changed the color, foot form and vessel shape from previous years (Pendergast 1986a:2). According to Pendergast (1993), there was a great deal of internal strength for traditional technologies among the Lamanai Maya prior to Spanish arrival which continued after 1544. His conclusion is based on the fact that local production of Yglesia pottery continued at Lamanai during the early Historic period. None of the major shifts in Maya technology took place during the early Historic period, and therefore would not likely have affected the activities of the sample population being examined. The manufacture of pottery by women continued regardless of Spanish presence and would cause stress and strain to the upper limbs.

3.11 Spanish Technology

Although Spanish technology had reached Lamanai in the form of two knives, a wedge, an axe head, a few beads, and two lock plates, none of these items would have altered the Maya technology that was present during the Historic period (Pendergast 1991:352). Pendergast's conclusion is based on several important finds during excavation. First, none of the Spanish items were usable in significantly different ways from the items they would have replaced. Second, none of the Spanish items were present in large enough quantities for traditional Maya technologies to be abandoned. Third, in every case the Maya items continued to be manufactured and out-numbered the Spanish counterpart. Fourth and last, none of the Spanish items out-performed what was already in place, and some were clearly non-utilitarian. If Spanish items were superior, a demand would have been created and thus there would have been an increased supply. Therefore, none of the technologies introduced by the Maya or Spanish would have really been significant enough to alter the daily subsistence activities during the early Historic period population.

3.12 Diet

The ability to determine what a particular ancient population ate depends on a multi-faceted approach. Archaeological excavations and analysis of middens, ethnohistoric documents, palynological, carbon and nitrogen isotope analysis, trace element analysis, and comparisons to modern Maya populations are some of the methods used to reconstruct diet at the Lamanai site during the early Historic period (Lambert and Arnason 1982; Pendergast 1990; White 1988, 1997; White and Schwarcz 1989; White et al. 1992). Regardless of the method used, all researchers who have attempted to reconstruct diet agree that the main food staple at Lamanai during the Historic period was maize. In fact, White's 1988 study of Lamanai reveals that consumption of maize doubles from the Postclassic period to the Historic period. Her finding is supported by ethnohistoric estimates that suggest that maize made up 65-86% of the Maya diet during the Historic period(White and Schwarcz 1989:466). White and Schwarcz (1989) also conclude that the diet was stable by gender and that males and females had even levels of magnesium and strontium which meant consumption of maize was equal between the sexes. Maize was not the sole food consumed by the Maya at Lamanai. In fact, Pendergast (1990) indicates that plant and animal protein intake were adequate. Other vegetable matter consumed includes ramon nuts, beans, squashes, chile, tomato, cassava, jicama, and camote (Marcus 1982; Lambert and Arnason 1982; White 1988). Animal protein, for the most part, appears to have come from herbivore flesh and includes deer, tapir, peccary, turtles, pomacea snails, and molluscs (White 1988; White and Schwarcz 1989; White et al. 1992). Emery's (1999 and 1989) findings suggest that fish was perhaps the greatest source of protein during the early Historic period. Pohl (1987:41) indicates that dogs were raised and consumed in Mesoamerica. Diet can have a very strong influence on one's ability to perform daily tasks and may also place individuals at greater risk of stress and injury on the joints. For example if too few calories are consumed or crucial nutrients are absent, it will affect the overall health of the individuals and may result in medical conditions such as anemia or osteoporosis. Anemia was, in fact, prevalent in the

Historic period sample at Lamanai and was documented by White (1988), and during this research project.

3.13 Overall Health

The most significant factor affecting the ability of individuals to carry out subsistence activities is health. The health of the population may be influenced by the local environment. The warm tropical climate at Lamanai would definitely impact when and how individuals performed their subsistence tasks. Subsistence activities, compounded by external forces (unique circumstances that could not be controlled or influenced by Lamanai's population), would have placed tremendous wear and tear on the individuals from this site. Regardless of the technique used to acquire food, the diet would further compromise the health of the Maya.

The health of a particular population can affect the ability of individuals to carry out subsistence activities. Poor subsistence health would cause poor physiological health which can cause greater stress to the joints, increasing the chances of development of osteoarthritis. Previous research attempted to measure stress (Appendix 4) based on other markers, experienced by Maya during various times throughout their occupation at Lamanai (White 1997, 1988; White and Schwarcz 1989; White et al. 1994; White et al. 1992; Wright 1990; Wright and Chew 1998). The quality of life of populations has often been assessed by determining the incidence of a pathology and then comparing the incidence from one period to another.

This method has recently been criticized by Wood et al. (1992:343) who caution against drawing conclusions about the health status of past populations from an archaeological skeletal series based on, for example, skeletal lesion frequencies and mean age at death. They indicate there are three conceptual problems (demographic nonstationarity, selective mortality, and unmeasured individual level heterogeneity in risks of disease) with making such direct links between statistics and health. Wood et al. (1992:344) provide the example of the problem with this measure of the health of a population sample, a 20 year old in a sample represents someone who died at 20 whether the result of a particular pathology, trauma, infection or any other cause. Another individual may have been at risk of death at 20 but died later at the age of 60 years and yet researchers tend to observe her/him at the age of death and not as a 20 year old. If the 20 year old has no pathological markers on the bone and the 60 year old has numerous lesions, which individual was more healthy? This and other thought provoking questions raised by Wood et al. (1992) challenge the validity of paleodemographic and paleopathology conclusions made in previous research.

Mark Cohen (1997) argues the other side of the debate indicating that certain markers of stress (e.g., enamel hypoplasia, porotic hyperostosis) can still provide useful information about the health, nutrition, stress and morbidity of the archaeological population. While Wood et al. (1992) question the value of some of the previous paleopathological studies that address population health, such studies still provide valuable information in the reconstruction and interpretation of the health of past populations. Researchers should not attempt to argue the health or lack thereof based on the frequency of a single pathology. Rather conclusions should be based on all pathological conditions left on the bone, as well as pathological conditions that may be documented in the literature but which do not leave traces on the bones. This multifaceted approach was adopted in this research project during the discussion of the health of the sample population at Lamanai. In the case of the Maya, researchers have attempted to determine the negative health effects of Spanish presence. When attempting to reconstruct the overall health of a particular population, physical anthropologists most often are forced to look for traces left on the bones. Areas of the body previously examined for signs of stress include the teeth, calvarium, and long bones.

Wright (1990) published a study examining two pathological conditions in teeth (Wilson bands and hypoplasia) in the Postclassic and the Historic period remains. She (Wright1990:33) found both of these dental pathological conditions were significantly higher in the Historic period and that the range in class status was small. This finding reveals the Maya population at Lamanai was under greater physiological stress after the arrival of the Spanish, and therefore provides one line of evidence that their health was compromised by contact. Pendergast (1991) notes that dental analyses were underway at Lamanai and Tipu sites and that a comparison of findings appears to alter the picture that Tipu weathered the Spanish presence better than Lamanai. Pendergast (1991:345) indicates there was less difference between the sites than previously thought, and there was less of a decline in health at Lamanai during the Spanish period. Song's (1997:192) Master's thesis on enamel hypoplasia and hypocalcifications in the Belize region, also found that the incidence of these dental pathological conditions did in fact increase after the arrival of the Spanish, which supports the notion that health stressors did increase during the early Historic period.

Another study completed at Lamanai compared the Postclassic period to the early Historic one. White (1988) examined the frequency of porotic hyperostosis as an indication of anemia. She (White1988:9) indicates that iron deficiency is the most important cause of anemia. Several explanations have been offered to explain the existing iron deficiency, including dietary deficiency, parasitic infection, and food preparation techniques. The resulting porotic lesions cause an abnormal thickening of the outer-table of the cranium. However, White cautions that thickness does not equal severity. White also reveals there was an increase in porotic hyperostosis from Postclassic to Historic times, which suggests an increase in those afflicted with anemia. Well over 1/3 of the population was anemic at some point in life from Postclassic times on. White suggests the increase in porotic hyperostosis may be the result of parasitic infection which increased after conquest.

White also noted the incidence of caries, which was high as a consequence of the increased maize consumption during the early Historic period. This maize-dependent diet meant that the Maya at Lamanai were both iron and protein deficient, even when maize was processed with alkali (White 1997). The general health status must have been poor at the time of conquest, although White (1997:172) stresses that there is no evidence of an ecological collapse via malnutrition and starvation during this Historic period. White's conclusions suggest that the health of these individuals would have had great influence on their ability to carry out subsistence activities.

Neither of these conditions had as severe an impact on the population as the epidemics sweeping through the Maya population after the arrival of the Spanish. The incidence of each epidemic reaching Lamanai is not clear since none leaves traces on the hard tissue. The epidemics brought by the Spanish were not the first health disasters to deplete the population. According to White et al. (1992:12) pneumonia, and famines were present 100 years prior to the arrival of the Spanish. However, new epidemics had the most severe impact because the Maya had no natural immunity to them.

With the aid of historic documents and ethnohistorical accounts, anthropologists have been able to classify the types of new epidemics and identify when they arrived in Mesoamerica. The first epidemic to arrive was small pox in 1520, followed by measles in 1529, influenza in 1557 and yellow fever in 1648-50 (Farriss 1992; Marcus 1982; Pendergast 1990). The loss of life that resulted from these epidemics meant a decrease in the labour pool, and social upheaval. In turn, this meant decreased food production, resulting in cycles of famine and flight to the forest (Pendergast 1990:169).

The most obvious evidence of the effects of the epidemics is the decrease in population in Mesoamerica. Wright (1990:25) estimates a 90% decrease of the population in Central America between the years of 1520-1580. In the Maya lowlands alone the population of over one million declined to 240,000 by 1549-50 (Pendergast 1990:169). According to Pendergast (1991:338) the exact population numbers at Lamanai during the early Historic period are difficult to estimate because of the impermanent nature of much of the late architecture. However, based on the number of burials found, the population would have been at least a few hundred. Other than the rapid transmission of these diseases, Graham et al.(1989) suspect massacre and war would have also accounted for such a rapid decrease in the population.

The above-mentioned factors would have drastically increased the stress and strain placed on the joints as poor health decreases a population's ability to perform subsistence activities and increases its risk of injury to the major joints in the body. The pathology evident on the bones, indicates that the Historic population experienced a heavier physiological stress load than their Postclassic ancestors (White et al. 1992:11). Therefore, the information provided in this section suggests that the general health of the Maya at Lamanai was poor and that the population decreased drastically. Some pathological conditions in the Historic population increased as a result of increased physiological stress, all of which raise the expectation of an increased incidence of osteoarthritis in the Historic population.

3.14 Spanish Impact on Subsistence Activities

Having discussed the impact of technology, diet, and health on the daily activities of the early Historic population, it follows to consider whether this impact was significant enough to alter the patterns of subsistence. The Spanish had greater challenges at Lamanai than at other Maya sites from the beginning. The first challenge was that the topography forced the Spanish to follow the pre-contact strip form settlement pattern. According to Pendergast (1991:343) this format caused isolation among the residences and prevented re-development of the community center, which was key to Spanish political and economic control. Pendergast (1991) suggests the challenging topography of the southern Maya lowlands offered little opportunity to pursue traditional European subsistence patterns.

The Spanish did manage to gain some control over Lamanai when they built a chapel and later a church. Associated with these two structures were cemeteries in which individuals were buried in Christian fashion: in supine position, head to the west, facing east with hands drawn over the stomach or chest (Graham et al.1989:1258). Apart from the chapel and church, no other Spanish structures were identified. Few nails were found, which indicates limited employment ofEuropean house construction technique(Pendergast 1986a:5).

Pendergast (1991) has speculated that the Spanish also transformed the site into a redductiones town, and this function remained throughout most of the colonial times. This meant that runaway Maya from other sites were being captured and forced to stay at Lamanai (Pendergast 1991:343). Pendergast indicates that this increase in the migrant population would have caused an increased burden on the subsistence activities of the permanent Lamanai Maya population. Perhaps the most profound effect felt by the original inhabitants during this time was their deteriorating health and their decrease in numbers.

The Spanish had little control over the Maya at Lamanai, and had very little if any influence on Lamanai material culture. The Maya retained their unique style of pottery developed just prior to the Historic period. They were able to revert back to their old religious beliefs , as can be seen by the erection of a stela and the manufacture of pottery of religious significance. The Spanish lost control over Lamanai and adjacent sites in the1638-41 rebellion, and this control was not regained for 60 years. There was mutual adaptation that took place between two very different value systems. The impact of the Spanish Conquest may well have had significant, negative influences on Maya health and thus, indirectly on their subsistence abilities but little to none on their material culture, technology, and work habits during the early Historic period.

Chapter 4- Etiology and Typology of Degenerative Joint Disease/Osteoarthritis

Regardless of and/or in addition to environment, genetic predisposition, diet, or biological ancestry, all human populations through time and space are affected with pathological conditions. According to Mann and Murphy (1990:16), there are seven basic categories of diseases that may affect any sort of tissue or organ: congenital or genetic, inflammatory, traumatic, toxic, endocrine or metabolic, neoplastic, and systemic. However, the majority of diseases are diagnostically differentiated based on features present on or in soft tissue. Unfortunately, there is seldom any soft tissue adhered to the skeletal remains at archaeological sites, which limits the information that can be obtained about the overall health and quality of life of the population being studied to mostly (though not exclusively) bony-hard tissue. Next to dental disease, arthritis, which can be grouped under degenerative joint disease, is one of the most common pathological conditions plaguing populations world wide; it affects not only soft tissue, but, as it progresses (due to advancing age), it leaves definite traces on the bones.

Prior to a discussion of arthritis, there are four important factors to consider. Apart from the preservation of the bones the other factors that may interfere with a researcher's ability to identify pathological conditions are: 1) knowledge of variation in the appearance of normal bone; 2) wear patterns caused by taphonomic forces; 3) recognition of trauma; and 4) effects of climate. With these considerations in mind, a detailed discussion of the types, causes, factors influencing presence and severity, and characteristics that distinguish one type of pathology from another will follow. In addition to being able to distinguish one type of arthritis from another, it is equally important to be able to separate arthritis from other pathological conditions which may present similar characteristics on the bones.

Since DJD/osteoarthritis is the most common form found globally, this thesis discusses and assesses what this disease can tell researchers about the life stresses and activity patterns of the population being studied. Knowledge about osteoarthritis in this population can provide an understanding of some aspects of its members' overall health, provide a basis of comparison to other populations, record a prominent pathology that still occurs today, and form a basis for comparing past populations to modern populations. More specifically, establishing the presence of osteoarthritis in the population, in conjunction with considering that population's material remains, historical documents, and ethnographic records, enables the researcher to determine the types of activities that may have occurred and their impact on the body. Finally, this discussion of whether links can be made between the presence of osteoarthritis and activity patterns will be followed by consideration of some of the limitations of such research analyses.

4.1 Factors Interfering With Research

Of primary importance in research dealing with human hard tissue is for the researcher to be familiar with inter- and intra- population variation in normal skeletal anatomy and the appearance of bones. Additional factors to consider, according to Mann and Murphy (1990: 14), are taphonomic forces, pre- or post-mortem trauma to the bone, and climate, all of which affect the state of preservation. These factors may, therefore, explain the appearance of bones and further limit the ability of the researcher to identify pathological conditions using human remains.

Regardless of what pathology is being examined, the researcher must be familiar with what "normal" bone looks like; if a bone appears to be abnormal this does not mean that a pathological condition is present. The researcher should also be familiar with collections from different populations because some features that are present in one population may be absent in another. For example, in the case of dental traits, shovel shaping appears in much higher frequencies in Native North American populations than in European populations, where it may be absent. Therefore, what is "normal" for one population may not be "normal" for another.

Natural taphonomic forces can cause destruction to the joint surface and other surfaces of bones, either by weathering from organismic activities, sun, water, or wind or by soil pressure, and chemistry after deposition, which can lead to erosion of these surfaces. The destruction of bone(s) under these natural forces usually occurs gradually after deposition; however, the rate of destruction will vary from one site to another or from one area of the body to another.

Pre- or post- mortem trauma to bones is another factor. Both may cause an accelerated rate of destruction, not only to the affected area, but also to that entire element (i.e., bone). It is imperative that a researcher be able to establish the presence or absence of trauma on the bone in order to determine if the destruction is the result of trauma or a pathological condition, if the trauma caused damage which resulted in the development of a pathological condition, or if a pathological condition caused the bone(s) to become fragile and therefore trauma occurred. All or any of these factors may explain the destruction present on the bone.

As well, climate plays a major role in the state of preservation of human remains. For example, remains which are located in the arctic regions or very arid regions usually have a much slower rate of erosion and decomposition than those found in warm tropical environments. The Maya humans remains at Lamanai, consequently, are poorly preserved because of the warm temperatures and humid conditions found in Belize.

These are a few examples of the factors that influence the preservation of skeletal remains; a researcher should keep these in mind and document the state of the remains before an analysis of pathological conditions takes place. Lack of preservation of certain elements such as extremities, which tend to deteriorate rapidly, may interfere with the researcher's ability to distinguish one form of arthritis from another. Finally, the size of the collection may bias a researcher's results: if the sample size is too small, there may be an over- or under-representation of pathological conditions present on the bones. Therefore, researchers must be extremely careful to remember that accuracy of assessment about a population decreases as the number of individuals in the research sample decreases. He/she should not draw general conclusions when dealing with a particularly small sample.

After consideration of the above factors prior to conducting an analysis, examination of the skeletal remains for the presence or absence of pathological conditions is possible. Researchers looking into pathological conditions may examine all possible forms present, or, as in this case, examine one major type of pathology such as arthritis. Prior to a discussion of degenerative joint diseases some basic definitions listed below provide clarification on the meaning of some common terminology that will be used.

Arthritis: an inflammation of the joints (Steele and Bramblett 1988:18).

Degenerative joint disease: is a non inflammatory, chronic, progressive pathological condition characterized by the loss of joint cartilage and subsequent lesions resulting from direct interosseous contact within diarthrodial joints (Aufderheide 1998:93).

Osteoarthritis: is the most common form, characterized by destruction of the articular cartilage in a joint and the formation of adjacent bone, in the form of bony lipping and spur formation (osteophytes) around the edges of the joint. It is also characterized by presence of eburnation and porosity (White 1991:350).

Degenerative disease of the spine: includes the alterations produced by intervertebral disk degeneration, spinal osteophytosis, spinal ligament disturbances and degenerative joint disease of the articular facets that lead to nerve or blood vessel compression (Aufderheide 1998:96).

Osteophytosis: is a degeneration of the intervertebral disks permitting closer approximation of the vertebrae. Irritation from vertebral contact at the vertebral margins stimulates the periosteum to form nodules of new bone (Aufderheide 1998:96).

Degenerative joint disease is an umbrella term used by researchers (e.g., Aufderheide 1998) to encompass osteoarthritis, hypertrophic arthritis, degenerative arthropathy, and deforming arthropathy. This means of classification outlined by Aufderheide, and the definitions given by Aufderheide and White were used in this thesis. Specifically, the presence of osteoarthritis and osteophytosis are of particular interest to researchers due to their high frequency in past and present populations and to the fact that they have been linked to subsistence activities. Larsen (1997:162) argues that the term osteoarthritis is a misnomer since its presence does not always imply an inflammatory response, therefore, a better term would be degenerative joint disease.

4.2 Degenerative Joint Disease

Before specific analysis of osteoarthritis can take place, the researcher must first be able to identify or separate degenerative joint disease from other forms of arthritis. This is not an easy task given the fact that arthritis is still a poorly understood and defined disease, even with the progress that has been made in the past thirty years. According to Steele and Bramblett (1988:18), arthritic disorders are distinguished on the basis of the cause of the inflammation, the joints affected, and the specific nature of the destructive changes. Types of arthritis have been classified into groups that share many of the same characteristics: for example, adult rheumatoid arthritis, juvenile rheumatoid arthritis, and ankylosing spondylitis are all classified as polyarticular inflammatory arthritis (PIA).

Adult Rheumatoid Arthritis

Adult rheumatoid arthritis (RA) has been defined as " . . . a chronic, non-suppurative, systemic, inflammatory disease of synovial joints and connective tissue producing both articular and extra articular signs and symptoms" (Aufderheide 1998:99). The exact cause has yet to be determined. However, researchers have linked it to an auto-immune component that is associated with the presence of a unique antibody -- " the rheumatoid factor"-- and with the HLA-DR4 haplotype (Kilgore 1989:177). Ortner and Putschar (1981:403) believe that, in addition to genetic components, the environment may play an important factor. The environment is disputed by rheumatologists as a causative factor for rheumatoid arthritis. While the exact etiology remains unclear, researchers agree that when rheumatoid arthritis is present, the cells in the affected tissue release enzymes which cause pain and swelling of the joint capsules eventually causing destruction of articular cartilage and bone (Boyce 1993:178).

There are several factors which influence the presence and severity of rheumatoid arthritis as well as all other forms of arthritis. These include age, sex, obesity, and mechanical stress. Currently, adult rheumatoid arthritis strikes 2% of the population around the world, and its onset can occur as early as 20 and as late as 50 years of age (Aufderheide 1998:99). This variability in the age of onset indicates that it is not a disease caused by aging, although its incidence and severity tends to increase with age once the disease is present (Kilgore 1989:177). There seems to be a positive correlation between female sex and increased incidence of adult rheumatoid arthritis (Aufderheide 1998; Kilgore 1989; Ortner and Putschar 1981). A genetic factor is also suspected since such a correlation seems to exist. The specific effects that obesity and mechanical stress play on the severity of rheumatoid arthritis are still unclear, since these factors may influence individuals differently, though both place greater stress on the affected joints. Identification of one pathology from another is critical because researchers cannot draw accurate pictures of the health of a population or trace the antiquity of a particular disease. Rather than discussing the similarities between different types of arthritis, a more fruitful exercise will be to discuss characteristics that distinguish rheumatoid arthritis, for example, from other types.

Ortner and Putschar (1981:403) indicate that rheumatoid arthritis has the most significant involvement of joints and typically involves every appendicular joint in the body (Rothschild et al. 1990:44). In fact, in 85% of documented cases, the metacarpophalangeal joints are affected (Aufderheide 1998:99). Aufderheide further indicates that if it progresses, rheumatoid arthritis can cause subluxation or dislocation of the involved joints. Ortner and Putschar (1981) indicate that in addition to joints in the extremities, the cervical spine is involved in 2/3 of known cases, with the hip and trunk being least affected. As well, there tends to be a correlation between rheumatoid arthritis and the presence of osteoporosis and/ or ankylosis (Aufderheide 1998; Steele and Bramblett 1988). It should be noted that they do not always appear in conjunction with rheumatoid arthritis, and when they do, they usually occur as a secondary condition.

Finally, one feature thought to distinguish rheumatoid arthritis from other types of arthritis is peripheral joint fusion (Rothschild and Woods 1991:131). However, Rothschild and Woods argue that rheumatologists are very much divided in opinion as to the significance of this characteristic. One group accepts peripheral joint fusion as part of the spectrum of rheumatoid arthritis; the second, including Rothschild and Woods, do not agree. Researchers in the second group state that before the pre-steroid therapy of the 20th century, no cases have been found. This fusion has only occurred in recent cases that have had corticosteroid therapy. Another type of arthritis most closely resembling adult rheumatoid arthritis (RA) is juvenile rheumatoid arthritis, but this type is distinct enough to merit a separate discussion.

Juvenile Rheumatoid (Chronic) Arthritis

Juvenile chronic arthritis is a "noninfectious articular inflammation persisting for more than 3 months in an individual less than 16 years of age" (Aufderheide 1998:101). Aufderheide (1998) indicates that, as for adult rheumatoid arthritis, the cause of juvenile RA remains unknown. An additional similarity to adult rheumatoid arthritis is that the sex of individuals plays a role in prevalence; females are 3 times more likely than males to have the disease. Age does play an important factor not only in its presence but in its severity. Onset usually occurs around the time of puberty and peaks anywhere from 2 to 4 years after onset.

Therefore, juvenile rheumatoid arthritis is quite unique from all other types of arthritis in that onset is much earlier, so it can be considered a childhood disease that increases in severity with age. While its pathology is identical to adult rheumatoid arthritis, there are some noticeable differences. According to Ortner and Putschar (1981:405), the primary differences are in location and the type of joint involved. Ortner and Putschar give the example of the high frequency of occurrence in the hips and the low frequency in the temporomandibular joint which is exactly the opposite of the joint involvement pattern in the adult form. They also indicate that the occurrence of subluxation of metacarpophalangeal joints toward the radius is less marked in the juvenile form than in the adult form. Both Ortner and Putschar (1981) and Aufderheide (1998) say that, unlike adult rheumatoid arthritis, juvenile rheumatoid arthritis usually begins in a large joint such as the knee and/or joints in the spine. Also it usually begins as being monoarticular or pauciarticular (few joints) in half of the known cases, and it does not become polyarticular until later. One problem that should be noted is that when juvenile rheumatoid arthritis becomes polyarticular, it is difficult to distinguish from adult RA when the individual sufferer is considered to be an adult (over eighteen). Ortner and Putschar (1981:405) state that, in the juvenile form, ankylosis occurs more often in the carpal/ tarsal joints than in large joints.

Aufderheide (1998) notes three additional distinctive features as a means of separating adult from juvenile rheumatoid arthritis. First, the juvenile form does not have the symmetrical appearance that predominates in the adult form. Second, fusion of the spine is a common occurrence in juvenile arthritis, whereas erosion in the spine is a feature of adult rheumatoid arthritis. Third, epiphyseal overgrowth has been commonly observed in cases of juvenile arthritis. Ankylosis is one common feature in both adult and juvenile rheumatoid arthritis, although its manifestation was once thought to be just part of the spectrum for rheumatoid arthritis. However, as additional information became available, ankylosis was granted status as a distinct polyarticular disease. Due to its close association with adult and juvenile rheumatoid arthritis, it has been included within this section of the paper.

Ankylosis / Ankylosing Spondylitis

Aufderheide (1998:102) defines ankylosis spondylitis (AS) as "a systemic, progressive, noninfectious, inflammatory disorder of connective tissue calcification involving the spine, sacroiliac and peripheral major joints". Like the two previously discussed types of arthritis, the exact etiology is unknown. What is known, however, is that this condition has a 95% frequency of the histocompatibility complex antigen HLA-B27. This finding strongly suggests that a genetic factor may be able to explain the presence of ankylosis spondylitis. This pathological condition tends to be present in 1 in 2000 people globally (Steele and Bramblett 1988:135). The sex of the individual appears to play a major role in susceptibility to the disease, but contrary to findings linking the female with susceptibility to adult and juvenile rheumatoid arthritis, 90% of known cases are male. Onset occurs between the ages of 15 to 35, but rarely before puberty (Aufderheide 1998:102). In his study, Aufderheide also found a higher prevalence among Caucasians than among other "racial" groups. As with other forms of arthritis, after onset severity increases with age. One of the hallmark features of ankylosis spondylitis is the presence of sacroiliac involvement (Aufderheide 1998; Ortner and Putschar 1981; Rothschild and Woods 1991). This erosive joint disease usually strikes the sacroiliac joint first, often causing fusion, and then it proceeds upwards (Rothschild and Woods 1991:125). Rothschild and Woods also explain that fusion occurs after the healing of the inflamed tendons, ligaments and joint capsules. The healing of these tissues causes them to become calcified. Aufderheide (1998:102) adds that, as this disease progresses, calcification can also occur in the intervertebral disks which then limits mobility. This limitation, in turn, may lead to symmetric syndesmophytes (bony bridges), otherwise referred to as "bamboo spine". The presence of synodesmophytes further limits mobility, and Aufderheide suggests that this may explain the presence of osteopenia and the erosion of vertebrae known as the squaring effect.

Ankylosing spondylitis is often confused with diffuse idiopathic skeletal hyperostosis (DISH). Aufderheide (1998:98) indicates that ankylosis spondylitis usually has an earlier onset, its syndesmophytes are thinner and vertically oriented, it fuses apophysial joints and no extra spinal bone formation occurs. All these features distinguish it from DISH. He notes, however, that final effects make ankylosis spondylitis indistinguishable from rheumatoid arthritis. Aufderheide stresses that the patterns of joint involvement differ; ankylosing spondylitis tends to involve major joints and generates a more vigorous response of new bone formation, whereas rheumatoid arthritis tends to affect mainly small joints. Rothschild and Woods (1991:125) indicate that psoriatic arthritis and Reiter's syndrome should also be classified in the subgroup of spondylitis.

Psoriatic Arthritis

Psoriatic arthritis is "... a systemic disease with prominent cutaneous manifestations that can involve joints in a manner similar to that of RA and AS" (Aufderheide 1998:104). Aufderheide says that the cause is also unknown, but, just as with ankylosis spondylitis, the histocompatibility complex antigen HLA-B27 is present, though only in 60% of known cases instead of 95%. This presence suggests that genetic factors may play a role in psoriatic arthritis. Of the individuals with psoriatic arthritis, 5-10% more are women. The severity of this condition tends to increase after onset.

Klepinger (1979:121) says that one hallmark of psoriatic arthritis is the erosion of distal interphalangeal joints of hands and feet, which creates a "pencil in cup" deformity. This extensive erosion results in the shortening of bone. Aufderheide (1998:104) indicates that psoriatic arthritis primarily affects the joints of the lower limbs. Common features also include subchondral cysts, ankylosis, and subluxation of the affected joints, and these lesions tend to be asymmetrical. Aufderheide (1998) also explains that osteopenia is often absent in psoriatic arthritis, unlike in the previous types of arthritis discussed. Ortner and Putschar (1981:405) state that contrary to the usual progression of AS, the severity of psoriatic arthritis tends to decrease as it descends the spine. Another unique feature commonly found is calcaneous heel spurs (Aufderheide 1998:102). Finally, Rothschild and Woods (1991:127) indicate that psoriatic arthritis is easy to distinguish from osteoarthritis and aging which do not produce sacroiliac joint erosion. Although Reiter's syndrome has been found to affect hand joints minimally in ½ of documented cases, in most cases of this form of arthritis, few joints tend to be affected, and there is usually less destruction than with other serogenative types. Reiter's syndrome is another form of spondylitis identified by Rothschild and Woods (1991).

Reiter's Syndrome

Reiter's syndrome (RS) "consists of the triad of nonspecific urethritis, conjunctivitis and polyarthritis" (Aufderheide 1998:104). According to Aufderheide this syndrome has been shown to be related to the bacterium Chlamydia trachomatis. He indicates that there is evidence that conjunctivitis and urethritis are direct infections by this organism and that the latter of the two is usually sexually transmitted. Aufderheide also says that regardless of whether the arthritis is a nonspecific, reactive form or whether it is a direct infection by Chlamydia trachomatis, its exact cause has not been determined with any degree of certainty. As in ankylosing spondylitis, in Reiter's syndrome, 90% of known cases seem to affect males, and 75% of cases possess the HLA-B27 complex antigen, suggesting a familial pattern of genetic contribution.

This form of arthritis (RS) seems to target mainly the lower limbs, affecting joints in the knee, ankle and foot and commonly occurring with calcaneous spurs, and new bone formation around the Achilles tendon insertion is a frequent occurrence in Reiter's syndrome (Aufderheide 1998:104). He warns that enteropathic arthropathies is another condition that closely resembles RS.

Septic Arthritis

Septic arthritis (SA) has been defined as ". . . infection of the synovium and later all structures within a joint by a pathogenic infectious agent that can lead to joint destruction" (Aufderheide 1998:106). Septic arthritis occurs as a result of bacteria that have entered the synovium and the joint cavity via the blood stream. The disease may then be an extension of infection of the bone (osteomyelitis) or of soft tissue (Ortner and Putschar 1981:399). Ortner and Putschar also explain that infection can be introduced to the bone by a penetrating wound. One of the most common types of infections associated with septic arthritis are streptococci; others include gonococci, pneumococci, and meningococci.

According to Aufderheide (1998:106), since SA attacks soft tissue primarily, it is difficult to distinguish unless subchondral bone becomes involved. However, he indicates that when signs are present on the bone, the arthritis will often terminate in bony ankylosis. Ortner and Putschar (1981:402) believe that septic arthritis can be distinguished from other forms of arthritis based on its close association with the marked destructive changes of chronic osteomyelitis. They also state that when analyzing skeletal remains, periosteal reactive bone, sclerosis, and cloaca are indicative of infection and inflammation; these indicators are important to keep in mind when attempting to determine the presence of septic arthritis. Aufderheide (1998:107) concludes that, unlike degenerative joint disease, septic arthritis tends to have the following features: a higher frequency of monoarticular involvement, demonstrable abscesses, and presence of fistulae and ankylosis.

Gouty Arthritis or (Metabolic Arthritis)

Gouty arthritis (GA) " is a disease of metabolic alteration characterized by elevated serum levels (hyperuricemia) of urate (uric acid) and a well patterned tissue deposition of urate crystals into joints and periarticular soft tissue associated with intense local inflammation" (Kelley and Palella, in Aufderheide, 1998:108). Aufderheide (1998) says that in a small number of individuals, the cause of hyperuricemia is obviously inherited enzyme deficiency and overactivities, some of which are linked to X chromosome mutations. However, he stresses that, in the majority of cases, no such specific change is attributable to a positive family history. Aufderheide's cautionary note indicates that researchers are still unclear as to the precise etiology of metabolic arthritis.

The factors that influence the presence and severity of GA seem to depend very much on whether one is considering primary or secondary gout. Aufderheide (1998:108) states that primary gout shows the presence of genetic features and may be influenced by dietary and other environmental factors responsible for hyperuricemia. Secondary gout is anything that interferes with renal excretion of even normally produced quantities of uric acid. Aging and the sex of the individual play a role in the presence of gouty arthritis: 95% of these affected are males over the age of 50 (Aufderheide 1998). These two factors also tend to help distinguish gouty arthritis from other common forms of arthritis.

Gouty arthritis seems to appear mainly in extremity joints, with a higher frequency in lower limbs than upper ones (Ortner and Putschar 1981: 416). Ortner and Putschar also identify para-articular tophi as a trademark of gouty arthritis. Para-articular tophi are scooped-out defects that results from specific pressure erosion. Ortner and Putschar state that gouty arthritis tends to be unilateral and frequently affects the first metatarsal-phalangeal joint. Unfortunately, once cartilage destruction takes place, changes to the bone are very similar to those of osteoarthritis. This similarity makes it difficult to separate them; however, lytic lesions are one of the most distinctive trademarks of gouty arthritis, and are not found in osteoarthritis (Ortner and Putschar 1981). Furthermore, even if this trademark is absent, osteoarthritis is rarely limited to distal hand and foot joints (Aufderheide 1998:108). Another difficult condition to separate from osteoarthritis or degenerative joint disease is traumatic arthritis.

Traumatic Arthritis

Aufderheide (1998:105) defines traumatic arthritis as ". . . permanent joint changes secondary to trauma (fractures, wounds, dislocations)". The cause of this type of arthritis is self explanatory: any trauma that insults the bones and surrounding tissue, whether it be the result of a fall or a deep, penetrating wound by a sword, for example. The severity of the arthritis depends on the severity of the fracture, wound or dislocation.

One of the biggest problems in distinguishing traumatic arthritis is the fact that the lesions induced by such trauma are indistinguishable from degenerative joint disease (DJD) that occurs over time (Aufderheide 1998). He stresses that there are three features that can be used to separate traumatic arthritis from DJD: first, any age group may be involved in a traumatic event; second, traumatic arthritis is usually monoarticular; and third, severe injury commonly produces bony ankylosis, which is rare in DJD. It is important to note that there exists a vast difference in opinion. As a result, some researchers do not separate traumatic arthritis from DJD; instead they classify it as a contributing factor to DJD.

Osteoarthritis

Although the ending "- itis" implies an inflammation,Tyler and Anderson (1986:222) define osteoarthritis as " a degeneration of a joint owing to 'wear and tear' over a period of years rather than an acute process". Aufderheide (1998:93) adds that osteoarthritis " is a non-inflammatory, chronic, progressive pathological condition characterized by the loss of joint cartilage and subsequent lesions resulting from direct interosseous contact within diarthrodial joints". According to Boyce (1993:179), osteoarthritis is caused by excessive wear and tear on joints in conjunction with poorly understood susceptibility of joint cartilage to degenerative enzymatic action in some individuals. Although the literal definition of osteoarthritis means bone inflammation and could include most forms ofDJD, use of this term in this research refers to the general form of degenerative changes to joints from wear and tear resulting from repetitive subsistence activities, trauma, and aging; and not from an acute inflammation that is associated with pathological conditions such as RA. Aufderheide

(1998:93) argues that osteoarthritis can be subclassified into two categories: primary and secondary. He says that in the case of primary or idiopathic osteoarthritis, which accounts for 80% of cases, there is no single evident cause. In the case of secondary osteoarthritis, the involved tissue is altered by some other disease or event (trauma, infections, vascular and other types of extra articular causes) such as obesity and occupational stress (Aufderheide 1998).

Tyler and Anderson (1986:222) indicate that age plays a major role in the identification of the presence of primary degenerative joint disease, since DJD usually affects individuals over the age of forty. They also say that many individuals experience some degree of osteoarthritis if they live long enough. This is a bit of a circular argument since not all individuals who live long lives (ie. over eighty) will necessarily be afflicted with osteoarthritis, although they will likely have some form of arthritis. Tyler and Anderson are correct when they say that, after onset of osteoarthritis, it is an age-progressive condition which tends to involve weight-bearing joints and has no sex predilection. Ubelaker (1991:108) and Mann and Murphy (1990) suggest that DJD presence may be the result of long-term mechanical stress, which causes repeated minor irritation of the cartilage. Pfeiffer (in Ortner and Aufderheide,1991:73) argues that this mechanical stress may be compounded by obesity, which drastically increases the stress placed on weight bearing joints. Jurmain (1980:143) says that in addition to the above-listed factors, heredity and endocrine agents may be responsible for a body's gradual loss in the ability to maintain joint cartilage.

Regardless of the factors that may influence the presence and severity of osteoarthritis, Boyce (1993:179) indicates that once it is present, it most frequently affects more stressed joints, i.e. the knee, hips, and spine. Schwartz (1995:238) states that one feature that most distinguishes osteoarthritis from other forms of arthritis is that it is non-inflammatory. Lipping (i.e. bony spurs of osteophytic development marginal to the articular surface) and porosity of the surface both characterize the presence of osteoarthritis (Buikstra and Ubelaker 1994:122). One of the most frequently associated "hallmark" features is called eburnation. Rogers and Waldron (1987:267) define eburnation as a trait that ". . . occurs as the result of the movement between two joint surfaces on which the articular cartilage becomes damaged and worn; it is, therefore, the consequence of pathological change in a dynamic, not a static joint". Rothschild (1997:530), however, warns other researchers not to use the presence of eburnation as a trademark indication of the presence of DJD. He states that eburnation has been used erroneously as the major marker of osteoarthritis; rather, it should be used as an indication of the severity of arthritis. While this may be true it may still act as a general indication of the presence of DJD, since fusion of the joint takes place much more frequently in other types of arthritis, before eburnation occurs.

The principal features osteoarthritis are perhaps best summarized by Aufderheide (1998:94). They include loss of cartilage normally covering the central areas of bone ends in diarthrodial joints with consequent exposure of the bone surface within a joint; bone remodeling, producing focal nodules of new bone formation at the margins (osteophytes lipping and calcification of cartilage); small (up to 1 cm) cysts and surrounding sclerosis within the bone in areas devoid of a cartilaginous cover; eburnation; and fibrotic thickened capsules. While these general features provide a good summary of the effects that DJD has on bone, some researchers (e.g., Aufderheide 1998) believe that the distinctive nature of degenerative joint disease which involves the spine warrants a separate discussion.

Degenerative Disease Of The Spine

Degenerative disease of the spine (DDS) " includes the alteration produced by intervertebral disk degeneration, spinal osteophytosis, spinal ligament disturbances, and degenerative joint disease of the articular facets that lead to nerve or blood vessel compression" (Aufderheide 1998:96). Chapman (1970:31) cites the cause as being the result of stresses and strains of "man's" upright posture and physical exertions. She also says that this exertion becomes evident in the lumbar vertebrae and sacrum by about the fourth decade of life. Furthermore, Chapman believes that metabolic or genetic predispositions are causative agents. Lovell (1994:149) says that hormones, heredity, obesity, age, and functional stress may cause or exacerbate this type of DJD.

Aufderheide (1998:96) agrees that age may play a role in the presence of DDS since it does not appear to be a childhood condition and since it rarely affects individuals under the age of 30. He also believes that, after onset, it is a progressive pathological condition since it affects 80-90% of individuals over the age of 75. He explains that facets are synovial lined joints, and when involved by degenerative joint disease, they demonstrate lesions that are said to characterize DJD described in the previous section. Distinguishing characteristics of degenerative joint disease in the spine include loss of cartilage, subchondral sclerosis, and porosity eburnation features. In severity, DJD in the spine most commonly affects the lower cervical vertebrae (C6-T1), then thoracic (T2-T5), followed by lumbar (L2-L4). DJD of the spine is one of the most common pathological conditions to effect the vertebrae. It is also one of the most common forms of arthritis found on skeletal remains. It is therefore crucial to be able to separate DDS from all other forms of arthritis. Some forms of arthritis are easily distinguished from degenerative joint disease because of the joints involved, the age at onset, and the traces left on the bones; however, there are sometimes areas of overlap which complicate the researcher's ability to make such a distinction. A summary of features that distinguish osteoarthritis from other types of arthritis provides a quick reference for cases where doubt exists (Table 1). Equally important is the ability to identify and separate other pathological conditions from arthritis as they present themselves on skeletal remains. Within the confines of this paper it would be impossible to summarize all the pathological conditions left on the bones which resemble arthritic changes. Therefore, the focus will be to identify some that pathological conditions that may be confused with degenerative joint disease or DJD that may involve a secondary process.

4.3 Other Pathological Conditions

If research is being conducted based on the presence of a particular pathological condition such as degenerative joint disease, researchers need to be aware of other conditions that may strongly resemble it so that they can make accurate assessment. Furthermore, it is important to understand that DJD may be present for reasons other than "wear and tear" over time and/or trauma. If the researcher can rule out the presence of DJD resulting from the aging process or traumatic event, he/she maybe able make a link to activity patterns. For example, Larsen (1997:162) says that osteoarthrosis involves the surfaces and margins of vertebrae bodies. He also indicates that osteoarthrosis has virtually identical pathological responses as osteoarthritis.

Table 1: Quick Reference Guide

Types of Arthritis	Age Onset	Sex Ratio	Principle Joints Affected	# of Joints Affected	Areas of the Body Affected	Hallmark Features	Pattern
Osteoarthritis	40+	N/A	- Large joints - knee - hip - shoulder - elbow	polyarticular	- mainly lower limbs	- non-inflammatory - new bone formation -loss cartilage - small cysts -ebunation	- major weight bearing joints - asymemetrical
Traumatic Arthritis	- all ages	1:1	- knee - hip - ankle	- monoarticular	- lower limb	- any age - severe injury produces bony ankylosis	-asymmetrical
Gouty Arthritis	- typically 50+	f to m 1:9	-mostly extremity joints - lower extremities more than upper - first metatarsal- phalangeal joints	-monoarticular	- appendicular joints	- paraarticular tophi - lytic lesions -subluxation -fingers and toes	- unilateral
Septic Arthritis	N/A	f to m 1:1	- any synovial joint	monoarticular	-any joint that has synovial tissue - infected by Bacteria	- demonstrable abscesses, fistulae, ankylosis -periosteal reactive bone sclerosis	- Asymmetrical - often terminates i bony ankylosis
Psoriatic Arthritis	N/A	female 5-10% higher rate	- distal interphalangeal joint of hands and feet	- polyarticular	- primary joints in lower limbs	- calcaneous heal spur - subchondral cysts - ankylosing - pencil and cup deformity - produces sacroiliac joint erosion	- Lesions asymmetrical - spreads down the spine - absence of osteoporosis

Reiter's Syndrome	N/A	f to m 1:9	- knee - ankle -foot joints	pauciarticular	- principally lower limbs	- Calcaneous spurs - Achilles tendon associated with new bone formation	- Asymmetrical
Juvenile Rheumatoid Arthritis	- less than 16yrs	f to m 3:1	- hips - knee -hands - feet	-monoarticular -pauciarticular -polyarticular	-large joints esp. - knee, hip, and spine	- Inflammatory - epiphyseal overgrowth fusion of the spine -ankylosis	asymmetrical
Adult Rheumatoid Arthritis	20-50 yrs	f to m 3:1	-metacarpophalangeal joints - cervical spine - TMJ - most significant # of joints	polyarticular	primarily appendicular joints	- inflammatory - often accompanied by osteopenia and ankylosis - subluxation or dislocation -minimal marginal extosis	symmetrical
Ankylosing Sondylitis	15-35 yrs	f to m 1:9	- spine - sacroiliac -major peripheral joints	polyarticular	- tendency to affect spine - major joints both upper and lower	- inflammatory - bamboo spine - squaring affect -osteopenia	- bilaterally symmetrical - usually starts socroiliac joint

N/A = not applicable
f = female
m = male

Another disease that has been mis-classified or confused with osteoarthritis is calcium pyrophosphate deposition disease (CPPD) (Rothschild 1997:531). Rothschild states that this condition, like DJD, is not really influenced very much by the age or sex of the individual. Aufderheide (1998:114) adds that radiological study identifies calcification of knee menisci and articular cartilage that can closely resemble an exaggerated form of DJD. One diagnostic feature of CPPD that can be used to differentiate it from degenerative joint disease is the linear calcification in the fibro-cartilage of the pubic symphysis (Aufderheide 1998). Aufderheide states that joint sarcoidosis causes endosteal bone sclerosis, subperiosteal erosions or mild periosteal reaction, as well as changes resembling DJD. Therefore, it is crucial to consider the above pathological conditions as possible explanations for the appearance of the skeletal remains when attempting to identify degenerative joint disease.

Degenerative joint disease may be a secondary or tertiary response to a different initial disease. Boyce (1993:183) gives the example of Paget's disease, which increases the incidence of fractures and deformities leading to arthritis in nearby joints. Another example, given by Ortner and Putschar (1981:411), is hemophilic arthropathy, in which degenerative joint disease becomes a part of the end stage of various inflammatory, traumatic, metabolic, and congenital or acquired joint disease secondarily induced by hemophilia. A third disease which may lead to degenerative joint disease is ochronosis.

Ochronosis (Alkaptonuria) is " . . . characterized by precipitation of an organic pigment into the body's cartilaginous and fibrous tissue and the reactive changes which that deposition pigment initiates" (Aufderheide 1998:111). This disease affects the spine, knees, hips, and shoulders, but small joints such as sacroiliac, hands and feet are not affected. The distribution of the black pigment to these large joints is followed by inflammation, which is followed by features of osteoarthritis. Aufderheide suggests that if ochronosis progresses sufficiently, the black pigment may eventually be deposited on the bone. While finding this black pigment on the bones may not always be possible, one should note it when attempting to understand this as a source of DJD (primary versus secondary). Finally, Aufderheide (1998:114) provides the example of synovial osteochondromatosis which is known to produce DJD as a secondary change. With an understanding of the existing types of arthritis, their areas of overlap, and other pathological conditions that may confuse the diagnosis of degenerative joint disease, one is able to attempt to understand what the presence of a particular pathological condition can tell researchers about a particular population.

4.4 Degenerative Joint Disease: What Can It Tell Us?

Unfortunately, most records of pathological conditions are found on or in soft tissue, and therefore the evidence of their presence is lost once soft tissue is absent from human remains. When physical anthropologists conduct research on ancient remains, they are frequently forced to narrow their research on pathology to those diseases that leave traces on the hard tissue. Degenerative joint disease is one of the few diseases which leaves its marks on skeletal remains and which has therefore been often documented.

In broad terms, documentation of pathological conditions, such as DJD, can tell researchers the following about a population: the incidence of the disease within that group of individuals as an indicator of the level of stress experienced by this particular culture, and the impact DJD has had on the overall health of this particular population. All of this serves as a means to assess the quality of life experienced by the population being examined.

In general, Jurmain (1990:83) believes that researchers may gain a better understanding of the incidence of a disease in the population being researched by comparing this incidence to that experienced by other populations, whether in modern times or in the past. By comparing the incidence of DJD in one population to another population, researchers can determine whether the disease had a significant impact on that population.

In addition, a comparison of incidences of DJD in modern and past populations allows researchers to have a point of reference, which enables conclusions to be drawn as to the overall life stresses and health of a certain population. For example, if there is a higher incidence of DJD in one particular population than in another among young adults, researchers can conclude that this culture or time period placed greater demands on its people whether these were the result of forced labor or coping with external forces such as a challenging environment or terrain. With this information, researchers are able to look for unique factors that may be present in one population but not in another and that have increased susceptibility to degenerative joint disease. Much of the focus on DJD has been narrowed to looking specifically at osteoarthritis because researchers such as Loughlin et al. (1995:1186) were able to conclude that osteoarthritis remains one of the most common debilitating diseases resulting from the degeneration of cartilage.

Pfeiffer (1991:12) points out that having knowledge of a specific pathological condition may give researchers the ability to help modern populations anticipate and solve contemporary health problems. For example, while little is known about OA in ancient populations, what is known may help us to predict its frequency in a given population and so plan for health needs of the future. Pfeiffer also indicates that understanding a particular pathological condition such as osteoarthritis may help to predict which groups in a population are more susceptible to the disease. Physical anthropologists' current understanding of DJD comes from our knowledge of its presence in the past, and from the scientific and medical communities' understanding of it in the present day. With this knowledge, physical anthropologists' research on past populations concludes that few people are able to escape this disease and that people are vulnerable whether it be through wear and tear on joints over time, traumatic injury, or DJD as a secondary response to another disease. Furthermore, paleopathological studies help researchers to ascertain the antiquity of certain maladies (Pfeiffer 1991). If researchers can ascertain when a disease began, they may then be able to conclude that the pathology was caused by genetic factors or recent changes in lifestyle or environment. For example, according to Ortner and Utermohle (1981:23), if a disease is recent, it is helpful to know what factors contributed to its advent and how these factors relate to the development of human society.

By studying DJD's antiquity, which can be traced to the earliest hominids " Lucy" (Cook et al. 1983) and Neanderthal times (Straus and Cave 1957:348; Trinkaus 1985), researchers may be able to determine if there were any behavioral or environmental shifts that explain the increase, decrease, presence or absence of this particular pathological condition. For example, Pfeiffer (1991:13) indicates that the "New World Syndrome" (obesity) in North America may become responsible for an increased incidence and/or severity of degenerative joint disease. This may, in fact, be the case; however, it is equally important to note that variation between individuals also plays a role as to whether someone will develop DJD and how severe it will become. Obese people will not necessarily develop this disease. This same caution should be applied to Ubelaker's (1991:84) suggestion that degenerative joint disease can be an indication of age. He claims this because onset, in the majority of cases, occurs in people over forty and DJD's severity increases with age. This correlation with age must be used only on a general sense and in conjunction with well established aging methods, since not all individuals will develop DJD, and its severity will vary from one individual to the next.

Lovell (1994:160) reinforces the value of paleopathological studies by stating that many paleopathology findings can be supported with clinical data from modern populations. According to Lovell, paleopathological studies can help determine whether the disease affects the sexes differently in a population, whether age plays a role in the presence of a disease, and such knowledge may serve as a test for current knowledge.

4.5 Can Links Be Made Between Activities and Presence of Osteoarthritis?

Studies attempting to link activity patterns to osteoarthritis continue to be considered controversial. The reason these studies remain controversial is that they are difficult to replicate from one population to another. Therefore, some researchers (e.g. Hadler et al. 1978; Lockshin et al. 1969) question the validity of such links. Lockshin et al. (1969, in Stirland, 1991) and Merbs (1983) exemplify the two sides of the debate. Generally, the method that emerges from pro-link studies is establishing activity-osteoarthritis patterns and then arguing for causal links. Finally, this section will discuss the methods of analysis, age of onset for example, used to assess whether these links can be made.

Before being able to understand how physical activity relates to DJD, it is crucial to define what is meant by the term physical activity. Larsen (1997:161) defines it as characteristic of human adaptive regimes. However, this definition is too broad for the purpose of this particular study. Not all adaptive regimes, religion for example, necessarily would involve physical exertion leading to degenerative joint disease. Therefore, the term 'physical activity' herein refers to habitual subsistence activities that are carried out on a regular basis. Specifically, the focus centers on subsistence activities causing stress to the major joints which may lead to the development of degenerative joint disease. Some researchers (e.g., Bridges 1991; Ortner 1968) have argued that early onset of DJD could equally result from the performance of those activities that are not regularly undertaken, and which place greater than normal stress or trauma on joints. Their theory may in fact have merit; however, it may be very difficult to identify these infrequent activities. This study will attempt to identify pathology that has resulted from a single event, but will only attempt to see if a link can be made between regular subsistence activities and DJD.

Some researchers (e.g., Hadler et al. 1978; Lockshin et al. 1969, in Stirland, 1991) reject the theory of a link between DJD and physical activity. Lockshin et al. (1969, in Stirland, 1991:40) examined 1100 males from three mining communities in West Virginia. These researchers found no difference in the prevalence of disk degeneration in the lumbar portion of the spine between miners and non-miners, causing them to question whether these positive links are tenable. Since both groups had similar patterns, no link could be made between mining and DJD of the spine. Lockshin et al. (1969, in Stirland,1991)do not indicate what type of activities non-miners engage in which may explain the similarities present. Another point raised by those who do not favor this type of research is that not all research populations have ethnographic and historical records, oral history, good archaeological context, and good preservation to support making a link between an activity and OA.

Countering the arguments above, Larsen (1997) provides numerous examples for positive links between physical activity and DJD. Specifically, he cites research conducted by Merbs (1983) -a pioneer for this type of research- on the skeletal remains of the Sadlermiut Eskimo of the Canadian Arctic in what was formerly known as the Northwest Territories, but is now called Nunavut. After gathering information regarding pathology and cultural activity, Merbs found distinctive patterning of degenerative articular pathology among young males having a high frequency of bilateral involvement in the shoulder joints. This finding enabled Merbs to conclude that osteoarthritis was the result of the repetitive motion of kayak paddling. Females, on the other hand, had a high frequency and severity of DJD in their temporomandibular joint, resulting from heavy loading on the mandible, which Merbs linked to chewing and softening animal hides with their teeth. A knowledge of accurate and detailed ethnographic and historical records and the osteological traces of DJD enabled Merbs to arrive at such conclusions.

A third group of researchers take a middle position (Bridges 1991; Jurmain 1977a, 1977b, 1978, 1980, 1990; Merbs 1983; Olsen-Kelley and Angel 1987 ;Ubelaker 1979; Wells 1982). They favor the theory that a link can be made, recognizing the potential weaknesses, and feel that such research needs to be examined on a population-to-population basis. Both views, however, acknowledge that limitations do exist in the evidence and research methods used to link degenerative joint disease to activity patterns.

This thesis will argue that links can in fact be made as long as the proper precautions are taken and limitations are recognized. The inability to establish a link in one population, whether it be the result of poor preservation or lack of corroborating evidence, does not mean that links cannot be made in other populations. Furthermore how specific the links can be depends on the particular population and the information available.

Researchers who have attempted to establish links have outlined some important considerations that need to be examined in this process. For example Stirland (1991:40) warns that it is important to recognize that interpretations concerning the use of tools (how frequently and exactly how a tool was used) rely heavily on assumptions based on ethnographic and Historical parallels. Therefore, these interpretations tend to be speculative. Jurmain (1990:88) indicates that in all populations used in the study of degenerative joint disease there will always be patterns of severe involvement; therefore, the incidence of this disease has to be based on several factors such as age and sex. He (Jurmain 1980:143) also stresses that factors other than activity -such as, heredity, and endocrine agents- may influence the presence and severity of DJD.

In order to determine whether links to activities can be established, researchers must ascertain the age of onset of DJD, the frequency and severity of involvement in males and females, the way in which DJD advances with age, the relative amount of bilateral/unilateral i.e. spine involvement, and population affinity (Jurmain 1980:143; 1990:88). Prior to being able to ascertain this information, the sex and age of the individuals being studied must be determined, in addition to the absence and presence and location of degenerative joint disease. Bridges (1991:380) outlines a scoring method ranging from 0-4, with zero being absence, and four being severe incidence. She indicates lipping, porosity, and eburnation should be scored separately. Researchers should consult Buikstra and Ubelaker (1994:122-123), who provide useful scoring methods for the latter mentioned features of degenerative joint disease. With all of this information gathered, researchers can then attempt to correlate general data and specific data more closely to activity patterns such as upper versus lower appendage involvement, across joint comparisons, and other patterns of involvement (Jurmain 1980: 143), to name a few. Researchers should compile all of this information with any other archaeological information pertaining to the population in order to determine what activities took place and what repercussions these activities have/had on the bones.

Several researchers (Lovell 1994; Jurmain 1980; 1990; Stirland 1991; and Larsen 1997) who have either completed this type of research or examined the usefulness of activity pattern studies caution that there are numerous factors that need to be considered in advance. For example, Lovell (1994: 149) warns researchers attempting to link activity pattern to the presence of degenerative joint disease that no consensus on the nature of specific relationships between physical activity and joint modifications may exist. Furthermore, Lovell (1994) suggests that it is important to consider individual and population variation; because similar activities may be carried out differently. As well, different activities may produce similar patterns of DJD. Having considered some of the preexisting limitations, it is also important to be clear on what degree of certainty can realistically be concluded about the population being researched.

Bridges (1991: 385) states that earlier studies linking DJD to a particular subsistence economy cannot be supported. She challenged the theory that earlier hunter/gatherer populations suffered more severe stresses and consequently a higher incidence of DJD by comparing hunters/gatherers (6000-1000 BC) to agriculturalists (AD 1200-1500) in Alabama.

Both had the same affected joint pattern and severity, which indicates that similar patterns of arthritis cannot clearly be related to a subsistence economy. With all of these considerations in mind, one can examine the connection between degenerative joint disease and activity patterns on a one- to- one basis.

It is important to understand how paleopathology linkage studies can contribute to current archaeological research. For example such studies provide knowledge about a particular pathology, about lifestyles and affected changes to these lifestyles. According to Jurmain (1990:83), paleoepidemiological comparisons of now extinct groups offer a broader basis for understanding general lifestyles, for example, hunters and gatherers versus agriculturists. In an earlier article, Jurmain (1980:143) also indicates that osteologists may be able to help prove what has already been speculated about after considering the archaeological record. Much of anthropological research already tries to establish culturally patterned activities of pre-Historic and Historic times by examining material remains; therefore, studies on DJD may test and/or strengthen such convictions.

Stirland (1991:40) believes research linking DJD to activities has value because occupations in the past changed very little until recently, and therefore cross- temporal and cross-cultural comparisons might be made if enough similarities between two populations are present. Stirland gives a three point argument about why researchers have such an interest in research linking activity patterns to the presence of DJD. First, occupations tend to be non-random and habitual; therefore, such repetitive tasks will have a measurable toll on the body. Second, if some occupations can be diagnosed, then the information gained will provide an important tool in archaeological reconstruction of past life ways. Third, the ability to identify some skills, trades or professions can lead to the extrapolation of conclusions concerning the existence of these activities at other sites and in other periods.

Bridges (1991:379) points out that conducting this type of research, linking OA to activity patterns, gives researchers an understanding of variation in work burdens and activities among and between groups. Bridges' adds that the examination of arthritis patterns may help to interpret the impact of a shift in subsistence practices. Finally, Larsen (1997:164) believes insight can be gained into behavioral characteristics ofhuman populations by looking at the incidence of degenerative joint disease.

Researchers rely on the presence or absence, severity and topography of patterns of degenerative joint disease to inform them about the frequency of the disease, health, and stress level faced by particular individuals within a culture, and by the population as a whole. Specifically, researchers are interested in determining patterns such as joint involvement, age of onset, sex differences, and incidence of DJD, and whether other osseous changes correspond with patterns of DJD. The establishment of the patterns must take place prior to links being made and this will enable researchers to make inferences about the behavior or lifestyle of a population. Past exploration of this topic has attempted to link certain patterns with whether age at onset will indicate when individuals began physical subsistence practices, whether there is any sexual dimorphism within a population indicating that either sex had more demanding tasks, whether a social hierarchy was present indicated by the finding that higher status meant less DJD, whether patterns present indicate handedness, and whether temporal trends and adaptive shifts were present (Larsen 1997:178). Existing research relies on these assumptions. The first task, after the raw data documenting DJD has been gathered, is to identify as many types of patterns as possible, so researchers can determine whether any links exist between the DJD present and causal activities.

The primary means of doing this is to look at patterns of joint involvement. Jurmain (1980) suggests six types of patterns to look for: 1) what joints are most frequently affected; 2) what degree of severity is present; 3) what is the relative amount of bilateral involvement; 4) what influence does age have on those affected; 5) what influence does the sex of the individual seem to play; and 6) what role do different populations have on the pattern. With this information, researchers can access what these patterns mean and what they can tell researchers who are attempting to reconstruct what life was like while the individual(s) were living.

Most researchers (e.g., Bridges 1992; Jurmain 1980,1990; and Tainter 1980) now recognize that age plays a very important role as to whether findings are significant or not. By looking at the age of onset, researchers can determine whether the degenerative changes are the result of the normal wear and tear associated with the aging process, or whether they can be linked to stressful activities that cause an accelerated rate. For example, if a large number of very young individuals have osteoarthritis a researcher may be able to conclude two things. First, life was very strenuous for that population, and second, the young individuals were introduced to subsistence activities at an early age, thus increasing the frequency of osteoarthritis among the relatively young. Age of onset will be a very important pattern to look for in the Maya population from Lamanai, since ethnographic material suggests that participation in subsistence activities begins at an early age (Smith 1982:University of California).

Another means utilized by researchers to assess the type and level of stress experienced by a particular population or culture is to look at which joints are primarily affected by DJD, to determine male/female differences and their meaning. A recent study examines skeletal remains from two locations, Ensay and Wharram Percy (UK), from the 16th to the 19th century (Sofaer-Derevenski 2000:333). She uses both ethnographic and historical documents to support her findings. Both groups of people where known to have a distinct division of labor between the sexes. Looking at the population from Ensay, the researcher determined that women performed the domestic tasks to maintain a household as well as the majority of the heavy lifting. For example, the women would transport 80 lbs of peat and seaweed for fuel on their backs. Men on the other hand, would dig, make rope, and hunt birds. It can be expected that osteoarthritis would affect different locations of the body in males and females and that women would have more severe degeneration.

Sofaer-Derevenski's results confirm the hypothesis. Women in Ensay did have more severe affliction and a much greater prevalence in the upper thoracic region, whereas males had greater affliction in the lower thoracic vertebrae. These findings illustrate the value in determining differing patterns of joint involvement by sex, especially when the division of labor is so distinct. In this case, females seem to experience more stress than males. The author found the opposite to be true in the Wharram Percy area. These and other findings (Slaus 2000) are pertinent to this thesis, since the Maya are known to have had a very distinct division of labour between males and females (Feldmar 1987a, 1987b, 1987c:Penn State University; Smith 1982:University of California; and National Geographic Society).

In addition to division of labour between the sexes, status difference is another area considered by researchers when they determine what patterns of DJD are present and what links can be made between these patterns and activity, or inactivity for that matter. Tainter (1980) attempted to determine whether status differences could be distinguished based on the frequency and severity of degenerative joint disease. He carried out research on a Middle Woodland (Hopewellian) mortuary population from the Illinois Valley. The basic premise is that those of higher status would have: 1) less frequent incidence; and 2) less severe osteoarthritis. Tainter's results support the latter part of the hypothesis that higher ranked individuals had less severe osteoarthritis. Of course this type of analysis is only possible when the social hierarchy of a population can be confirmed by documents, oral history, mortuary practices, and structural diversity. The relation between patterns of joint disease and status, while important to consider, will be of little use in assessing the sample from Lamanai since status distinction in the early Historic period has not been confirmed.

Another pattern frequently considered is handedness, with the idea that the majority of individuals are right handed and therefore the right arm would have a higher frequency and severity of DJD than the left. Ortner (1968) examines this possibility in his research examining degenerative joint changes in the elbow joint. But handedness may not be a significant factor related to the type of activity causing stress to joints. For example, when the Maya use the digging stick both upper limbs are used. Consequently, one would expect bilateral stress regardless of handedness. Furthermore, poor preservation may eliminate any distinction between the left and right side of the body.

Finally, patterns such as severity of degeneration have been used in the past to suggest that certain types of subsistence activities may produce greater stress on one population than another. One theory that has proven to be false is the generalization that more 'primitive' hunter/gatherers had a more stressful lifestyle that agriculturists and would therefore have greater severity and incidence of osteoarthritis. This theory, based on the work of Braidwood (1967:113), depicted hunter-gatherers as living the more demanding lifestyle. While this conclusion may have been true for that particular research project, it has not proven to be the case in more recent research (Bridges 1991; 1992). Therefore, caution should be used before suggesting such a broad conclusion. Bridges' 1991 study which examined both hunters and gatherers and agriculturalists in Alabama, found each group had severe osteoarthritis but that the region of the body affected varied, depending on subsistence activity. Bridges (1991: 386) also points out that the population from Dickson mounds actually had an increased incidence of OA with agricultural intensification. Her findings therefore discount the Braidwood's theory that agriculture was less stressful than hunter-gathering. In the case of the early Historic Maya from Lamanai, there was no transition from hunting and gathering to agriculture; however, there was a transition in technology from the use of a spear to bow and arrows and the consumption of maize doubled. Therefore, the way hunting was carried out changed the way stress would have been placed on the body, and is an important consideration.

4.6 Limitations

Even when they take all possible precautions, researchers on both sides of the debate over connecting DJD and subsistence activities recognize limitations. However, these limitations do not mean that there is no validity to results of this type of research results. Researchers need to acknowledge restrictions, and try to eliminate them where possible. One limitation, given by Pfeiffer (in Ortner and Aufderheide 1998:12), stresses that the dead can teach us about the living only if there is commonality between the two with regards to genetic factors, behavior, and environment. Stirland (1991:40) points to the fact that not many archaeological sites have the documentary records that Merbs had access to. Stirland adds that it is sometimes problematic to separate age degeneration from development defects specifically related to occupation. Olsen-Kelley and Angel (1987:99) point out the difficulty of separating degenerative joint disease resulting from an activity from the impact that other external forces might have such as poor diet, genetic makeup, accidents and violence. Finally, Rothschild (1997:530) states another limitation is that perception of association between activity and arthritis is valid only if osteoarthritis has accurately been diagnosed in the first place.

Familiarity with the detailed discussion of the different types of arthritis, outlined in this paper, is one way to ensure that the initial diagnosis of DJD is accurate. As well, confirmation of the presence of degenerative joint disease should only occur after researchers have considered all other pathological conditions which can interfere with an accurate diagnosis. Not all of the limitations mentioned above can be avoided, but they must at least be acknowledged by researchers prior to making any decisive conclusions about the population being studied. Having established that degenerative joint disease was present in a particular population, researchers can gain valuable insight as to the overall impact that osteoarthritis had on the quality of life. While the usefulness of this type of study (linking the presence of DJD to activity patterns) remains highly controversial among anthropologists, the general consensus favors a continuation of research of this nature because, at the very least, it provides a more complete understanding of the past.

In any research concerning paleopathological conditions the temptation to speculate beyond the limits of the evidence exists. Therefore, researchers must not make any concrete determination based on physical evidence alone. Future research must utilize all available information (e.g., ethnographic and historical records, oral history, material remains, archaeological records et cetera) to support any conclusion linking activity patterns and osteoarthritis, on skeletal remains in the particular population(s) being studied. If researchers believe that a link exists, they should consider looking at non-pathological articular modifications such as squatting facets and pronounced muscle markings, which may strengthen their arguments. Another means to avoid this temptation would be to complete all skeletal analyses first, and then complete a detailed literature review of the site history, thus avoiding biased results. Researchers may be well advised also to avoid the pitfall of making concrete conclusions about numerically limited skeletal populations or non stratified populations (e.g., majority over 50 years of age and predominately one sex).

If nothing else, research of this nature may provide a basis for comparison to other populations and help to determine the quality of life of it's people. The ability to link a particular task (e.g., kayak paddling) to osteoarthritis requires accurate detailed records. However, if records are lacking, researchers may still be able to gain a general sense of the level of stress being experienced by the population being studied by comparing it to other populations, both past and present. Furthermore, although a link between activity patterns and the presence of DJD may not be established for one population, this does not mean that links cannot be found in for another. Finally, if a researcher is unable to establish the presence of such links, does this mean that they do not exist or that the means to do so are unknown?

Chapter 5

5.1 Materials and Methods

During the 1985 excavation of the Lamanai Church site, 105 burials were unearthed and their contents were catalogued and transported to Trent University. The burials contained a total of 152 (Appendix 1). Initial examination revealed varying degrees of preservation from one burial to the next. For example, some burials contained some cranial elements only, while other skeletal remains were virtually complete and very well preserved.

The contents of each of the 105 burials were laid out on separate sectioned spaces on the tables in the laboratory. The skeletal remains were placed on their dorsal side in anatomical position in order to determine the minimum number of individuals present and the level of preservation. A detailed inventory of each individual was compiled, starting at the cranium and progressing inferiorly to the feet. Each element was assessed separately, and its level of preservation recorded (see sample of recording form Appendix 2). Once this information was recorded, each individual within that particular burial was examined to determine their sex and approximate age at death. Note that the less definite term approximate age at death was used due to the fact that researchers have recognized that age of death is more difficult to ascertain in adults especially over the age of fifty. Due to this difficulty and the level of preservation adults were only broadly divided into three age ranges (20-34 years, 35-50 years, and 50 +) when attempting to draw any meaningful conclusions about the individuals at Lamanai (see Jackes 2000: 417-455 for a discussion of the problems associated with assigning an age at death).

The determination of sex was based on overall size and on the well recognized sexually dimorphic features of the skull and pelvis (Anderson 1962; Buikstra and Ubelaker 1994; Lovejoy et al. 1985; Meindl and Lovejoy 1989; Phenice 1969; Stewart 1979; Brooks and Suchey 1990; Todd 1921a, 1921b; Ubelaker 1989a). For example, morphological features of the skull included the size of the mastoid process, the slope of the forehead, the size of the superciliary arches, the size and robustness of the mandible, and the muscle markings in the nuchal region. Some of the morphological traits utilized in the pelvic region to determine sex were the presence or absence of a pre-auricular sulcus, the size and shape of the greater sciatic notch, the angle of the ventral arc, the size of the acetabulum, and the thickness of the ischial tuberosity.

The skull and pelvic regions were also examined in order to approximate the age of the individual at the time of death. Tooth eruption, and ectocranial and endocranial suture closure were the two principle methods used in the cranial region. In the pelvic region, the assessment of the pubic symphysis, and auricular facets were used as the visual markers of age changes. In addition to these two regions the long bones and portions of the axial skeleton provided clues as to approximate age based on the fusion of epiphysis to diaphysis, which not only helped to separate sub-adults from adults but also proved a useful tool when separating infants (0-13 years of age) and juveniles (14-19 years of age). All of the above-mentioned methods used in the determination of sex and approximate age relied on morphological traits found on the bones. However, it should be noted that it was not always possible to use all methods on each individual, since the level of preservation was not consistent from one individual to the next. In each case all possible morphological traits present were used to make these determinations.

Osteometry is another means by which to determine the sex and approximate age of individuals, but its overall application was not appropriate in the case of the individuals from the Lamanai Church site for several reasons. First, there has to be a certain level of preservation present to be able to use this method, and this level was not consistently present among the Lamanai sample. Second, the laboratory was only available during the summer months, and using osteometric means in addition to all of the morphological means would have taken too long to complete within this time frame. Third, some of the most accurate means of age and sex determination are based on the morphological traits mentioned above.

While osteometry was not widely used in this research project, it did prove to be useful in a number of ways. With regards to sex determination, metric data lent support to morphological findings in cases where the level of preservation of the morphological traits was poor or most of the key morphological traits were absent. For example, the circumference of the femur midshaft can help to assess the sex; therefore, to achieve a more accurate demographic record. Osteometry also proved to be useful in the approximation of age. Measurements of long bones help to distinguish an infant (0-13 years) from a juvenile (14-19) and, in the case of infants, enabled a more precise estimate of the age of, when none of the dentition was present (Johnston 1962). After the sex and approximate age of each individual was known, in that particular burial, all elements were examined for signs of trauma and pathology.

Every bone was examined for trauma that occurred antemortem and peri-mortem, in order to provide clues as to whether the trauma resulted in the death of the individual or whether the individual survived the trauma. If trauma was present on the skeletal remains of a particular individual, the bone, its side, the exact type (e.g., fracture), location on the bone, and whether it was antemortem of peri-mortem was noted. Once the relevant information about the populations' sexes, ages, and traumas were gathered, the focus switched to the main purpose of the analysis, pathology.

As with trauma, all pathological conditions found on the skeletal material from Lamanai were documented as to the affected location and type of pathology present. The presence and severity of degenerative joint disease may be influenced by the overall health, and therefore, need to be considered before examining the incidence of DJD in the adult Historic population at Lamanai. All pathology was recorded with particular emphasis on degenerative joint disease (or osteoarthritis) and osteophytosis of the spine, both of which are common and tend to occur as a part of the aging process. Both conditions can also result from a single trauma, or from intense wear and tear on the joints. Unlike other forms of degenerative changes (juvenile arthritis or gouty arthritis), OA does not discriminate against a particular sex or age group. Its severity is measured in the same manner regardless of the age or sex of the affected individual, although the type and number of criteria (establishing presence) vary from one researcher to the next. The presence or absence of degenerative joint disease in the Lamanai sample was scored based on the method outlined below by Buikstra and Ubelaker (1994), with minor adjustments to fit the needs of this research.

Lipping , Degree

1= Barely Discernible
2= Sharp ridge, sometimes curled with spicules
3= Extensive spicule formation
4 = Ankylosis

Surface Porosity, Degree

Pinpoint
Coalesced
Both pinpoint and coalesced

Porosity, Extent of Surface Affected

< 1/3
1/3-2/3
> 2/3

Eburnation, Degree

1= Barely discernable
2= Polish Only
3= Polish with groove(s)

Eburnation, Extent Of Surface Affected

< 1/3
1/3-2/3
> 2/3

All joints of the body including superior and inferior facets of the vertebrae were scored according to this method. The vertebral column was scored separately according to the method outlined by Steinbock (1976:303), for the presence of osteophytosis. His method is described below.

Degree	0	No lipping present.
Degree	1	Slight lipping at the inferior and superior margins of the centra.
Degree	2	More pronounced lipping at the margins
Degree	3	Extensive lipping often resembling a mushroom-like eversion with bony spurs.
Degree	4	Actual ankylosing or bony union between two or more vertebrae.

The process of identifying the minimum number of individuals present in the sample, its level of preservation, the sex, age, trauma, pathological conditions of its individuals and degree of degenerative joint disease was repeated on each of the burials.

The term porotic hyperostosis was first used by Angel in 1966, and refers to porotic lesions in the external table of the cranium. The lesions result in the expansion of cranial diploe in response to anemia. Diploe expansion puts pressure on the thin external table of the person's cranium, which becomes thinner and porotic. As the tissue expands further new bone production occurs along the path of the expanding tissue, resulting in vault thickening and the pathognomic, radiographic "hair on end" appearance (Stuart-Macadam 1987, in Wright and Chew 1998). Fortunately, these bones are much thicker and stronger, and tend to be preserved. Once complete, the assessment of the degree of degenerative joint disease was repeated in order to verify the results and to see if the scoring could be repeated accurately. After having completed the laboratory recording, the analysis of the data was performed using the statistical program " Statistica" (1995) on which all results are based and where possible Chi Square was used to test for statistical significance.

Chapter 6- Results

The first portion of the results provides the reader with a comprehensive breakdown of the demographics of the early Historic sample population from Lamanai. A summary of the catalogue numbers, sex, and age of all individuals in the sample is followed by demographic information which differentiates individuals based on age sets and biological sex. Incidences of trauma and other pathological conditions found on the skeletal remains were documented to provide a means of assessing overall health. The remainder of this chapter documents (Appendix 3) all findings of degenerative joint disease including incidence, type, location, and patterns (e.g., sex most afflicted, side of the body, upper versus lower limbs, and age of onset). Finally, other patterns such as sex and severity, age and severity, and incidence of osteoarthritis and amount of joint preservation were considered in order that a determination could be made as to whether links exist between the presence of osteoarthritis and subsistence activities.

6.1 Demographics

The initial survey of the minimum number of individuals, sex and age is summarized in Appendix 1, Table 2.

It should be noted that burial numbers 28 and 36 were not on the shelves at the time of this assessment. Fortunately, the age and sex of burial 36 had already been compiled by Dr. Helmuth and was included in the demographics. The information concerning burial 28 is not known. With a complete summary of the contents of the burials from Lamanai, it was possible to reconstruct the population's demographics of this sample in order to determine whether any bias may be present. If, for example, the burials contained only males or 90%

sub-adults, then the sample would be biased and therefore would not be appropriate for this particular research topic. All samples of populations, living or not, contain some degree of bias by virtue of several sampling processes and depending on the type of research being done. Therefore, in order to reduce the level of bias present, the researcher must consider whether the research project is appropriate for the particular population sample. Variation is the key factor to consider when attempting to reduce bias. While bias may never totally be avoided, if it is present, it must at least be acknowledged.

Table 3 presents a summary of the age distribution. Tremendous age variation exists between the youngest and the oldest individual. The youngest individual was approximately 6 months gestation- newborn and the oldest individuals were above 50 years of age. Table 3 shows a breakdown of the sample population based on the following age classifications: infants (0-13), juveniles (14-19), and adults 20+.

Table 3 Population Age Distribution

	Infants 0-13	%	Juveniles 14-19	%	Adults 20+	%
Totals: n=152	50	32.9	10	6.6	92	60.5

It is difficult to say whether these figures correspond with the living population at the time. However, it does indicate that the majority of this sample population did survive to adulthood. The sub-adults (0-19) make up 39.5% of the population while 60.5 % percent are at least over the age of 20. The first and last of these categories in Table 3 were further subdivided into more precise age ranges (Table 4).

The Infant category was divided into three age sets; gestation to newborn, newborn to 5 years, and 6 to 13 years. Juveniles remained as one category that contained individuals between 14 and 19 years of age. The adult category was split into four subgroups which include young adults aged 20-34, middle adults aged 35-50, old adults who were over the age of 50, and, finally, Adult + -(a category assigned to adults, who, because of a lack of preservation could not be assigned to one of the three adult groups). The results of this breakdown are displayed below in Table 4.

Table 4 Age Range

Age Set	Number of Individuals	%
Gestation to newborn	4/152	2.6
Newborn to 5 years	30/152	19.7
6 years to 13 years	16/152	10.5
14 years to 19 years	10/152	6.6
Young Adult (20-34)	40/152	26.3
Middle Adult (35-50)	20/152	13.2
Old Adult (50 +)	4/152	2.6
Adult +	28/152	18.4
Totals:	152/152	100%

The youngest and oldest age categories are the least represented in this population sample. In contrast, young adults comprise 26.3% of all individuals in this population. One obvious problem with regards to the above numbers is that any of the adult age sets may be under represented, since 18.4% of all 92 adults present cannot be assigned to a particular age group. However, in most cases these adults could at least be distinguished from one another based on sex; therefore, they should not be totally eliminated from this research.

By examining the ratio of adult females to adult males, the researcher can determine if bias exists between the sexes in the sample population from Lamanai. The totals are displayed in Table 5.

Table 5 Adult Sex Demographics

Sex		Number of Individuals	%
Female		45/92	48.9
Female?		2/92	2.2
Male?		12/92	13.0
Male		30/92	32.6
? (unknown)		3/92	3.3
	Totals:	92/92	100.00

Combined Totals			
Females		47/92	51.1
Males		42/92	45.6
Unknown		3/92	3.3
	Totals:	92/92	100.00

The ratio of adult females to adult males is close to 1:1, which means that both sexes are equally represented in this population. There were only three individuals who were too poorly preserved to determine their sex. However, it should be noted that the ratio does not remain constant across the three adult age sets (Table 6).

Table 6 Adult Age Sets

	Young Adults	%	Middle Adults	%	Old Adults	%	Adult +	%
F=	20	50	9	45	3	75	13	46.4
F?=	2	2	0	0	0	0	0	0
?=	0	0	1	5	0	0	2	7.14
M?=	5	12.5	5	25	0	0	2	7.14
M=	13	32.5	5	25	1	25	11	39.3
Totals:								
	40		20		4		28	100%

As can be expected with any population, the number of individuals decreases with age. In the early adult category, females outnumber males only by 7%, and these numbers remain close to the overall ratio of females to males. These data also show that for whatever reason the majority of females and males in this sample died as young adults. Such an early mortality rate could be related to factors such as childbirth and disease for females and occupation and disease for males, but this is speculation at this point since there is no evidence as to the cause of death. Within the middle adult category, males outnumber females by five percent. In the last age set, females outnumber males by 3 to 1. All of these conclusions are based on the exclusion of 28 adults; therefore, it is not possible to fully reconstruct the demographics with regards to the age of this sample or as a means of comparison to the living population at that time. Although it is not possible to determine which individuals died as a result of contracting an epidemic disease, it is an important to consider as an explanation for the demographics of this sample population.

6.2 Trauma

According to Iscan and Kennedy (1989: 161), " Trauma occurs as a result of violent encounters with environmental hazards, inter and intraspecies conflicts, and in rare instances, self mutilation and suicide. The documentation of trauma may help to establish cause and manner of death. Severe trauma that has not healed may be an indication that the individual died as a result of the trauma and /or that the trauma took place pre- or perimortem. As well trauma may result from the presence of pathological conditions which weaken the strength of the bone (e.g., osteoporosis). On the other hand trauma may cause infection and inflammation, and consequently degenerative joint disease might result. Documentation of trauma may help to establish whether degenerative joint disease is primary, resulting from accelerated wear and tear on the joints from a repetitive activity or whether DJD is secondary, resulting from a single traumatic event to a particular joint.

All 151 individuals' remains were examined for the presence or absence of trauma. None of the sub-adults appear to have suffered trauma to the bone. As well, none of the visible trauma appears to have caused death to anyone, since all trauma to the bone shows signs of healing. However, due to poor preservation, no absolute conclusion can be made as to whether any of these individuals died as a result of severe trauma. Clearly some of the individuals showing evidence of trauma also have degenerative joint disease. Table 7 provides a summary of the frequency and location of trauma, which will be followed by a brief description of the trauma found on the bones of each individual.

Table 7 Documented Trauma

Burial #	Sex	20-34	35-50	Adult +	Element	Location	Side
85-1	M		X		Occipital	Central	N/A
85-2	F	X			Ulna	Mid-shaft	R
					Radius	Mid-shaft	R
85-15	F	X			Humerus	Distal end	R
					Sacrum	S3 & S4	Dorsal
85-16	M?		X		Fibula	Distal shaft	?
85-17	F	X			Radius	Proximal end	R
85-23	F	X			Femur	Distal shaft	R
85-32	M?		X		Tibia	Proximal shaft	R
85-76	M			X	Ulna	Proximal end	R
85-83	M		X		Ulna	Proximal end	L
85-85	M		X		Occipital	Central	N/A
85-95	M			X	Ulna	Distal end	R
					Tibia	Mid-shaft?	R
85-98	M			X	1st Metac.	Distal end	L
					2nd Metac.	Distal end	L
					3rd Metac.	Distal end	L
					4th rw prx ph.	Distal end	L
85-102	F	X			1st rw. 2nd Phal	(F)Proximal end	R
85-103	M		X		Rib	Posterior Shaft	?

Totals:	F=5	5	6	3	Upper Limb = 7	Right = 10
	F?=0				Lower Limb = 5	Left = 5
	M?=2				Axial region = 2	N/A = 2
	M=7				Cranium region = 2	? = 2
	? =0					

The two males, one from burial 85-1 and the other from burial 85-85, show signs of healed depressed fractures to the occipital region just above the external occipital protuberance. This trauma most likely resulted from a blow to the head with a blunt object.

The young female from burial 85-2 suffered from a complete transverse fracture to the right forearm. Regardless of how the injury occurred, both the radius and ulna failed to align properly as they healed, therefore, dislocating the position of the distal ends and causing degenerative changes to the wrist.

Burial 85-15 contained the remains of a young female with traumatic injuries to her distal right humerus and sacrum appear to be the result of a fall. The damage to the humerus is especially severe, and caused degeneration to the tissue and joint to the degree that lipping has occurred and eburnation is moderate to severe indicating that the injury healed to the point that the joint was still being used. Due to the young age (20-23) of this particular female it is unlikely that degenerative joint disease was already present to such a severe degree and that the trauma was a result of preexisting pathology. In this case there seems to be a connection between trauma sustained and the presence of osteoarthritis; however, this association is not always present.

The male from burial 85-16 has a healed fracture to the mid-shaft of a fibula, which is only evident due to periostitic reaction to some form of trauma. In this instance, degenerative joint disease is not a factor. Burial 85-17 also has trauma that did not result in any degenerative changes to the joint.

The female in burial 85-23 had suffered from a fracture to the distal end of the right femur shaft. In this particular case, the only remaining evidence is located on the medial side of the shaft. The bone seems to have aligned properly as it healed, which most likely indicates that it was not a complete fracture. There are degenerative joint changes to the epicondyles; however, it is not possible to relate this trauma to degenerative joint disease or vice versa.

Burial 85-32 contains the remains of a middle-aged male, whose trauma to the right proximal tibia shaft does not appear to have resulted in degenerative changes to the knee. The fracture is located approximately five centimeters from the proximal joint on the anterior surface of the bone. The individual from burial 85-76, also male, suffered from a traumatic fracture to the proximal end of his right ulna; however, no additional pathology appears to have developed as a result of the injury.

Unlike the male in burial 85-76, the male in burial 85-95 does appear to have degenerative joint disease of the distal end of the right ulna, resulting from trauma. This male also has evidence of trauma to the right tibia on the medial side; however, there appears to be no presence of degenerative changes. Degenerative Joint Disease did not result in three of the individuals with trauma (85-83, 85-102, and 85-103).

The individual whose trauma was of greatest interest was the male in burial 85-98, who suffered from a partial amputation of the left hand. The second digit was amputated anteriorly to the distal end of the 1st phalanx. The 1st phalanx of the 1st row shows degenerative changes to the distal end, as does the 1st phalanx of the 3rd row. In the 4th row the distal end of the middle phalanx displays the presence of degenerative changes in the form of new bone growth. Having documented the trauma present which may have contributed to the presence of degenerative joint disease in the major weight bearing joints, consideration will be given to other possible pathological conditions.

6.3 Other Pathological Conditions at Lamanai

Few pathological conditions were present on the skeletal remains from Lamanai, but, this does not mean that the individuals were healthy. Most of the pathological conditions found among human populations effect only the soft tissue, and therefore any trace is absent by the time archaeological populations are examined. Therefore, it would be inappropriate to conclude that these individuals were healthy based on what is absent (see Wood et al. 1992 article on the osteological paradox). In order to ensure that degenerative joint disease is accurately diagnosed, it is important to be familiar with other pathological conditions. As well the presence of certain pathological conditions may contribute to the presence of degenerative joint disease (osteoarthritis) and osteophytosis. Other pathological conditions present on the skeletal remains from Lamanai fall into several categories, which include dental pathological conditions, infections, and anemia. In addition to these pathological conditions, several individuals from Lamanai have pathological spines, the etiology of which has yet to be identified.

Dental pathological conditions found among this sample include dental calculus, abscesses, dental caries, attrition, and severe alveolar resorption. Another pathology present on the bones was periostitis, which results from infection of the periosteum, usually a result of trauma to that area. The second most common pathology found on the bone, next to degenerative joint disease, was anemia. Although the manifestation of anemia does not directly manifest itself in the same region as degenerative joint disease, it may indirectly contribute to its presence. Individuals with anemia would be unable to withstand as much stress and strain to their bodies, and would be at greater risk of degenerative joint disease.

One of the initial tell tale signs for anemia is cribra orbitalia which was only found in one young adult individual from burial 85-21 in both orbits. The incidence of this condition was likely much higher, but unfortunately most of the orbit areas were absent on the majority of the individuals as a result of the fragile nature of the bones that form the upper orbit. The next stage of anemia manifests itself as porotic hyperostosis of the frontals, parietals and occipital bones.

Table 8 provides a summary of the individuals who have confirmed cases of porotic hyperostosis. Due to poor preservation, the totals below reflect a conservative estimate of the minimum number of afflicted individuals.

Table 8 Incidence of Porotic Hyperostosis

Burial #	**Sex**	**Age**	**Side**	**Location**	**Severity**
84-4	?	14-19	R	Parietal	Moderate
85-7	?	15 +/- 36m.	R & L	Parietals	Severe 15mm
85-14	M?	35-50	R & L	Temporals	Severe
84-24	F	20-25	R	Temporal	Moderate
85-25	F	35-50	R & L	Par. and Occip.	Mild
85-26	F	45 +	R & L	Parietals	Moderate
85-47	M	12-16	R & L	Temporals	Moderate
85-50c	M	Adult	R	Temporal	Moderate
85-53	F	18-23	R & L	Parietals	Moderate
85-54	?	6 +/- 12m.	R	Par. and Occip.	Mild
85-56	M	45 +	R & L	Parietals	Moderate
85-68a	M	20-30	R & L	Par.and Occip.	Severe
85-71a or b	?	6-7	R	Temporal	Moderate

85-74a	M	20-30	R & L	Parietals	Moderate
85-81	F	40 +	R & L	Par.and Occip.	Severe
85-83	M	30-40	R & L	Parietals	Moderate
85-84a	M	40 +	R	Temporal	Moderate
85-85	M	40 +	N/A	Occipital	Moderate
85-86	M?	20-25	R	Temporal	Moderate
85-91a	?	8-9	R & L	Parietals	Mild
85-92	M?	25-35	R & L	Par. and Occip.	Mild
85-98	M	Adult	L	Temporal	Moderate
85-99	?	4-5	N/A	Occipital	Moderate
85-101	F	45 +	R & L	Temporals	Moderate
85-102	F	30-35	R	Temporal	Moderate

The adults (20%) and/or (16.5%) of the sample population with porotic hyperostosis would not have died from anemia since healing of the cranial bones had already taken place. However, their health would have been compromised, and they would have had less resistance to stress and strain being placed on their bodies.

6.4 Degenerative Joint Disease

Although all types of degenerative joint disease were documented and identified, where possible, the main types focused upon were osteoarthritis (OA) and osteophytosis (OP) since the presence of both types is commonly used to assess activity patterns of populations. Due to the poor preservation of the spines only a handful of Schmorl's nodes were observed, and categorization of upper versus lower thoracic was not possible. Therefore, the spinal column was only divided into three major regions, the cervical, thoracic, and lumbar vertebrae. All of the individuals in Tables 9, 10, and 11 have osteophytosis of the spine. Those individuals who have been highlighted in these tables also have osteoarthritis. The individuals recorded as having osteoarthritis possessed a minimum of two criteria (e.g., lipping, new bone formation, porosity, and eburnation).

Osteophytosis and Osteoarthritis in the Vertebral Column

Table 9 Cervical Region

A= 20-34 yrs. B= 35-50yrs. C= 50 + D= Adult + E=14-19yrs

Burial #	Sex	Age	Score (1-4)
85-1	M	35-45	2
YDL-Ia	F	33-46	2
85-2	F	25-30	2
85-2a	F	35-50	1
85-06	F	20-24	1
85-09	F	50+	3
85-13	F	33-46	1
85-14	M?	35-50	1
85-17	F	20-40	2
85-21	F	20-30	1
85-22	**F**	**20-40**	1
85-23	F	20-30	2
85-27	F	20-30	2
85-29	M?	33-42	2
85-31f	**F**	**20-25**	1
85-31m	M	54-64	1
85-32	M?	40 +	2
85-33	**M**	**25-30**	2
85-35	M	30-40	1
85-39	F	Adult	1
85-46c	F	20-30	2
85-62	F	20-25	1
85-66	**M**	**30-35**	1
85-69	F	20-25	1
85-76	M	Adult	2
85-76a	M	35-40	2
85-82b	**F**	**50 +**	2
85-98a	M	Adult	1
85-102	**F**	**30-35**	2

Totals

Sex	%	Age	%
F=17	18.5	A=15	16.3
F?=1	1.1	B=7	8.7
M?=3	3.3	C=3	3.3
M=8	8.7	D=3	3.3
? = 1	1.1		

29/92= 31.6%

Male to Female: 11:18

Score 1:	F= 9	A= 6	B= 2	C= 0	D= 1
	M=5	A= 0	B= 3	C= 1	D= 1
Score 2:	F=8	A= 6	B= 1	C= 1	D= 1
	M=6	A= 1	B=4	C= 0	D= 1
Score 3:	F=1	C= 1			

Close to 20% of individuals with osteophytosis were female and only 12% were male. One individual of unknown sex had osteophytosis in the cervical region of the spine. The majority of the individuals with degenerative changes in the cervical region were female at

16.3%. Middle-age adults made up half that amount, while old adults and adult + age sets are tied at 3.3%. It appears that young females had the greatest frequency of osteophytosis in the cervical vertebrae. A total of 14 individuals, 9 females and 5 males, had score 1 lipping in this region . Out of those 9 females, 6 were young adults, 2 were middle-age adults, and one was in the adult + classification. Two of the 5 males were young adults and 2 were middle adults. The last male with mild degenerative joint disease was in the adult + category. Three young adult females also had osteoarthritis in their necks. There was also 1 female from burial 82 who had osteoarthritis, but she was an old adult. Determination of whether these or other results to follow are significant a Chi Square was used.

Formulas Utilized:(Healey 1993:256)

$$f(\text{expected}) = \frac{(\text{row marginal})\ (\text{column marginal})}{N\ (\text{number})}$$

$$X2\ (\text{obtained}) = \frac{[f(\text{observed}) - f(\text{expected})]2}{f(e)}$$

Chi Square of Sex versus Presence or Absence in Cervical Region

1.4780 =X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

Table 10 Thoracic Region

Burial #	Sex	Age	Score (1-4)
85-1	M	35-45	2
YDL-Ia	F	33-46	3
85-2	F	25-30	2
85-4	?	18-20	3
85-06	**F**	**20-24**	3
85-09	F	50+	1
85-13	F	33-46	1
85-14	M?	35-50	1
85-15	**F**	**20-24**	2
85-17	F	20-40	2
85-22	F	20-40	1
85-23	**F**	**20-30**	1
85-27	F	20-30	2
85-29	M?	33-42	1
85-31	M	54-64	1
85-32	**M?**	**40 +**	2
85-33	**M**	**25-30**	1
85-35	M	30 +	2
85-39	F	Adult	1
85-52	F	20-30	2
85-64	F	50 +	2
85-67a	M	35-50	3
85-69	F	20-25	1
85-73	M?	20-25	2
85-74	M	20-30	1
85-76	M	Adult	1
85-81	F	40+	2
85-81a	M	30 +/-5	2
85-87a	M	30-40	2
85-93	F	Adult	3
85-102	F	30-35	2
85-103	M	30-40	1

Totals

Male to Female: 14:17

Sex	%	Age	%
F=17	18.5	A=16	17.4
F?=0	0.0	B=9	9.7
?=1	1.1	C=3	3.3
M?=4	4.3	D=3	1.1
M=10	10.9		
32/92 = 34.8			

Score 1:	F=6	A=3	B=1	C=1	D=1
	M=7	A=2	B=3	C=1	D=1
Score 2:	F=8	A=6	B=1	C=1	D=0
	M=6	A=3	B=3	C=0	D=0
Score 3:	F=3	A=1	B=1	C=0	D=1
	M=1	A=0	B=1	C=0	D=0
	?=1	E=1			

The area of the body most frequently affected by DJD in the Lamanai sample was the thoracic region. Eighteen point five % of adult females in the sample population had OP in the thoracic region, only slightly less than in the cervical vertebrae. Adult males, on the other hand, account for 14% and seem to have greater involvement in the thoracic region than in the cervical region of 12%. The percentage of young adults with OP (17.4%) outnumbers all other adult age groups, followed by middle adults (9.7%). The old adult and adult + designation each have 3.3% of the population with osteophytosis in the thoracic region. A total of 13 individuals (f = 6; m = 7) had mild lipping in the thoracic region, 6 females and 7 males. Three of the 6 females were young adults, and there was 1 female in each of the remaining adult age sets. Overall as to age, 2 young adults, 3 middle adults, 1 old adult, and 1 adult+ (male) showed OP. In the thoracic region, score 2 was present on the remains of fourteen individuals. Six of these are young adult females, three are young adult males and four are middle adults (one female and three males). The last of the fourteen individuals with moderate lipping in the thoracic region was a female over fifty. There are a total of five individuals with severe osteoarthritis in this region: three females, one male, and one juvenile. The three females are evenly distributed in the young adult, middle adult, and adult + categories. The single male was an adult between age 35-50. The other individual with osteoarthritis, sex is unknown but is between the ages of 18-20.

Chi Square of Sex versus Presence or Absence in Thoracic Region

0.0788 = X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

Table 11 Lumbar Region

Burial	Sex	Age	Score (1-4)
YDL-Ia	F	33-46	1
85-02	F	25-30	1
85-06	F	20-24	3
85-15	**F**	**20-24**	1
85-17	F	20-40	2
85-31m	M	54-64	2
85-32	**M?**	**40 +**	1
85-64	F	50 +	2
85-67a	M	35-50	1
85-69	**F**	**20-25**	1
85-74a	**M**	**20-30**	1
85-76	M	35-40	2
85-81	**F**	**40 +**	3
85-97	M	25-30	2
85-102	F	30-35	2

Totals

Sex	%	Age	%
F=9	9.8	A=8	8.7
F?=0	0.0	B=5	5.4
M?=1	1.1	C=2	2.2
M=5	5.4	D=0	0.0
15	16.3	15	16.3
92	100	92	100

Male to Female: 6:9

Score 1:	F=4	A=3	B=1	C=0	D=0
	M=3	A=1	B=2	C=0	D=0
Score 2:	F=3	A=2	B=0	C=1	D=0
	M=3	A=1	B=1	C=1	D=0
Score 3:	F=2	A=1	B=1	C=0	D=0
	M=0				

The incidence of osteophytosis in the lumbar region versus the cervical (31.6%) and thoracic (34.8%) is dramatically lower at 16.3%. Note that this lower incidence may reflect the fact that there are fewer vertebrae in the lumbar (5) than in the cervical (7) or thoracic (12) regions. As in data represented for the two upper regions of the spine, females outnumber males by 1/3. Again the young adult population represent 8.7% of the adult population with osteophytosis, having had the highest incidence in this region, followed by 5.4% of middle adults of the population with OP. Only 2 individuals over the age of fifty had osteophytosis in the lumbar region. There are 7 individuals (f = 4; m = 3) with mild lipping. Two of the 3 males were middle adults, and the 3rd was a young adult. Three out of 4 females were young adults and the 4th was a middle adult. There are 3 males and 3 females with moderate degree of lipping. Among the males, 1 each is in the young, middle, and old adults categories. Two of the three females were young adults, and the third was over 50 years of age. Two females, one a young adult and one a middle adult, had score 3 lipping. Finally, two females and two males also had osteoarthritis.

Chi Square of Sex versus Presence or Absence in Lumbar Region

0.3748 = X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

Sterno-clavicular Joint

The sterno-clavicular joint, unlike the spinal column, is not considered a true weight bearing joint, and therefore osteoarthritis in this region is not likely the result of upright posture.

Table 12 Osteoarthritis of the Sterno-clavicular Joints

Burial #	**Sex**	**Age**	**Element**	**Side**	**Score**
85-02	F	25-30	Clavicle Prox. End	Right	2
85-13	F	33-46	Clavicle Prox. End	Left	2
			Clavicle Prox. End	Right	2
85-69	F	20-25	Clavicle Prox. End	Right	1
85-73	M?	20-25	Clavicle Prox. End	Left	1
85-79	M?	Adult	Clavicle Prox. End	Left	2

Totals:	F=3	A=3		Ratio: R to L= 1:1					
	F?=0	B=1							
	M?=2	C=0	Score 1:	F=1	A= 1	B= 0	C= 0	D= 0
	M=0	D=1		M=1	A= 1	B= 0	C= 0	D= 0
			Score 2:	F=2	A= 1	B= 1	C= 0	D= 0
				M=1	A=0	B= 0	C= 0	D= 1
	F:M = 3:2							

Out of 92 adult individuals, females with osteoarthritis outnumber the males by a ratio of 3 to 2. The females seem to have more severe osteoarthritis (score 2) in this region; however, but none of the individuals had severe (score 3) degenerative changes in the sterno-clavicular joint. Of particular interest is the age of these individuals; 3 out of the 5 individuals are young adults (20-34) and therefore did not develop these degenerative changes as a result of wear and tear over a long period of time. Two of these three were female. The third female individual was a middle adult and the fifth individual, a male, could not be assigned to an age bracket other than adult +. The left and right side of the body are equally affected with a 1 to 1 ratio of left to right and equal severity. Both sides of the body in this region seem to be equally stressed.

Upper Extremities

Shoulder

The shoulder joint is comprised of the lateral end of the clavicle, the glenoid fossa of the scapula, and the proximal end of the humerus. Due to the lack of preservation of the bones, this region is numerically too low to be representative, however, the results are displayed in Table 13.

Table 13 Osteoarthritis of the Shoulder Joints

Burial #	Sex	Age	Element	Side	Score
85-02	F	25-30	Humerus Head	Right	2
			Humerus Head	Left	2
			Glenoid Fossa	Right	2
			Glenoid Fossa	Left	2
85-76	M	Adult +	Clavicle	Right	1
			Glenoid Fossa	Right	1
			Gelenoid Fossa	Left	1
Totals:	F=1	A=1			
	M=1	D=1	Ratio: R to L = 1:1		
			F : M = 1:1		

Score 1: M=1 A= 0 B= 0 C= 0 D=1 Score 2: F=1 A= 1 B= 0 C= 0 D= 0

One young adult female has osteoarthritis with a score of 2 (as defined in Chapter 5) in both shoulders affecting the humeri and glenoid fossae. The adult male has mild osteoarthritis , score 1, in both shoulders. Both sides of the body seem to be affected in these two individuals. The severity is equal on the left and right sides; however, the female does have more severe osteoarthritis than the male.

Elbow

Elbow joints are not weight bearing joints and are likely a good indicator as to whether the upper limbs are being stressed. The incidence of osteoarthritis in the elbow (Table 14) is higher than in the shoulder joints.

Table 14 Osteoarthritis of the Elbow Joints

Burial #	Sex	Age	Element	Side	Score
85-02	F	25-30	Prox. Ulna	Right	1
85-105a	M	Adult	Prox. Ulna	Left	1
85-83	M	30 +	Prox. Ulna	Left	2
85-25	F	35-50	Prox. Ulna	Left	2

85-102	F	35-50	Distal Humerus	Left	2
			Prox. Ulna	Left	2
85-74a	M	20-30	Prox. Ulna	Left	1
			Prox. Ulna	Right	1
			Prox. Radius	Left	1
			Prox. Radius	Right	1
85-84a	M	40 +	Prox. Ulna	Right	1
85-15	F	20-24	Prox.Ulna	Right	3
			Distal Humerus	Right	3
85-81	F	40 +	Prox. Radius	Right	1
			Distal Humerus	Right	N/A
85-18a/b	F	Adult +	Prox. Radius	?	1

Totals:

10	F=6	A=4	Humerus=3	Ratio: R to L= 6:5
	F?=0	B=4	Radius=4	
	M?=0	C=0	Ulna=9	
	M=4	D=2		

Score 1:	F= 3	A= 1	B= 1	C= 0	D= 1	M=3	A= 1	B= 1	C= 0	D= 1
Score 2:	F= 2	A= 0	B= 2	C= 0	D=0	M=1	A= 1	B= 0	C=0	D= 1
Score 3:	F= 1	A= 1	B= 0	C= 0	D=0	M=0	A=0	B= 0	C=0	D=0

Next to the spinal column, the elbow joints are the second most frequent joints affected by osteoarthritis in the early Historic period. Eleven percent of the adults in the sample have arthritis in this joint, of which adult females comprise 7% and males 4%. There are equal numbers of males and females with mild osteoarthritis in the young, middle and adult + categories. The ratio of females to males with moderate osteoarthritis is 2:1. The two females were middle adults, and the male was a young adult. A young female (20-24) had severe osteoarthritis in her right elbow, which most likely was the result of a traumatic injury. The right side of the body is affected only slightly more than the left. The right side has a greater incidence of mild and severe osteoarthritis and the left side has more moderate osteoarthritis.

Wrist

Another non weight bearing joint is the wrist. The results are displayed in the Table15 that follows.

Table 15 Osteoarthritis of the Wrist Joints

Burial #	Sex	Age	Element	Side	Score
85-02	F	25-30	Distal Radius	Right	2
			Distal Ulna	Left	2
85-67a	M	35-50	Navicular	Left	1
85-82a	M?	Adult	Hamate	Right	1
85-84a	M	40+	Distal Ulna	Right	1
85-95	M	Adult	Distal Ulna	Left	2

Adults:								
5	F=1	A=1		Ratio: L to R= 3:3				
	F?=0	B=2						
	M?=1	C=0	Score 1: F=0	A= 0	B= 0	C= 0	D= 0	
	M=3	D=2	M=3	A= 0	B=2	C= 0	D= 1	
			Score 2: F=1	A= 1	B= 0	C= 0	D= 0	
			M=1	A= 0	B= 0	C= 0	D= 1	

Four out of 5 adults with osteoarthritis in the wrist are male. The only female is a young adult, and she had a moderate degree. Another individual with moderate lipping was an adult male from burial 85-95. The remaining 3 males had mild osteoarthritis in their wrist. The most common bone affected was the distal ulna. The left and right sides of the body are equally affected, but the left side has more severe osteoarthritis.

Hand

Half a dozen individuals from the Lamanai Historic sample population have degenerative joint disease in the hands(Table 16).

Table 16 Osteoarthritis of the Hand Joints

Burial #	Sex	Age	Element	Side	Score
85-18 a or b	F	Adult	2nd row Middle Phalanx	Left	1
			4th row Prox. Phalanx	Left	1
			2nd row prox. Phalanx distal end.	Right	1
			3rd row Prox. Phalanx, distal end.	Right	3
85-21	F	20-30	2nd row middle Phalanx Prox. End	Left	1
85-29	M?	33-42	2nd row middle Phalanx	Left	2
			Prox. 3rd metacarpal	Right	1
85-45	M/F	Adult	2nd metacarpal prox. end.	Right	1
85-53	F	16-19	2nd Metacarpal prox. end	Left	N/A
85-98	M	Adult	1st metacarpal distal end.	Left	2
			2nd metacarpal distal end	Left	1
			3rd metacarpal distal end	Left	3
			4th prox. Phalanx distal end.	Left	2
Totals:					
6	F=3	A=1	Ratio: L to R = 4:2		
	F?=1	B=1			
	M?=0	C=0	Score 1: F= 2 A= 1 B= 0 C= 0 D= 1		
	M=2	D=3	M=2 A=0 B= 1 C= 0 D= 1		
		E=1	?=1		
			Score 2: F=0 A= 0 B= 0 C= 0 D= 0		
			M=2 A= 0 B= 1 C= 0 D= 1		
			Score 3: F=1 A= 0 B= 1 C= 0 D= 1		
			M=1 A= 0 B= 1 C= 0 D= 1		

The youngest individual was probably female, between the ages of 16-19 years. The second youngest, also female, had mild osteoarthritis. The individual from burial 85-29, a middle adult male, had mild and moderate level osteoarthritis. In burial 85-18, there were 2 adult females one of which had degenerative joint disease in both hands. Based on joint involvement and symmetry present, rheumatoid arthritis was the likely explanation for the degeneration of the joints. The severity in this individual ranged from mild to severe. Burial 85-45 contains the remains of 2 adults, 1 male and 1 female. Since they display little sexual dimorphism, the element with mild osteoarthritis cannot be attributed to the male or female.

The 6th individual had mild, moderate and severe osteoarthritis that developed as a result of a traumatic injury. One unusual factor that counters expectations was that the left hand with more mild and moderate DJD is involved twice as often as the right. The right side does have one individual with score 3 but the left has none. Unfortunately, faulty preservation of the remains at Lamanai interfered with the researcher's ability to assess osteoarthritis in the wrist and hand region. The bones in the extremities tend to deteriorate at a higher rate, and this decomposition can be accelerated in cases were a pathology is present. This level of preservation in this region is extremely poor, and may explain the results.

Lower Extremities

Hip Joint

The hip joints are the most superior aspects of a two-pillar support system which bear the weight of the upper body. Therefore, this region would be subject to the stress that results from upright posture, as well as the stress induced by daily subsistence activities. With only 4 individuals affected, the results from Lamanai indicate a low incidence of osteoarthritis in this joint, shown in Table 17.

Table 17 Osteoarthritis of the Hip Joints

Burial #	Sex	Age		Element	Side	Score
85-32	M?	40 +		Femur Head	Left and Right	1
				Acebutabulum	Left and Right	1
85-33	M	25-30		Femur head	?	N/A
85-76	M	Adult +		Acebetabulum	Left and Right	2 & 3
85-81	F	40 +		post auricular facet	Left and Right	2
Totals:						
4	F=1		A=1		Ratio: R to L= 3:3	
	F?=0		B=2			
	M?=1		C=0			
	M=2		D=1			

Score 1: F=0	A= 0	B= 0	C= 0	D= 0	M=1	A= 0	B=1	C= 0	D= 0
Score 2: F=1	A= 0	B=1	C= 0	D= 0	M=1	A= 0	B= 0	C= 0	D= 1
Score 3: F=0	A= 0	B= 0	C= 0	D= 0	M=1	A= 0	B= 0	C= 0	D= 1

Three out of the 4 individuals (4.3%) were male. One male was a young adult, another a middle adult and the 3rd was placed in the adult + classification. The female sufferer from burial 85-81 was between the ages of 35 to 50. Except for the young adult male, both right and left sides of the body were equally involved. Both sides also had the same frequency of mild and severe osteoarthritis; however the left side of the body of the sample had more moderate severity. The middle adult male has the mildest level of osteoarthritis. The individuals from 85-76 (m) and 85-81 (f) had moderate to severe osteoathritis.

Knee

Seven individuals or 8% of the adult early Historic population sample at Lamanai had osteoarthritis in the knee (Table 18).

Table 18 Osteoarthritis of the Knee Joints

Burial #	Sex	Age	Element	Side	Score
85-1	M	35-45	Patella	Right	3
85-23	F	20-30	Distal Femur	Right	2
			Patella	Right	2
85-26	F	45 +	Patella	Right	2
85-40	F	Adult +	Patella	Right and Left	1 & 2
			Distal Femur	Left, Lateral	3
			Proximal Tibia	Left	1
85-81	F	40 +	Patella	Left	1
			Distal Femur	Left, Medial	1
85-82a	M?	Adult +	Patella	Right	2
85-82b	F	50 +	Patella	Right	2

Results:

# of In.	%	Sex	%	Age	%
7	7.6	F=5	5.4	A=1	1.1
92	100	F?=0	0.0	B=3	3.3
		M?=1	1.1	C=1	1.1
		M=1		D=2	2.2
Totals:		7	7.6	7	7.6
		92	100	92	100

Left Side v.s. Right = 3 to 6

Score 1:	F=2	A= 0	B= 1	C= 0	D= 1
	M=0	A=0	B= 0	C= 0	D= 0
Score2:	F=4	A= 1	B= 1	C= 1	D= 1
	M=1	A= 0	B= 1	C= 0	D= 1
Score3:	F= 1	A=0	B= 0	C= 0	D= 1
	M=1	A=0	B= 1	C= 0	D= 0

Females with osteoarthritis in the knee outnumber males 5 to 2. The female from burial 85- 23 was a young adult with osteoarthritis in the knee. One adult male and 2 adult females are between the ages of 35 to 50 and form the largest age set frequency. Burial 85-82b contained 1 female over the age of fifty who had osteoarthritis in her right knee. The remaining two affected adults, one male and one female, were assigned to the adult+ age set. The patella was the bone in the knee most frequently afflicted followed by the distal femur and then the proximal tibia. The right knee seems to be involved twice as often as the left. There was more mild OA in the left side, and both sides have one individual with severe osteoarthritis. The right side has 2/3 more moderate osteoarthritis than the left knee. Mild osteoarthritis was present in two females, one from burial 85-40 and the other from 85-81. The majority of the individuals with osteoarthritis in the knee had moderate (score 2) osteoarthritis. Four of the individuals with moderate degree OA were female and each of the four adult age sets were represented. The fifth and last individual with score 2 was an adult+ male. There are two individuals who had severe (score 3) osteoarthritis, in this joint, one middle adult male and one adult female.

Ankle

The incidence of osteoarthritis in the ankle joint is displayed in the Table 19 below.

Table 19 Osteoarthritis of the Ankle Joints

Burial #	Sex	Age	Element		Side	Score
85-40	F	Adult +	Distal Tibia		Left	1
85-53	F	16-20	Talus		Right	1
85-82a	M?	Adult +	Distal Fibula		Left	1
85-105a	M	Adult+	Talus		Left	1
Totals:						
4		F=1	A=0	E(juv)=5		Ratio:L to R= 3:1
		F?=1	B=0			
		M?=1	C=0			
		M=1	D=3			

Score 1: F=2 A=0 B= 0 C= 0 D= 1 E=1 M=2 A=0 B= 0 C= 0 D=2

Even numbers of females and males had degenerative joint changes in the ankle joint. Three out of the 4 individuals could only be identified as adults. The fourth individual was an older juvenile between the ages of 16-19 years of age. All individuals had only mild (score 1) osteoarthritis. Unlike the findings shown by data concerning knee joints, the left side was more frequently involved than the right.

Foot

As can be seen in Table 20 below, the joints in the feet were the least affected by degenerative changes in the early Historic period sample. Note, this low frequency could be due to the fact that the extremities were poorly preserved and/or missing.

Table 20 Osteoarthritis of the Foot Joints

Burial #	Sex	Age	Element	Side	Score
85-31m	M	54-64	Navicular	Left	1
			1st row prox. phalanx	Left	1
85-98	M	Adult +	5th row prox. Phalanx distal end.	Left	2

Totals:				
2	M=2	C=1 D=1		Ratio L to R: 1:0

Score 1:	F= 0	A= 0	B= 0	C= 0	D= 0	M= 1	A=0	B=0	C=1	D=0
Score 2:	F=0	A= 0	B= 0	C= 0	D= 0	M= 1	A=0	B=0	C= 0	D= 1

Only 2 males, 1 old adult and one adult +, had osteoarthritis in their left feet. The 50 + male from burial 85-31 had mild osteoarthritis on the navicular and the first row proximal phalanx, whereas the adult male had moderate osteoarthritis on the 5th row proximal phalanx on the distal end. Based on the above overview of all major joints in the body it is clear that there is tremendous variation in the severity and incidence of DJD from one joint to the next and from one side of the body to the next. Knowledge of the connections between factors such as sex, age, and side involvement and the incidence and severity of DJD in all joints, enables the discovery of larger patterns such as the incidence of upper versus lower limb involvement, and whether one area of the body was placed under greater stress than another. The information below (Table 21) provides a comparison of the incidence of degenerative joint disease in the upper versus the lower limbs.

6.5 Table 21 Upper Limbs v.s. Lower Limbs

Upper Limbs

Left						**Right**					
# Of In.	%	Age	%	Sex	%	# of In.	%	Age	%	Sex	%
15/ 92	16.3	A=6	6.5	F=7	7.6	8/92	8.7	A=3	3.3	F=4	4.3
15/53	28.3	B=3	3.3	F?=0	0.0	8/53	15.1	B=3	3.3	F?=0	0.0
		C=0	0.0	?=1	1.1			C=0	0.0	?=0	0.0
		D=6	6.5	M?=1	1.1			D=2	2.2	M?=1	1.1
				M=6	6.5					M=3	3.3

Totals: 15/92 = 16.3 %   8/92 = 8.8%

Combined Totals: Right and Left = 23/92 = 25%   Incidence: 23/53=43%

Lower Limbs

Left						**Right**					
# Of In.	**%**	**Age**	**%**	**Sex**	**%**	**# of In.**	**%**	**Age**	**%**	**Sex**	**%**
8/92	8.7	A=0	0.0	F=2	2.2	11/92	12	A=3	3.3	F=6	6.5
8/53	15.1	B=2	2.2	F?=0	0.0	11/53	20.8	B=4	4.3	F?=0	0.0
		C=1	1.1	?=0	0.0			C=1	1.1	?=0	0.0
		D=5	5.4	M?=2	2.2			D=3	3.3	M?=2	2.2
				M=4	4.3					M=3	3.3
Combined Totals:											
		8	8.7	8	8.7			11	12	11	12
		92	100	92	100			92	100	92	100

Combined Totals: Right and Left =19/92 = 20.7%   Incidence: 19/53 =35.8%

Upper: Combined Totals: Right and Left = 23/92 = 25%   Incidence: 23/53=43%
Lower: Combined Totals: Right and Left =19/92 = 20.7%   Incidence: 19/53 =35.8%

Of the adult population 16 % had degenerative joint disease of the left upper limb, and only 8.7% of the right upper limb. The incidence of lower left limb involvement is 8.7% compared to12% for the lower right limb. Adult females had DJD of upper limb more frequently than on the lower limb, but males were affected at the same rate in the upper and lower limbs. Young adults' upper limbs are 2/3 more frequently affected than their lower limbs. Middle adults have equal incidence in upper and lower limbs. Old adults have osteoarthritis more frequently in their lower limbs as no individuals in this age set had upper limb involvement. The last age set, adult+ individuals had equal involvement in the upper and lower body. Generally, the upper limbs of adults were affected more frequently than the lower limbs, and therefore the upper body may have been under greater relative stress.

Chi Square of Upper and Lower Limbs Versus Side of Body

2.2345 = X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

6.6 Sex and Severity

After discussing the role of sex, age, side affliction, and location of osteoarthritis within the research sample; a general assessment of the connection between sex and the severity of DJD is now possible. The sex classification was divided into five categories female, questionable female, unknown, questionable male, and male. The severity was scored according to the methods described in Chapter 5.

Score 0 means that there was no visible sign of osteoarthritis or osteophytosis on the skeletal remains (Figure 6). Approximately 16% of adult females did not have any degenerative joint disease on their bones. Males that were free from this pathology also comprised 16% of the adult population sample. Finally, just over 3% of the adult individuals free of degenerative joint disease could not be assigned to any sex and are classified as unknown.

The largest number of individuals with degenerative joint disease had a score 1 in severity. Adult females from Lamanai with score 1 comprised 29.8% of the sample. Those adults who could not be assigned to the female or male classifications are equally 6.4%. Fifteen percent of those with score 1 were from the combined male categories.

Chi Square of Sex and Presence or Absence of Score 1

6.47 = X2 distribution
Alpha = 0.05
Degrees of freedom = 2
X2 = 5.991

* Therefore the Null hypothesis must be rejected and there is statistical significance.

There were slightly fewer individuals with moderate levels of degenerative joint disease. Only 23.4% of adult females had score 2 and 11.7% of adult males had score 2. The unknown adult individuals made up just over 5% of the population with moderate degenerative joint disease (Figure 7).

Chi Square of Sex versus Presence and Absence of Score 2

6.74 = X2 distribution
Alpha = 0.05
Degrees of freedom = 2
X2 = 5.991

* Therefore the Null hypothesis must be rejected and there is statistical significance.

Very few individuals had severe degenerative changes (Figure 8). The level of preservation often necessitated that a conservative score be given. As well, the majority of adult individuals in the research sample were young adults (Table 6), and therefore did not live long enough to suffer the affects of stress and strain being placed on their bodies that they developed severe DJD. Only 6.4% of females had degenerative joint disease with a score 3 in severity. Only half as many males as females had the most severe level of osteoarthritis present in this sample. Individuals in the unknown category made up 2.2% of those with severe degenerative joint disease.

Chi Square of Sex versus Presence or Absence of Score 3

2.770 = X2 distribution
Alpha = 0.05
Degrees of freedom = 2
X2 = 5.991

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

The last and most severe degree of degenerative joint disease was not present or not preserved on any of the individuals from Lamanai (Figure 9). In all degrees of severity females are most frequently affected with degenerative changes to their joints. Therefore, females seem to have been under greater amounts of stress than their male counterparts. Determination of the connection between sex and severity of DJD allows researchers to consider whether the subsistence activities carried out by one sex was more stressful than those undertaken by the other. Equally important is to consider age and severity in order to determine whether individuals were stressed at an early age or whether the osteoarthritis occurred as a result of wear and tear over the years.

Sex and Severity

Figure 6: Score 0

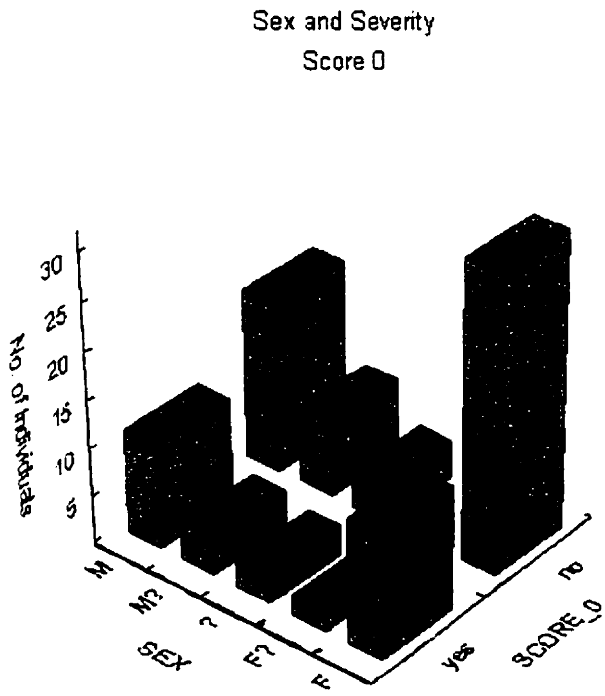


Table 22: Sex and Score 0

	SCORE_0 no	SCORE_ 0 yes	Row Totals
Female	31.000	13.000	44.000
Total %	32.98%	13.83%	46.81%
Female?	0.000	2.000	2.000
Total %	0.00%	2.13%	2.13%
Unknown?	4.000	3.000	7.000
Total %	4.26%	3.19%	7.45%
Male?	8.000	4.000	12.000
Total %	8.51%	4.26%	12.77%
Male	18.000	11.000	29.000
Total %	19.15%	11.70%	30.85%
All Grps	61.000	33.000	94.000
Total %	64.89%	35.11%	

Figure 7: Score 1

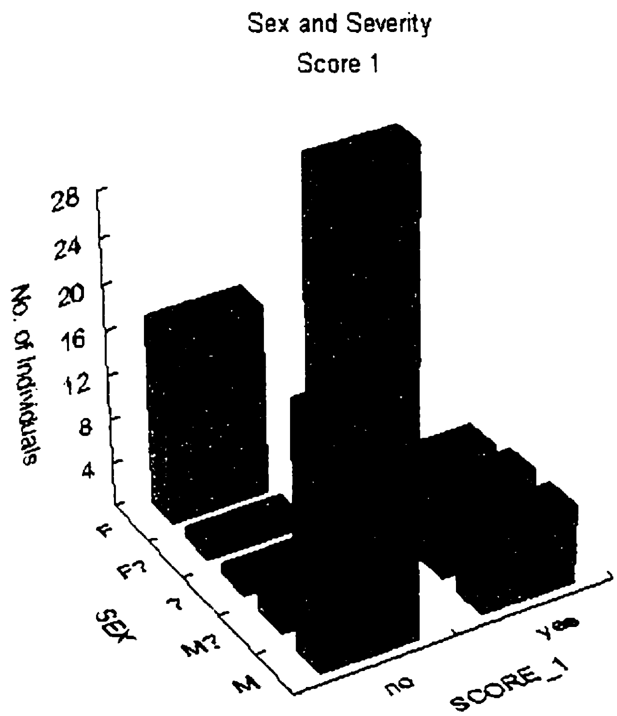


Table 23: Sex and Score 1

	SCORE_1 no	SCORE_1 yes	Row Totals
Female	17.000	27.000	44.000
Total %	18.09%	28.72%	46.81%
Female?	1.000	1.000	2.000
Total %	1.06%	1.06%	2.13%
Unknown?	1.000	6.000	7.000
Total %	1.06%	6.38%	7.45%
Male?	5.000	7.000	12.000
Total %	5.32%	7.45%	12.77%
Male	22.000	7.000	29.000
Total %	23.40%	7.45%	30.85%
All Grps	46.000	48.000	94.000
Total %	48.94%	51.06%	

Figure 8: Score 2

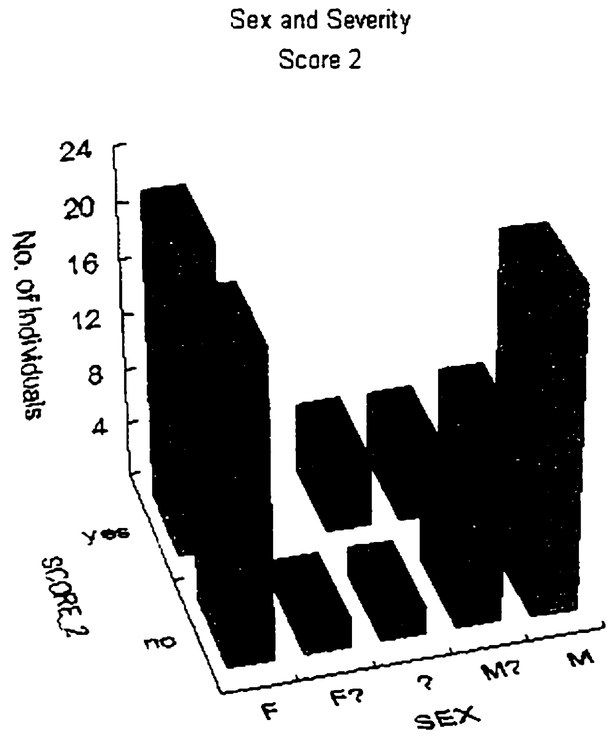


Table 24: Sex and Score 2

	SCORE_2 no	SCORE_ 2 yes	Row Totals
Female	22.000	22.000	44.000
Total %	23.40%	23.40%	46.81%
Female?	2.000	0.000	2.000
Total %	2.13%	0.00%	2.13%
Unknown?	2.000	5.000	7.000
Total %	2.13%	5.32%	7.45%
Male?	7.000	5.000	12.000
Total %	7.45%	5.32%	12.77%
Male	23.000	6.000	29.000
Total %	24.47%	6.38%	30.85%
All Grps	56.000	38.000	94.000
Total %	59.57%	40.43%	

Figure 9: Score 3

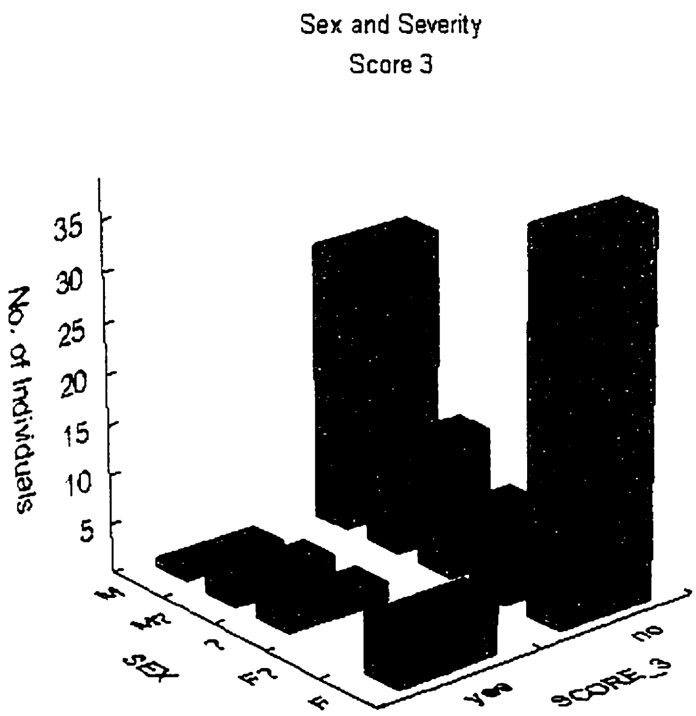


Table 25: Sex and Score 3

	SCORE_3 no	SCORE_3 yes	Row Totals
Female	38.000	6.000	44.000
Total %	40.43%	6.38%	46.81%
Female?	2.000	0.000	2.000
Total %	2.13%	0.00%	2.13%
Unknown ?	5.000	2.000	7.000
Total %	5.32%	2.13%	7.45%
Male?	10.000	2.000	12.000
Total %	10.64%	2.13%	12.77%
Male	28.000	1.000	29.000
Total %	29.79%	1.06%	30.85%
All Grps	83.000	11.000	94.000
Total %	88.30%	11.70%	

Figure 10: Score 4

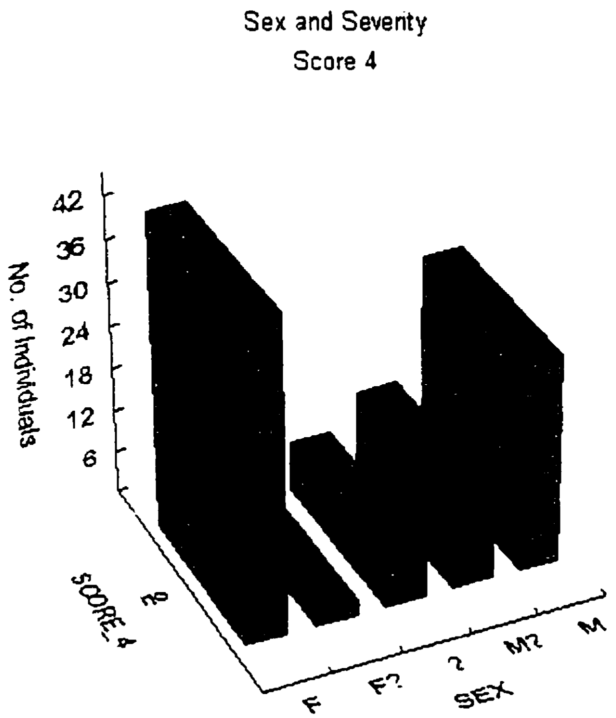


Table 26: Sex and Score 4

	SCORE_4 no	SCORE_4 yes	Row Totals
Female	44.000	0.000	44.000
Total %	46.81%	0.00%	46.81%
Female?	2.000	0.000	2.000
Total %	2.13%	0.00%	2.13%
Unknown ?	7.000	0.000	7.000
Total %	7.45%	0.00%	7.45%
Male?	11.000	0.000	11.000
Total %	11.70%	0.00%	11.70%
Male	29.000	0.000	29.000
Total %	30.85%	0.00%	30.85%
All Grps	94.000	0.000	94.000
Total %	100.00%	0.00%	

6.7 Age and Severity

With the exception of 2 juveniles, all skeletal remains included in this area of the research were adult. Within the young adult category, 19.2% had no degenerative joint disease (Figure 11). Middle adults with score 0 made up 4.3% of the population. Old adults without degenerative joint disease could only be placed in the adult + category.

Young adults are by far the largest group to have score 1 degenerative joint disease (23.4%). The second largest group was comprised by those adults in the middle adult category (12.8%). The third largest age set having mild degenerative joint disease was adult+ with 8.5% which was followed by 4.3% of old adults. Finally, two juveniles also appear to have the beginning indications that they suffered from osteoarthritis (Figure 12).

Chi Square of Young and Young Adults versus Presence or Absence of Score 1

0.3882 = X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

Young adults with moderate degenerative joint disease (Figure 13), like those with score 1, had the highest rate at 15%. The number of middle adults in this category is less at 11.7%. Adults over the age of fifty account for 4.3% of those with moderate degenerative joint disease, and juveniles for 2.2% of this group.

Chi Square of Young and Young Adults versus Presence or Absence of Score 2

2.181 = X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

Very few individuals had severe osteoarthritis or osteophytosis in the sample population (Figure 14). Approximately 12% of the adult population had severe degenerative joint disease. The largest percentage of individuals fall into the middle adult category as is outlined in Table 30. The adult+ specimen (3.2%) formed the second largest group and young adults with severe DJD, was the third largest group. Finally one of the juveniles did in fact have score 3 OA.

Chi Square of Young and Young Adults versus Presence or Absence of Score 3

0.3333 = X2 distribution
Alpha = 0.05
Degrees of freedom = 1
X2 = 3.841

* Therefore the Null hypothesis must be accepted and there is no statistical significance.

The most severe degree of degenerative joint disease was not observed (Figure 15). A discussion of what these findings mean will follow in Chapter 7.

Age and Severity

Figure 11: Score 0

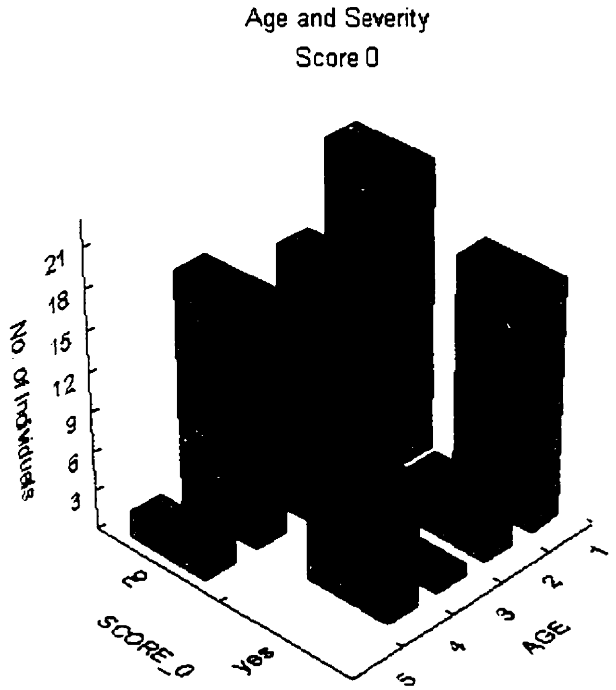


Table 27: Age and Score 0

	SCORE_0 no	SCORE_0 yes	Row Totals
Y.Adult	22.000	18.000	40.000
Total %	23.40%	19.15%	42.55%
M.Adult	16.000	4.000	20.000
Total %	17.02%	4.26%	21.28%
O.Adult	3.000	1.000	4.000
Total %	3.19%	1.06%	4.26%
Ad. +	18.000	10.000	28.000
Total %	19.15%	10.64%	29.79%
Juv.	2.000	0.000	2.000
Total %	2.13%	0.00%	2.13%
All Grps	61.000	33.000	94.000
Total %	64.89%	35.11%	

Figure 12: Score 1

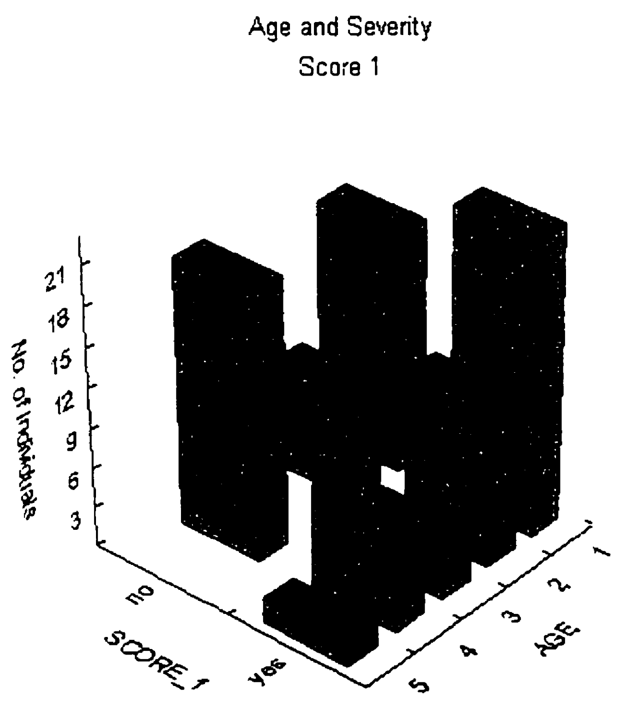


Table 28: Age and Score 1

	SCORE_1 no	SCORE_1 yes	Row Totals
Y.Adult	18.000	22.000	40.000
Total %	19.15%	23.40%	42.55%
M.Adult	8.000	12.000	20.000
Total %	8.51%	12.77%	21.28%
O.Adult	0.000	4.000	4.000
Total %	0.00%	4.26%	4.26%
Ad.+	20.000	8.000	28.000
Total %	21.28%	8.51%	29.79%
Juvenile	0.000	2.000	2.000
Total %	0.00%	2.13%	2.13%
All Grps	46.000	48.000	94.000
Total %	48.94%	51.06%	

Figure 13: Score 2

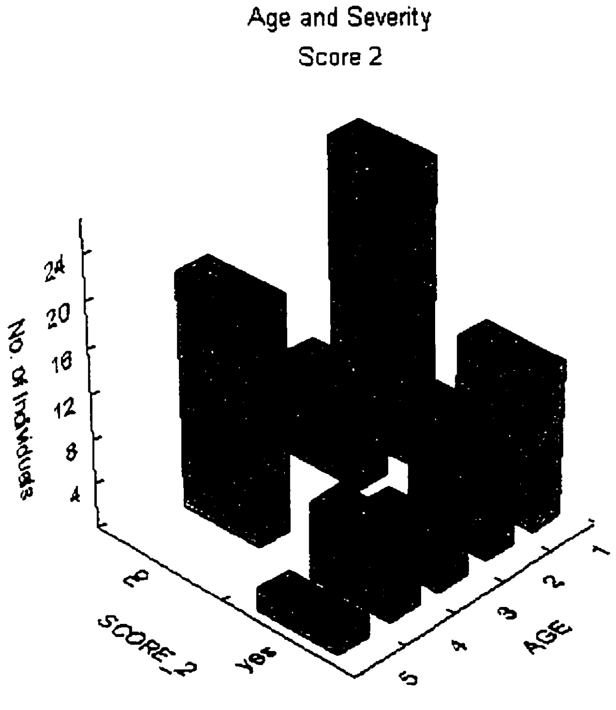


Table 29: Age and Score2

	SCORE_2 no	SCORE_ 2 yes	Row Totals
Y.Adult	26.000	14.000	40.000
Total %	27.66%	14.89%	42.55%
M.Adult	9.000	11.000	20.000
Total %	9.57%	11.70%	21.28%
O.Adult	0.000	4.000	4.000
Total %	0.00%	4.26%	4.26%
Ad.+	21.000	7.000	28.000
Total %	22.34%	7.45%	29.79%
Juv.	0.000	2.000	2.000
Total %	0.00%	2.13%	2.13%
All Grps	56.000	38.000	94.000
Total %	59.57%	40.43%	

Figure 14: Score 3

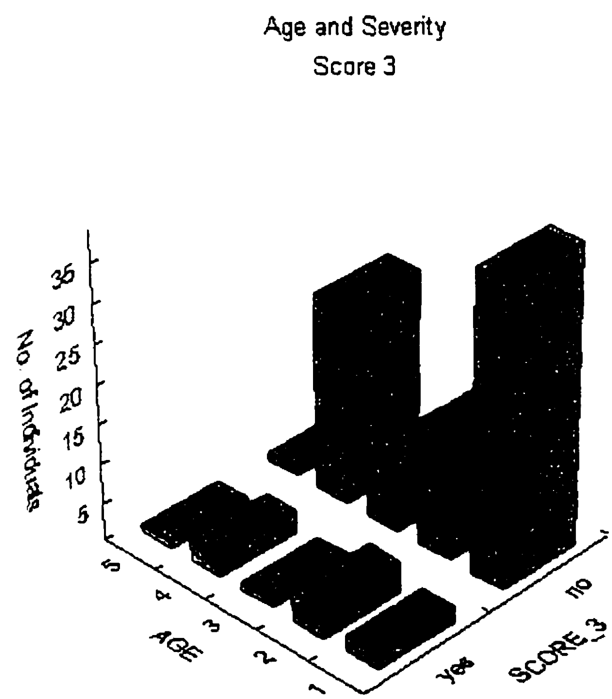


Table 30: Age and Score 3

	SCORE_3 no	SCORE_ 3 yes	Row Totals
Y.Adult	38.000	2.000	40.000
Total %	40.43%	2.13%	42.55%
M.Adult	16.000	4.000	20.000
Total %	17.02%	4.26%	21.28%
O.Adult	3.000	1.000	4.000
Total %	3.19%	1.06%	4.26%
Ad.+	25.000	3.000	28.000
Total %	26.60%	3.19%	29.79%
juv.	1.000	1.000	2.000
Total %	1.06%	1.06%	2.13%
All Grps	83.000	11.000	94.000
Total %	88.30%	11.70%	

Figure 15: Score 4

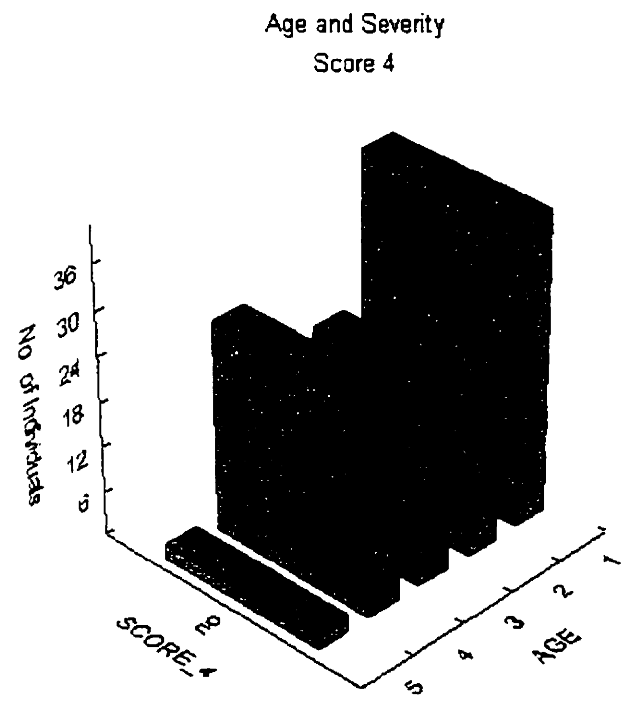


Table 31: Age and Score 4

	SCORE_4 no	SCORE_4 yes	Row Totals
Y.Adult	40.000	0.000	40.000
Total %	42.55%	0.00%	42.55%
M.Adult	18.000	0.000	18.000
Total %	19.14%	0.00%	19.14%
O.Adult	4.000	0.000	4.000
Total %	4.26%	0.00%	4.26%
Ad.+	27.000	0.000	27.000
Total %	28.72%	0.00%	28.72%
juv.	2.000	0.000	2.000
Total %	2.13%	0.00%	2.13%
All Grps	94.000	0.000	94.000
Total %	100.00%	0.00%	

Chapter 7 Discussion

7.1 Age Demographics at Lamanai

To date, 105 burials from the early Historic period of Lamanai have been cataloged at Trent University. The age distributions of the 152 individuals suggest that 32.9% of the population did not live past the age of 13 years. The majority of the remaining population seemed to reach adulthood since only 6.6 % were juveniles. While the majority of individuals lived to be over the age of twenty, there was dramatic decrease in the number of individuals in the middle adult population. The number of young adults, 40 individuals (or 26.3%), is double the number of middle adults, making this age category the largest of the sample population. Not surprisingly, given the size of the sample and the large number of young individuals in it, few people beyond the age of fifty were present. There are several explanations as to why so many young adults were amongst the burials. One explanation could be that the population's age at reproduction was low, thus creating a large base of young individuals. Other rationalizations could involve the death of young adults resulting from war, epidemics or child birth. Lamanai was transformed into an area were Spanish collected runaways and therefore, it is not inconceivable that conflict led to the killing of young adults. At present this idea is speculation, some of the males in the sample do have blunt trauma to the occipital region. The killing of young adults would take away valuable labor from this population's labor pool. Death by epidemic could explain the decrease in the small number of individuals who survive to the next age set. As was previously noted in Chapter 3, diseases such as yellow fever, and small pox were introduced by the Spanish explorers. These various unusual population stresses should be considered because they may explain why so many young people lost their lives and what stresses were imposed on the population. Young adults are normally considered the healthiest and are usually given the best chances for survival during hardships. It is not likely that so many young individuals died of natural causes. No single explanation can be offered at this point, since the sample only represents a small portion of the living population, and especially because the specific ages of 28 adults within the sample are unknown. What is important to note here is that there are a sufficient number of adults for this research project.

Knowing the ages of the individuals in this research is crucial to understanding whether this population developed premature degenerative joint disease, due to an acute response to a physically demanding lifestyle, or whether the onset was gradual, induced by wear and tear over many decades of life. Determination of the age of onset allows for this distinction to be made. As was mentioned in Chapter 3, most individuals in the general human population do not begin to develop degenerative joint disease until they are middle adults. In the early Historic population sample from Lamanai, nearly half of all young adults had osteophytosis in the thoracic region. The fact that such a large percentage of young adults had degenerative joint disease suggests that the population was being stressed during the Historic times. It also indicates that individuals began to participate in subsistence activities at an early age. This finding can be supported by an ethnographic video called "Living Maya" which documents Maya children helping their parents with subsistence activities beginning at 4 or 5 years of age and being expected to work intensely along side their parents by 15 years of age if not sooner (Smith 1982: University of California).

7.2 Sex Demographics at Lamanai

Because of the specific nature of the research project, the inclusion of the sex demographics of the research sample is crucial. In populations like the Maya from Lamanai, subsistence activities are very much divided between males and females. Evidence of this division is perhaps most obvious in a video produced by Claudia Feldmar in 1987c called "Comalapa, Traditions and Textures" which illustrates that Maya men and women still participate in separate and distinct subsistence practices (Penn State University). Therefore, the researcher must know the sex ratio males and females in order to allow assessment as to whether one sex is experiencing more stress and consequently DJD. In addition, knowing the distribution of males (n = 42; % = 45.6) and females(n = 47; % = 51.1) is also useful in order to determine which sex had greater life stressors at an early age. For example, in the young adult category of the Lamanai sample, females outnumber males slightly, and of those in this age category who were suffering from degenerative joint disease, females outnumber males. Both results seem to suggest that females were experiencing more stress than their male counterparts at an early age.

Familiarity with the demographics of the particular population provides the researcher with the basic information necessary to determine the life span, the health and the level of stress of a population. From this information, it is possible to determine whether in fact links between the presence of DJD and subsistence activities can be made. Links can be made on either a general (e.g., hunting and gathering versus agriculture, or one type of agriculture versus another) or to a specific activity (e.g., grinding corn) level.

7.3 General Health at Lamanai

Prior to assessing whether a link exists between the subsistence activities carried out and the presence of degenerative joint disease at Lamanai, one must determine the catalysts for these joint changes. Trauma was one such catalyst at Lamanai, and it explains the presence of some of the DJD. What then can the presence of trauma tell us about the Lamanai Maya?

7.4 Trauma

In a very general sense, the presence of trauma to the bone gives the researcher an idea of the quality of life experienced on an individual basis. It may also indicate that the population was participating in stressful activities which placed unacceptable strain on the joint(s). If the trauma can be linked to the development of DJD, then a normal aging process cannot truly explain the degeneration and a more specific distinction between primary and secondary DJD can be made.

None of the trauma found on the skeletal remains at Lamanai seems to have resulted in death, since healing had taken place. Not all individuals with evidence of healed trauma developed DJD. For example two adult males had healed depressed fractures to the occipital bones and no DJD. Three individuals (burials 85-02, 85-15, and 85-98) show evidence of trauma which led to secondary osteoarthritis. In some instances some explanations as to how the trauma occurred can be offered. For example with regards to burial 85-02, there are several plausible explanations, one of which is that this is a defense wound, and another that she fell from a height. Two of the three individuals were young adults and may have suffered trauma, because of the degree of stress being placed on their bodies during subsistence activities. The 3rd individual (85-98) had partial amputation of the left hand. Several explanations for the amputations are possible. The first explanation would be that portions of his first four digits were cut off accidentally; the second is that these amputations were a means of punishments given by the Spanish. The third is that amputation was part a Maya cultural practice. This third explanation might be possible because "finger bowls", containing amputated digits, are found at other Maya sites (Iannone 2000:personal communication). The first explanation, accident, consequently seems more reasonable considering the oblique angle of the trauma. In some of the cases of trauma at Lamanai, the injuries may have been caused by intense stress being placed on the joint(s) during subsistence activities.

7.5 Pathological conditions Other than DJD at Lamanai

With all pathological conditions noted and identified, a more complete picture of the health of the Lamanai population will emerge and lead to a better understanding of the quality of life during the early Historic period at Lamanai.

As was previously mentioned in Chapter 1, research Maya at Lamanai were under greater stress during early Historic times than they were in pre-Historic times (Pendergast, Emery, White, and Wright). This conclusion was based on the increased incidence of dental disease, epidemics, anemia and on the early Historic population's change in diet as well as on evidence in Historical records. The poor health of the population would have been further compromised by the heat and humidity of a tropical climate. Hubert Smith (1982: University of California) filmed the Maya while they carried out their subsistence activities. His film discussed the effects of the intense heat and humidity as well as the annoyance of insects that the Maya encountered while clearing brush. In the earlier Historic period sample, 58% of all adults have degenerative joint disease. This incidence is fairly high given the fact that the majority of individuals in the population are young adults. Therefore, these findings agree with the conclusion that this group was under considerable muscular-skeletal stress. The question of whether the incidence of DJD was greater in the Historic rather than the pre-Historic period could only be answered with future research, should researchers attempt to make such an assessment. No conclusions regarding the incidence ofDJD in the pre-Historic period can as yet be reached.

7.6 Can Links be made between the subsistence activities and the presence of DJD at Lamanai?

Typology and DJD

One of the primary means used by researchers to link a particular subsistence activity to the presence of degenerative joint disease is to assess patterns of joint involvement. As was presented in Chapter 6, the spinal column was the region most frequently affected with degenerative joint disease. It is also the area that has the strongest evidence that onset occurred at an early age: almost half of young adults, sexes combined, have osteophytosis in the spine. The highest incidence was found in the thoracic followed by the cervical and then the lumbar vertebrae. While there are 12 vertebrae in this region, frequency was determined based on the incidence from one region to the next, rather than the number of vertebrae per region. The higher incidence in this region is likely due to the location and the fact that the Maya had not domesticated draft animals(Pendergast 1986a; Smith 1982:University of California).

The combined total number of adult males and females with osteophytosis of the neck was 32%. Most of these individuals were females, only 12% were men. A large number of young adult females had osteophytosis in their neck. The question, then, is what activities could cause stress to this region among females at such an early age. As was mentioned in the second chapter, ethnohistorical and archaeological records suggest that women would have carried heavy loads either on their heads or on their backs with a tump-line. The best evidence available to support this hypothesis is ethnographic videos. There are at least five videos (Amy 1981: Public Broadcasting Association; Feldmar 1987c:Penn State University , Ojo Video 1985; Smith 1982: University of California; and National Geographic Society 1993) at Trent University, that clearly show that women were the main ones to use both of these methods to carry heavy loads. At this point it is perhaps useful to qualify what would be considered to be a heavy load. In the video "Living Maya" it was not uncommon for females to carry loads of 80 lbs (Smith 1982: University of California). At Lamanai, women would have had to carry heavy loads of water uphill from the New River lagoon for 1/4 of a mile. These same five videos mentioned above also indicated that females began this method of carrying heavy objects at an early age. Both of these subsistence activities would have been carried out regularly since water and firewood would be required to maintain the household. In addition to having the highest incidence of DJD in the neck, females also had the most severe degree of osteophytosis in this region.

The most frequent region affected by OP in the spinal column was the thoracic region and, as was the case with the neck, females made up the majority of sufferers and had the greatest severity. This rate was only slightly less than it was in the neck. Males also have a greater incidence in the thoracic vertebrae than in the cervical vertebrae. Overall young adults have the highest incidence, but they have more mild and moderate levels than all other age categories. This finding suggests that the onset of degenerative changes occurred at an early age. One individual appears to have been stressed at a very early age. A juvenile, possibly female, had severe OP. Both females and males have the greatest incidence of DJD in the thoracic region. In males, development of OP may be due to the strenuous nature of swidden agriculture. Two possible activities that may have contributed to their development of DJD are clearing brush and using digging sticks to plant seeds. Females, on the other hand, may have stressed their backs while grinding corn in preparing food for consumption. Because the thoracic region is frequently affected in many populations, it is difficult to attribute responsibility for the onset of DJD to a single activity. At Lamanai, linking activity and degenerative joint disease is also complicated by the fact that the preservation of the bones is poor, and therefore it was not always possible to isolate whether the frequency was greater in the upper or lower thoracic region. Being able to do this would help to narrow the possible causes of DJD. Both females and males from Lamanai experienced a fair amount of stress and strain in their thoracic region.

Very few individuals at Lamanai had osteophytosis in the lumbar region. However, women continue to have a higher incidence and a greater severity of OP in this region. Young adults with DJD in the lumbar vertebrae only outnumber middle adults by three individuals. Given the types of activities carried out by males, it was surprising that with all the bending involved during clearing, harvesting and weeding there was not a high incidence of OP in the region. The "Living Maya" video part 2 provided the best support for the hypothesis that the lumbar vertebrae of the Maya males would be stressed. Males who were filmed while clearing brush complained of pain to this region of their back (Smith 1982: University of California). However, it is possible that the low levels found for this area may reflect the poor preservation of the research sample rather than an absence of stress.

What general conclusions can be made about the involvement of the spinal column? Females seem to have experienced greater stress. The incidence among young adults suggest that OP did not develop as a result of the aging process alone. Onset appears to be fairly early. Young adults in this sample do have severe degrees of OP. Young adult females have the highest incidence in the cervical region followed by the thoracic region. One logical explanation for the high stress and strain being placed on the spinal column of Lamanai people is the fact that no domestic animals existed to carry heavy loads. Women appear to have been the ones to shoulder these burdens. Osteoarthritis as oppose to OP was not significantly present in the spine; however, this, no doubt, is because the synovial joint regions were poorly preserved or absent altogether in most individuals' remains. Consequently there is not enough material to warrant a specific link between activity and DJD based on the facet joints alone.

Another result arguing for significant early stress being place on the Lamanai Historic population was found in the sterno-clavicular joints. The sterno-clavicular region was equally affected on the right and left sides of the body. Females at Lamanai were more frequently affected than males. Again, most of the adults with osteoarthritis in this region are young. Early onset of osteoarthritis appears to be the case. For example, one young female has score 2. No severe osteoarthritis was found, which was probably due to the fact that the majority were young adults. While it is tempting to attribute osteoarthritis in this joint to a particular activity like grinding corn, there is not really sufficient data to do so; therefore, it is really only possible to conclude that there was stress being placed on this region while individuals were alive.

Another region with DJD that affected more females than males was the shoulder joints. The shoulder was one region that one would expect to have a high incidence, particularly in males, given the repetitive use of this region when clearing brush and hauling brush and planting with digging sticks. "Swidden Horticulture Among the Lacandon Maya"(McGee 1986:University of Utah) is a video which proved to be very helpful in this research project because it clearly illustrated the repetitive nature of many of the male activities. Males in the video had to repeatedly thrust the digging stick into the ground to make a hole for planting which would have placed tremendous strain on the shoulder joints. All of these activities would have been made more difficult by the rugged terrain at the Lamanai site. However, the results did not bear out these expectations. Young adult females had more severe osteoarthritis in their shoulders. Both sides, when affected, were equally involved. The shoulder joints were poorly preserved, and the overall incidence of osteoarthritis was low. Therefore, no link should even be considered based on the shoulder joints alone.

Next to the spinal column, the elbow joint was the second most frequent region affected by degenerative joint disease. Bilateral involvement seems to be present in the Lamanai sample. As with previously discussed regions, more females had osteoarthritis and they had more severe cases than males. The right side of the body seems to have had more severe osteoarthritis than the left. Again the most obvious activity carried out by females that would account for these findings was grinding corn. In the video " Conversion Part 2 Before

Columbus" produced in 1993 (National Film Board of Canada), the Maya women were using the same tools to grind corn as did the Maya from the Lamanai site. This visual record clearly illustrated that repetitive stress was primary being placed on the elbows followed by the shoulders and then the wrists. The fact that White's 1988 study of Lamanai reveals that consumption of maize doubles from the Postclassic period to the Historic period is also significant evidence. An increase in consumption, means than women would have to grind twice as much, therefore increasing the stress on the involved joints. This activity required repetitive movement with the arms and therefore may explain the incidence of DJD in the elbows of females. Another activity that would require similar range of movement would be washing clothes on rocks (Iannone 2000:Personal Communication). In males, hunting using bow and arrows may explain the relatively high levels of osteoarthritis on the elbow joint. Another consistent activity that might explain OA in the males in this joint is fishing using nets. Emery's (1999:72) recent work at Lamanai, indicating riverine resources were overwhelmingly abundant and that consumption of fish was dominant during the colonial period.

Unlike all areas previously discussed above, males with osteoarthritis in the wrist joints outnumber females. One unusual finding is that the left and right sides were equally affected. The higher incidence in males may be due to a specific activity or may indicate that those subsistence activities being carried out by Maya males (e.g., clearing, planting, manufacturing stone tools, hunting, or harvesting) required the use of both sides of the body. One activity that would place increased strain on the wrist was the use of the bow and arrow for hunting. This was a new means of hunting. Archaeological and historic records show that this new means of hunting, a transition from the spear to bow and arrow, had just taken place. It is difficult to link the presence of degenerative joint disease to this particular activity given the low preservation of bone and low frequency found.

There was also a higher frequency of DJD than expected found in the left hand. In most populations, the majority of individuals are right handed and therefore, researchers have inferred that the right side would likely experience greater degenerative changes. While the left hand was more frequently affected among the individuals, the right hand had more severe degenerative joint disease.

Having found that males had a higher frequency of DJD in the wrist it would seem logical that the hands show the same pattern; however, the findings did not meet this logic. Females were affected twice as often as males. However, there were far too few individuals who had degenerative joint disease in their hands or in their hips to draw any meaningful links between subsistence activities and the DJD found in these areas.

As with the wrist region, mostly males had OA in the hip joints and there was bilateral involvement. Onset in this large joint does not appear to have been as early as in other joints, most individuals with osteoarthritis in this region were middle adults. Given that no real pattern was present, no specific link to an activity can be made, other than long distance walking may have been a contributing factor.

Another joint that was affected in more middle adults than young adults with DJD was the knee. Not surprisingly the right side was involved twice as often as the left, and the osteoarthritis was more severe. The majority of those with OA in their knee had degenerative changes to the patella, most were female and their OA was more severe than in males.

Overall females also have more severe levels of osteoarthritis in this joint. Of females with osteoarthritis in the knee all patellas were involved. One reasonable explanation for this pattern could be that females were participating in an activity that required kneeling. Information provided in the background chapters strengthens the hypothesis that grinding corn was the likely cause.

Links between DJD and activities could not even be considered when examining the results for the ankle joint. One reason little could be said about this joint was that 3/4 of the individuals with degenerative changes were in the adult+ category. Therefore, researchers cannot assess whether pathology present was part of the wear and tear that takes place during the aging process or whether development of DJD was premature in this region. One older juvenile had degenerative joint disease in his or her ankle. The ankles of females and males were equally affected. The left side of the body was affected more than the right.

Unlike the findings for all joints superior to the feet, the feet of the population show DJD only on the left side. No significant conclusions can be made based on the fact that only the left side was affected since too few individuals had degenerative changes in this region and many feet were absent from the research sample. There were again more males than females with DJD in their feet. All individuals were from the adult + category with the exception of one old adult. The findings suggest that wear and tear in the feet did lead to degenerative joint disease.

A comparison of the incidence of degenerative joint disease from one joint to another joint revealed some interesting patterns at Lamanai. A large number of young adult females had DJD in their cervical and thoracic vertebrae. In many instances their vertebrae were compressed. The second most common region next to the vertebral column was the elbow, followed by the knee. In all joints except for the wrists, hips, and feet, females were more frequently affected than males. With the exception of the hip and knee regions young adults were the largest group of individuals with degenerative joint disease in every joint. The middle adult category represents the largest number of adult individuals with DJD in their hips and knees. In addition to a discussion of what the findings of individual joint patterns mean, consideration of the larger patterns will follow.

7.7 Upper Limb versus Lower Limb and Side Comparison

The most obvious larger pattern considered was whether the upper body was under greater stress than the lower body or vice versa, and whether the right side of the body was under greater stress than the left side. One of the most surprising findings in the sample population at Lamanai was that the upper limbs had a greater incidence of degenerative joint disease than did the lower limbs. The upper left limb was affected more than the upper right limb, whereas, the lower right limb was affected more that the lower left limb. Males seem to have the same rate of upper and lower limb involvement, indicating that females, overall, had more upper limb involvement in the adult population. Young adults had 2/3 more involvement in their upper limbs than their lower limbs, whereas upper and lower limbs were equally affected in the middle adult population. Finally, old adults had higher rates of DJD in their lower limbs. Other major patterns to be scrutinized is the connection between sex and severity and age and severity.

7.8 Sex and Severity of DJD at Lamanai

Of the entire adult population in this research sample 58% had visible signs of degenerative joint disease on their skeletal remains. The largest number of individuals with DJD had a mild degree, the majority of whom were female representing 29.8% of the adult population. Males, with mild DJD, on the other hand, made up only 15% of the adult population. Not surprisingly, there were fewer individuals with moderate DJD, females represented 23.4% of the adult population and 11.7% of males. Females again made up the largest percentage of those with score 3 DJD; twice as many females were affected. Based on the above findings, the most obvious conclusion about the connection between the sex of the individuals and the severity of DJD is that overall females were affected more frequently and severely. More specifically, it is the upper body joints which are more stressed in the female than in the male sex. There are two possible explanations for the greater stress in this region among females. The first is that women have less upper body strength and are therefore more prone to the stress and strain of physical activity. The second is that women had more and demanding work and therefore more stress to their joints. The second explanation seems more plausible in this case since they worked without the aid of beasts of burden and seem to work longer and consistent hours carrying out daily subsistence activities.

7.9 Age and Severity of DJD at Lamanai

The larger weight-bearing joints were somewhat more affected in older males. The majority of adults with mild DJD were young adults. They also comprise the largest percentage of those with moderate degenerative joint disease. However, the middle adult category comprised the largest number of individuals with severe DJD. One of the most unusual findings is that a juvenile, who had no visible signs of trauma, had severe degenerative joint disease. In general, it appears that onset occurred at an early age and that young adults made up the majority of those with DJD. If there was little or no stress then the incidence of DJD would likely be less frequent in adults between the ages of 20-34. Furthermore, the strong muscle markings and cortical thickness found in this sample, support the evidence of stress to this sample.

Both the individual joint patterns and the larger patterns of degenerative joint disease involvement suggest the following: females were affected more frequently and severely than males; onset occurred at an early age; and, the group with the highest incidence was young adults.

Chapter 8- Concluding Remarks

Undoubtedly, the largest obstacle in this thesis was the poor degree of preservation. However, what is present is just as important as what is lacking. The findings of degenerative joint disease on the bones of the Lamanai sample are not so unique that they can be linked to the type of subsistence (hunter-gatherers versus agriculturalists). However, the results at Lamanai can be compared with other populations samples to determine if they were generally more or less stressed than another population. For example, in the early Historic sample at Lamanai there seems to be a connection between their subsistence practices and the presence of DJD; however, this Maya sample was not stressed to the same degree as, for example, the Sadlermiut Inuit. This conclusion is, and should be, based on the incidence, age at onset, and severity rather than on the major type of subsistence practiced (e.g., hunting versus agriculture).

The question still remains, can the presence of DJD in the Lamanai sample be connected to a specific subsistence activity (e.g., DJD in shoulder of Sadlermiut males to kayaking)? The frequency, severity, age, and sex allow us to conclude that some patterns on individual joints and larger patterns of topographical joint involvements exist. With support from archaeological data, ethnohistorical and ethnographic data, activity links to these patterns are possible.

In this research project, some valuable contributions have been made. First and foremost, the findings agree and support other research that suggested that Lamanai people were stressed during the early Historic period. The relatively high incidence (58%) and an early onset of DJD in the adult population concurs with the conclusion that the overall health was poor.

Fortunately, researchers have a wealth of information about the Maya culture past and present, and the subsistence activities have been well documented. While it would be tempting to give definitive links between the presence of DJD and specific subsistence activities (e.g., grinding corn) at Lamanai, the lack of preservation does not permit a strong conclusion. At best specific links can merely be suggested. Therefore, it appears that the osteophytosis in the cervical vertebrae of women is related to the burden of carrying heavy loads, maybe using a tump-line. As well the presence of DJD in the knees and elbows of females suggest that there may be a connection to grinding corn. In males, the high incidence of DJD in their thoracic region and elbows suggests that there may be a link to the use of digging sticks. Furthermore, the higher incidence in the wrists of males may mean that the use of the bow and arrow caused stress and strain in this region which was unique to the adult males in this sample.

This study demonstrates that a multi-faceted approach is necessary for connecting specific subsistence activities and DJD. Foremost, this research provides a record of a common pathology that has not previously been documented at a Maya archaeological site. The results from this research sample can provide a basis of comparison to other sites, to ascertain whether DJD was more frequent or severe in other Maya sites (e.g., Tipu) during the sample period. As well, due to the continuity in genetics, behavior, and environment, the results from Lamanai could potentially be compared to modern populations. It is, therefore, hoped that this study will be useful for future research attempting to make a connection between activities and degenerative joint disease. One area of interest in future research would be a comparison of the incidence and severity of DJD found in the early Historic period to the Classic and Postclassic period at Lamanai.

Perhaps the best testament to the Maya culture is to look at modern day populations. The Maya were not conquered; rather they are survivors of an oppressive culture. While much of their ancient culture has changed, we assume many of their subsistence patterns remain the same. For a culture that has supposedly been acculturated, the Maya are still a unique and strong presence in Belize and other Mesoamerican countries. Research on the Maya has and continues to fascinate anthropologists, and hopefully this focus stems from an interest in the strength of this culture and in its ability to withstand incredible challenges.

References Cited

Amy J. 1981. Odyssey- Maya, Lords of the Jungle. In: Berenson D, editor. [video recording VT 144]. Boston Massachusetts: Public Broadcasting Asso., inc.

Anderson JE. 1962. The Human Skeleton: A Manual for Archaeologists. National Museum of Canada, Ottawa.

Andrews AP. 1991. The Rural Chapels and Churches of Early Colonial Yucatan and Belize: An Archaeological Perspective. In: Thomas DH, editor. Columbian Consequences Vol. 3. Washington: Smithsonian Institution Press.

Angel LJ. 1979. Osteoarthritis in Pre-Historic Turkey and Medieval Byzantium. Henry Ford Medical Journal 27(1):38-43.

Aufderheide AC. 1998 Joint Diseases. In: The Cambridge Encyclopedia Of Human Paleopathology. Cambridge: Cambridge University Press.

Bass W. 1994. Human Osteology: A laboratory and Field Manual. Columbia, Mo.: Missouri Archaeological Society Inc.

Bolland NO. 1977. The Formation of a Colonial Society: Belize, from Conquest to Crown Colony. In: Price R, Knight F, editors. Baltimore, Maryland: Johns Hopkins University Press.

Bower B. 1989. Late Maya Culture Gets an Island Lift. Science News 136: 20.

Boyce B. 1993. Pathology of Metabolic Bone and Joint Disease. In: Grupe G, Garland AN, editors. Histology Of Ancient Human Bone: Methods of Diagnosis. Springer-Verlag Berlin.

Braidwood RJ. 1967. Prehistoric Men. Glenview: Scott Foresman. In: Larsen C, editor. Bioarchaeology-Interpreting Behavior from the Human Skeleton. Cambridge: Cambridge University Press.

Bridges P. 1991. Degenerative Joint Disease in Hunter-Gatherers and Agriculturalists From the Southeastern United States. American Journal of Physical Anthropology 85:379-391.

Bridges P. 1992. Pre-Historic Arthritis in the Americas. Annual Review Anthropology 21: 67-91.

Bridges P. 1994. Vertebral Arthritis and Physical Activities in the Pre-Historic Southeastern United States. American Journal of Physical Anthropology 93:83-93.

Brooks ST, Suchey JM. 1990. Skeletal Age Determination Based on the Os Pubis: A Comparison of the Acsadi-Nemeskéri an Suchey-Brooks Methods. Human Evolution 5:227-238.

Brothwell DR. 1981. Digging Up Bones. Ithaca, New York: Cornell University Press.

Buikstra J. 1997. Studying Maya Bioarchaeology. In: Whittington SL, Reed DM, editors. Bones of the Maya: Studies of Ancient Skeletons. Washington: Smithsonian Institution Press.

Buikstra J, Ubelaker D. 1994. Standards: For Data Collection From Human Skeletal Remains. Fayetteville, Arkansas: Arkansas Archeological Survey.

Chapman F. 1970. Vertebral Osteophytosis in Pre-Historic Populations of Central and Southern Mexico. American Journal of Physical Anthropology 36:31-38.

Coe M. 1993. The Maya. New York, NY: Thames and Hudson Inc.

Cohen MN. 1997. Does Paleopathology Measure Community Health A Rebuttal of The Osteological Paradox and Its Implication for World History. In: Payne RP, editor. Integrating Archaeological: Multidisiplinary Approaches to Pre-Historic Population. USA: Illinois University Press. p 242-260.

Cook DC. et al. 1983. Vertebral Pathology in the Afar Australopithecines. American Journal of Physical Anthropology 60:83-101.

Deevey SE. et al. 1979. Mayan Urbanism: Impact on a Tropical Karst Environment. Science 206:298-305.

Duncan H. 1979. Osteoarthritis. Henry Ford Hospital Medical Journal 27(1):6-9.

Dutour O. 1986. Enthesopathies (Lesions of Muscular Insertions) as Indicators of the Activities of Neolithic Saharan Populations. American Journal of Physical Anthropology 71:221-224.

Emery K. 1989 Snail Hunters of the Belizean Jungle. Archaeological Newsletter Series 2(34):1-4.

Emery K. 1999. Continuity and Variability in Postclassic and Colonial Animal Use at Lamanai and Tipu, Belize. In: White C, editor. Reconstructing Ancient Maya Diet. Utah: The University of Utah Press.

Engel A. 1968. Osteoarthritis and Body Measurements. Vital and Health Statistics: Data from the National Health Survey 11(29):1-3.

Farriss Nancy. 1992. Maya Society: Under Colonial Rule- The Collective Enterprise of Survival. Princeton, New Jersey: Princeton University Press.

Feldmar C. 1987a. Guatemalan Pottery. In: [video recording VT 272] Penn State University.

Feldmar C. 1987b. Chichicastenango Produ. In: [video recording VT 274] Penn State University.

Feldmar C. 1987c. Comalapa, Traditions and Textures. In: [videorecording VT 275] Penn State University.

Graham E. 2000. Personal Communication.

Graham E, et al. 1989. On the Fringes of Conquest: Maya-Spanish Contact in Colonial Belize. Science 246:1254-1259.

Hadler NM, et al. 1978. Hand structure and function in an industrial selling: influence of three patterns of stereotyped, repetitive usage. In: Larsen C, editor. Bioarchaeology-Interpreting Behavior from the Human Skeleton. Cambridge: Cambridge University Press.

Hawkins J. 1981. Oxford Universal Dictionary. London: Oxford University Press. p 709.

Helmuth H, Pendergast DM. 1987. Lamanai Tomb N9-58/1: Analysis of the Skeletal Evidence. Ossa 13:109-119.

Iannone G. 2000. Personal Communication.

Inoue K, et al. 1999. Erosive Peripheral Polyarthritis in Ancient Japanese Skeletons: A Possible Case of Rheumatoid Arthritis. International Journal of Osteoarchaeology 9:1-7.

Iscan YM, Kennedy AR. 1989. Reconstruction of Life From the Skeleton. New York: Alan R. Liss Inc.

Jackes M. 2000. Building the Bases for Paleodemography Analysis: Adult Age Determination. In: Katzenberg MA, Saunders SR, editors. Biological anthropology of the Human Skeleton. New York: Wiley-Liss Inc. p 417-455.

Jimenea V. 1979. Ankylosing Spondylitis. Henry Ford Hospital Medical Journal 27(1): 10-17.

Johnston FE. 1962. Growth of the Long Bones of Infants and Young Children at Indian Knoll. Human Biology 23:66-81.

Jones GD. 1989. Maya Resistance to Spanish Rule: Time and History on a Colonial Frontier, Albuquerque: University of New Mexico Press.

Jones GD, Pendergast DM. 1991. The Native Context of Colonialism in Southern Mesoamerica and Central America An Overview. In: Thomas DH, editor. Columbian Consequences Vol. 3. Washington: Smithsonian Institution Press.

Jurmain R. 1973. Stress and the Etiology of Osteoarthritis. American Journal of Physical Anthropology 46:353-366.

Jurmain R. 1977a. Stress and etiology of Osteoarthritis. American Journal of Physical Anthropology 46:353-366.

Jurmain R. 1977b. Paleoepidemiology of degenerative knee disease. Medical Anthropology. Medical Anthropology 1:1-14.

Jurmain R. 1978. Paleoepidemiology of degenerative joint disease. Medical College of Virginia Quarterly 14(1):45-6 In: Larsen C, editor. Bioarchaeology-Interpreting Behavior from the Human Skeleton. Cambridge: Cambridge University Press.

Jurmain R. 1980. The Pattern of Involvement of Appendicular Degenerative Joint Disease. American Journal of Physical Anthropology 53:143-150.

Jurmain R. 1990. Paleoepidemiology of a Central California Pre-Historic Population From CA-ALA-329: II. Degenerative Disease. American Journal of Physical Anthropology 83:83-94.

Kelley O J, Angel JL. 1987. Life Stresses of Slavery. American Journal of Physical Anthropology 74:199-211.

Kilgore L. 1989. Possible Case of Rheumatoid Arthritis From Sudanese Nubia. American Journal of Physical Anthropology 79:177-183.

Klepinger L. 1979. Paleopathologic Evidence for the Evolution of Rheumatoid Arthritis. American Journal of Physical Anthropology 50:119-122.

Lambert JDH, Arnason T. 1978. Distribution of vegetation on Maya ruins and its relationship to ancient land-use at Lamanai, Belize. Turrialba 28(1):33-41.

Lambert JDH, Arnason T. 1982. Ramon and Maya Ruins: An Ecological, Not an Economic, Relation. Science 216:298-299.

Lambert JDH, et al. 1984. Ancient Maya Drained Field Agriculture: Its Possible Application Today in the New River Floodplain, Belize, C.A. Agriculture, Ecosystems and Environment 11:67-84.

Larsen C. 1997. Bioarchaeology-Interpreting Behavior from the Human Skeleton. Cambridge: Cambridge University Press.

Larsen C.L. 2000. Reading the Bones of LaFlorida. Scientific American. June: 80-85.

Loten S. 1985. Lamanai Postclassic. In: Chase AF, Rice PM, editors. The Lowland Maya Postclassic. Austin: University of Texas Press.

Loughlin J. 1995. Differential Allelic Expression Of the Type II Collagen Gene (COL2AI) in Osteoarthritis Cartilage. American Journal of Human Genetics 56:1186-1193.

Lovejoy O. et al. 1985. Chronological Metamorphosis of the Auricular Surface of the Ilium: A New Method for the Determination of Adult Skeletal Age at Death. American Journal of Physical Anthropology 68:15-28.

Lovell N. 1994. Spinal Arthritis and Physical Stress at Bronze Age Harappa. American Journal of Physical Anthropology 93:149-164.

MacLeod JM.. 1991. Indian Riots and Rebellions in Colonial Central America, 1530-1720: Causes and Categories. In: Thomas DH, editor. Columbian Consequences Vol. 3. Washington: Smithsonian Institution Press.

Mann R, Murphy S. 1990 Regional Atlas of Bone Disease- A Guide to Pathological and Normal Variation in the Human Skeleton. In: The Human Skeleton. Springfield, Illinois: Charles C Thomas, Pub.

Marcus J. 1982. The Plant World of the Sixteenth-Century Lowland Maya. In: Smiley FE, editor. Maya Subsistence. London: Academic Press, Inc.

McGee JR. 1986. Swidden Horticulture Among the Lacandon Maya. In:[videorecording VT 488] Department of Sociology and Anthropology, Southwest Texas State: University of Utah Press.

McGee JR. 1988. The Lacandon Maya Balche Ritual In: [video recording VT 487] Department of Sociology and Anthropology: Southwest Texas State University.

McKillop H, Awe J. 1983. The History of Archaeology Research In Belize. Belizean Studies 11(2):1-22.

Meindl RS, Lovejoy CO. 1989. Age Changes in the Pelvis: Implications for Paleodemography. In: Iscan MY, editor. Age Markers in the Human Skeleton. Springfield, Illinois: Charles C. Thomas.

Merbs CF. 1983. Patterns of Activity-Induced Pathology in a Canadian Inuit Population. National Museum of Man Mercury Series, Archaeological Survey of Canada 119. Ottawa: National Museum of Man.

National Geographic Society. 1993. Lost Kingdoms of the Maya. In: [video recording VT 598] National Geographic Society.

National Film Board of Canada. 1993. Conversion Prt. 1 and Prt. 2 Before Columbus. In:[video recording VT 561] Montreal: National Film Board

Ojo Video. 1985. Maya in Exile In: [video recording VT 489]:Ojo Video

Olsen-Kelley J, Angel L. 1987. Life Stresses of Slavery. American Journal of Physical Anthropology 74:199-211.

Ortner DJ. 1968. Description and Classification of Degeneration Bone Changes in the Distal Joint Surfaces of the Humerus. American Journal of Physical Anthropology 28:139-156.

Ortner D, Utermohle C. 1981. Polyarticular Inflammatory Arthritis in a Pre-Columbian Skeleton From Kodiak Island, Alaska, U.S.A. American Journal of Physical Anthropology 56:23-31.

Ortner D, Putschar W. 1981. Identification of Pathological Conditions in Human Skeletal Remains. Washington: Smithsonian Institution Press.

Pendergast DM. 1980/81. An Ancient Maya Dignitary: A Work of Art From the ROM's Excavations at Lamanai, Belize. Rotunda 13(4):5-11.

Pendergast DM. 1981. Lamanai, Belize: Summary of Excavation Results, 1974-1980. Journal of Field Archaeology 8(1):29-53.

Pendergast DM. 1982. Lamanai, Belize, Durante el Post-Clasico. Estudios de Cultura Maya 14:19-58.

Pendergast DM. 1985. Lamanai, Belize: An Updated View. In: Chase AF, Rice PM, editors. The Lowland Maya Postclassic. Austin: University of Texas Press.

Pendergast DM. 1986a. Under Spanish Rule: The Final Chapter in Lamanai's Maya History. Belcast Journal of Belizean Affairs 3 (1&2):1-7.

Pendergast DM. 1986b. Stability Through Change: Lamanai, Belize, from the Ninth to the Seventeenth Century. In: Sabloff JA, Andrews EW, editors. Late Lowland Maya Civilization. V. Albuquerque, New Mexico: University of New Mexico Press.

Pendergast DM. 1990. Up From the Dust: The Central Lowlands Postclassic as Seen from Lamanai and Marco Gonzalez, Belize. In: Clancy FS, Harrison PD, editors. Vision and Revision in Maya Studies. New Mexico: The University of New Mexico Press.

Pendergast DM. 1991. The Southern Maya Lowlands Contact Experience: The View from Lamanai, Belize. In: Thomas DH, editor. Columbian Consequences V (3). Washington: Smithsonian Institution Press.

Pendergast DM. 1992. After the Dig is Over, After the Thrill is Gone. Rotunda 25(3):37-40.

Pendergast DM. 1993. Worlds in Collision: The Maya/Spanish Encounter in the Sixteenth and Seventeenth Century Belize. In: Bray W, editor. The Meetings of Two Worlds: Europe and the Americas 1492-1650. Toronto: Oxford University Press.

Pendergast DM, Graham E. 1987. No Site Too Small- The ROM's Marco Gonzalez Excavations in Belize. Rotunda 20(1):34-40.

Pfeiffer S. 1991. Is Paleopathology a Relevant Prediction of Contemporary Health Patterns? In: Ortner D, Aufderheide A, editors. Human Paleopathology- Current Synthesis and Future Options.Washington: Smithsonian Institution Press.

Phenice TW. 1969. A Newly Developed Visual Method of Sexing the Os Pubis. American Journal of Physical Anthropology 30(2):279-301.

Pohl M. 1987. An Ethnohistorical Perspective on Ancient Maya Wetland Fields and Other Cultivation Systems in the Lowlands. Harvard University Press. pp 35-45.

Pohl M, Miksicek C. 1987. The Development and Impact of Ancient Maya Agriculture Section A Cultivation Techniques and Crops. In: Pohl M, editor. Pre-Historic Lowland Maya Environment and Subsistence Economy. 2nd. Edition U.S.A: Edition U.S.A.: Harvard University Press. pp 9-20.

Rathbun TA. 1987. Health and Disease at a South Carolina Plantation: 1840-1870. American Journal of Physical Anthropology 74:239-253.

Reyman AT. 1979. The Search for "Arthritis" in Antiquity: Paleoarthritis Workshop. Henry Ford Medical Journal 27(1):32-37.

Riddle JM. 1979. Rheumatoid Arthritis. Henry Ford Medical Journal, 27(1):18-31.

Rogers J, Waldron T. 1987. Consequences of Osteoarthritis in early Neolithic skeletons from Denmark. Antiquity 61:267-268.

Rothschild B. 1997. Porosity: A Curiosity Without Diagnostic Significance. American Journal of Physical Anthropology 104:529-533.

Rothschild B, Woods R. 1991. Spondyloarthropathy: Erosive Arthritis in Representative Defleshed Bones. American Journal of Physical Anthropology 85:125-134.

Rothschild B, et al. 1990. Rheumatoid Arthritis " In the Buff": Erosive Arthritis in Representative Defleshed Bones. American Journal of Physical Anthropology 82: 441-449.

Schwartz J. 1995. Skeleton Keys: An Introduction to Human Skeletal Morphology, Development, And Analysis. New York: Oxford University Press.

Slaus M. 2000. Biocultural Analysis of Sex Differences in Mortality Profiles and Stress Levels in the Late Medieval Population From Nova Raca, Croatia. American Journal of Physical Anthropology, 11:193-209.

Smith H. 1982. The Living Maya. In:[videorecording VT 547]: programs 1-4. University of California.

Sofaer-Derevenski JR. 2000. Sex Differences in Activity-Related Osseous Change in the Spine and the Gendered Division of Labor at Ensay and Wharram Percy, UK. American Journal of Physical Anthropology, 111:333-354.

Song R-J. 1997. Developmental Defects of Enamel in the Maya of Altun Ha Belize: Implications for Ancient Maya. MA Thesis: Peterborough, Ontario pub.

Statistica 1995. Statistica for Windows, Vol 3, Version 6. Statsoft Inc., Tulsa.

Steele DG, Bramblett CA. 1988. The Anatomy and Biology of the Human Skeleton. Texas: A & M University Press.

Steen SL, Lane RW. 1998. Evaluation of Habitual Activities among Two Alaskan Eskimo Populations Based on Musculoskeletal Stress Markers. International Journal of Osteoarchaeology 8:341-353.

Steinbock TR. 1976. Paleopathological Diagnosis and Interpretation: Bone Disease in Ancient Human Populations. Springfield Illinois, U.S.A.:Charles C. Thomas Publishers.

Stewart TD. 1979. Essentials of Forensic Anthropology, Especially as Developed in the United States. Springfield: Charles C. Thomas Inc.

Stirland AJ. 1998. Musculoskeletal Evidence for Activity: Problems of Evaluation. International Journal of Osteoarchaeology 8:354-362.

Stirland AJ. 1991. Diagnosis of Occupationally Related Paleopathology: Can it be Done? In: Ortner D, Aufderheide A, editors. Human Paleopathology- Current Syntheses and Future Options. Washington: Smithsonian Institution Press.

Straus WL, Cave AJB. 1957. Pathology and the Posture of Neanderthal Man. Quaterly Review Biology 32:348-363).

Stuart-Macadam P. 1985. Porotic Hyperostosis: Representative of a Childhood Condition. American Journal of Physical Anthropology 66:391-398.

Stuart-Macadam P. 1887. In: Wright LE, Chew F. 1998. Porotic Hyperostosis and Paleoepidemiology: A Forensic Perspective on Anemia among the Ancient Maya. American Anthropologist 100(4):924-939.

Tainter JA. 1980. Behavior and Status In A Middle Woodland Mortuary Population From The Illinois Valley. American Antiquity, 45(2):308-313.

Trinkaus E. 1985. Pathology and Posture of the La Chapelle-Aux-Saints Neandertal. American Journal of Physical Anthropology 67:19-41.

Todd TW. 1921a. Age Changes in the Pubic Bone. I: The Male White Pubis. American Journal of Physical Anthropology 3:285-334.

Todd TW. 1921b. Age Changes in the Pubic Bone. III: The Pubis of the White Female. IV: The Pubis of the Female white-negro hybrid. American Journal of Physical Anthropology 4(1):1-70.

Turner BL. 1974. Pre-Historic Intensive Agriculture in the Mayan Lowlands: Examination of Relic Terraces and Raised Fields Indicates that the Rio Bec Maya were Sophisticated Cultivators. Science 185:118-124.

Tyler D, Anderson K. 1986. Industrial Medicine Desk Reference. Chapman and Hall Press.

Ubelaker D. 1979. Skeletal evidence for kneeling in prehistoric Ecuador. American Journal of Physical Anthropology 51:679-86.

Ubelaker D. 1989. The Estimation of Age at Death from Immature Human Bone. In: Iscan MY, editor. Age Markers in the Human Skeleton. Springfield, Illinois: Charles C Thomas.

Ubelaker D. 1991. Human Skeletal Remains: Excavation, Analysis, Interpretation. Washington: Taraxacum Press.

Ubelaker D, Ripley CE. 1999. The Ossuary of San Francisco Church, Quito, Equador: Human Skeletal Biology. Washington: Smithsonian Institution Press.

Waldron T, Rogers J. 1991. Inter-observer Variation in Coding Osteoarthritis in Human Skeletal Remains. International Journal of Osteoarchaeology 1:49-59.

Webster D. 1997. Studying Maya Burials. In: Whittington SL, Reed DM, editors. Bones of the Maya: Studies of Ancient Skeletons. Washington: Smithsonian Institution Press.

Wells C. 1982. The Human Burials. In: McWhirr L, Viner, Wells C, editors. Cirencester Excavations II: Romano-British Cemeteries at Cirencester. pp 135-202.

White CD. 1988. The Ancient Maya From Lamanai, Belize: Diet and Health over 2000 years. Canadian Review of Physical Anthropology 6(2):1-21.

White CD. 1997. Ancient Diet at Lamanai and Pacbitun: Implications for the Ecological Model of Collapse. In: Whittington SL, Reed DM, editors. Bones of the Maya: Studies of Ancient Skeletons. Washington: Smithsonian Institution Press.

White CD, Schwarcz H. 1989. Ancient Maya Diet: as Inferred from Isotopic and Elemental Analysis of Human Bone. Journal of Archaeological Science 16:451-474.

White CD, et al. 1994. Biological Disruption in the Early Colonial Period at Lamanai. In: Larsen CS, Milner GR, editors. "In the Wake of Contact": Biological Responses to Conquest. Wiley-Liss, Inc. p 135-145.

White CD, et al. 1992. Cultural Stability vs. Biological Disruption in the Early Colonial Period at Lamanai, Belize: A Study on Contrast. In: Larsen CS, Milner GR, editors. The Frontiers of Biocultural Adaption New York: Wiley Liss Inc.

White TD. 1991. Osteological Non metric Variation and Pathology In: White TD, editor. Human Osteology. London: Academic Press Inc.

Wood JW, et al. 1992. The Osteological Paradox: Problems of Inferring Pre-Historic Health from Skeletal Samples. Current Anthropology 33(4):343-370.

Wright LE. 1990. Stresses of Conquest: A Study of Wilson Bands and Enamel Hypoplasias in the Maya of Lamanai, Belize. American Journal of Human Biology 2:25-30.

Wright LE, Chew F. 1998. Porotic Hyperostosis and Paleoepidemiology: A Forensic Perspective on Anemia among the Ancient Maya. American Anthropologist 100(4):924-939.

Appendix 1 Table 2: Individuals from Lamanai Chapel Floor 1544-1640

CATALOGUE NUMBER	SEX	AGE
YDL-85-1	M	35-45
YDL-1a	F	33-46
YDL-1b	F?	13-18
YDL-85-2	F	25-30
YDL-85-2a	F	35-50
YDL-85-3	F	35-40
YDL-85-4	?	14-19
YDL-85-5	?	Adult +
YDL-85-6	F	20-24
YDL-85-7	?	15 +/- 36months
YDL-85-8	?	16-18
YDL-85-9	F	50 +
YDL-85-10	?	1 ½
YDL-85-11	?	9-12 months
YDL-85-12	?	6-12
YDL-85-13	F	33-46
YDL-85-14	M?	35-50
YDL-85-15	F	20-23
YDL-85-16	M?	35-50
YDL-85-17	F	20-40
YDL-85-18a	F	Adult +
YDL-85-18b	F	Adult +
YDL-85-19	?	NB-6 months
YDL-85-20	?	6-9 months
YDL-85-21	F	20-30
YDL-85-22	F	20-40
YDL-85-23	F	20-30
YDL-85-24	F	20-25
YDL-85-25	F	35-50
YDL-85-26	F	45 +
YDL-85-27	F	20-30
YDL-85-28	missing	missing
YDL-85-29	M?	33-42
YDL-85-30	M?	20-30
YDL-85-31f	F	20-25
YDL-85-31m	M	54-64
YDL-85-31a	?	3-4
YDL-85-31b	?	10-15
YDL-85-31c	?	7mon.gest.- Newborn
YDL-85-32	M?	40 +

YDL-85-33	M	25-30
YDL-85-34	F	adult +
YDL-85-35	M	30-40
YDL-85-36	?	Newborn
YDL-85-37	?	1- 1 ½
YDL-85-38	?	1 ½- 2
YDL-85-38a	?	1- 1 ½
YDL-85-39	F	Adult +
YDL-85-40	F	Adult +
YDL-85-41	F	18-25
YDL-85-42a	?	5-6
YDL-85-42b	?	Newborn-2yrs
YDL-85-42c	?	18 mon.-2yrs
YDL-85-43a	?	1- 1 ½
YDL-85-43b	?	Newborn- 6 months
YDL-85-43c	?	6-9 months
YDL-85-44a	?	6-7
YDL-85-44b	?	6mon.gest.- Newborn
YDL-85-45a	F	Adult +
YDL-85-45b	M	Adult +
YDL-85-46a	?	3-4
YDL-85-46b	?	2-3
YDL-85-46c	F	20-30
YDL-85-47	M	12-16
YDL-85-48	?	2 +/-
YDL-85-49	?	4-5
YDL-85-50a	?	18 mon.-2yrs
YDL-85-50b	F	Adult +
YDL-85-50c	M	Adult +
YDL-85-51	?	2-3
YDL-85-52	F	20-30
YDL-85-53	F	16-23
YDL-85-54	?	6 yrs. +/- 12 mon.
YDL-85-55	?	18 mon. - 2
YDL-85-56	M	45 +
YDL-85-57a	?	5 yrs +/- 12 mon.
YDL-85-57b	?	6mon.gest.- newborn
YDL-85-58a	?	10-16
YDL-85-58b	?	40 +
YDL-85-58c	?	1 +/- 6 months
YDL-85-59	F?	7 +/-
YDL-85-60	F?	7 +/-
YDL-85-61	F	Adult +

YDL-85-62	F	20-25
YDL-85-63a	?	8 +/-
YDL-85-63b	?	3 +/-
YDL-85-64	F	50 +
YDL-85-65	?	6-7
YDL-85-66	M	30-35
YDL-85-67a	M?	35-50
YDL-85-67b	M	Adult +
YDL-85-68a	M	20-30
YDL-85-68b	?	8-12
YDL-85-69	F	20-25
YDL-85-70	M	30-40
YDL-85-71a	?	6 +/-
YDL-85-71b	?	6-7
YDL-85-71c	?	Adult +
YDL-85-71d	?	12-16
YDL-85-72	F?	18-30
YDL-85-73	M?	20-25
YDL-85-74a	M	20-30
YDL-85-74b	?	7-8
YDL-85-75	?	4 +/-
YDL-85-76	M	Adult +
YDL-85-76a	M	35-40
YDL-85-77	?	5 +/-
YDL-85-78	M	Adult +
YDL-85-78a	M	Adult +
YDL-85-78b	M	Adult +
YDL-85-78c	F	Adult +
YDL-85-78d	F	Adult +
YDL-85-78 inf. 1	?	12 +/-
YDL-85-78 inf. 2	?	7-8
YDL-85-79	M?	Adult +
YDL-85-80	?	10-12
YDL-85-80a	?	14-18
YDL-85-81	F	40 +
YDL-85-82a	M?	Adult +
YDL-85-82b	F	50 +
YDL-85-82c	?	5-8
YDL-85-83	M	30-40
YDL-85-84a	M	40 +
YDL-85-84b	M	20-30
YDL-85-84c	F?	16-20
YDL-85-85	M	40 +

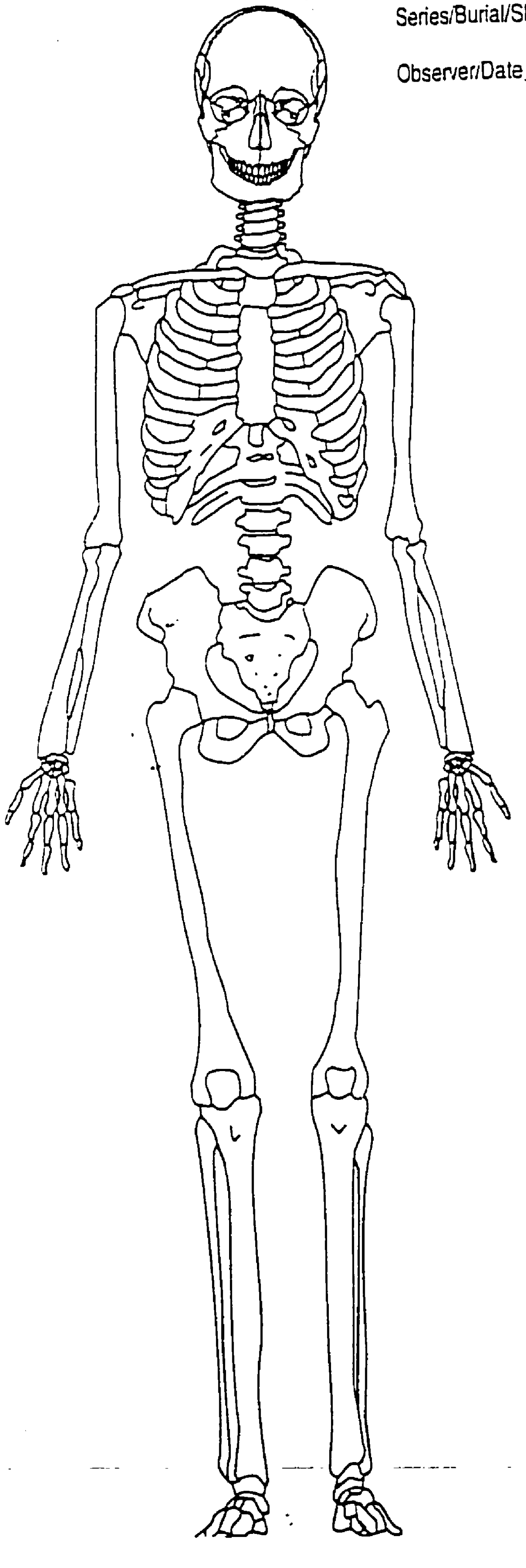
YDL-85-86	M?	20-25
YDL-85-87a	M	30-40
YDL-85-87b	M	30-40
YDL-85-88	F	Adult +
YDL-85-89	M	25-30
YDL-85-90	F	25-30
YDL-85-91a	?	8-9
YDL-85-91b	?	5 +/-
YDL-85-91c	?	Newborn +/- 2 months.
YDL-85-92	M?	25-35
YDL-85-93	F	Adult +
YDL-85-94	F	18-23
YDL-85-95	M	Adult +
YDL-85-96	F	45 +
YDL-85-96a	M?	25-30
YDL-85-97	M	25-30
YDL-85-98	M	Adult +
YDL-85-98a	F	Adult +
YDL-85-99	?	4-5
YDL-85-100	F	20-30
YDL-85-101	F	45+
YDL-85-102	F	30-35
YDL-85-103	M	30-40
YDL-85-104	M	Adult +
YDL-85-105a	M	Adult +
YDL-85-105b	F?	13-16
YDL-85-105c	?	Newborn to 5yrs.

Appendix 2: Example of Preservation Recording Form

Adult Recording Form: Anterior View (Buikstra and Ubelaker 1994)

Series/Burial/Skeleton________________

Observer/Date________________



Appendix 3: Description of Degenerative Joint Disease from the Early Historic Period at Lamanai

Catalogue #: YDL-Ia
Sex: F
Age: 33-46

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae:(C3 or C4)	(2)	Pinpoint	Absent
(C5 or C6)	(1)	Pinpoint	Absent
3 Pieces (T1-6)	(2)	Pinpoint	Absent
	(2)	Pinpoint	Absent
	(3)	Pinpoint	Absent
4 Pieces (Lum.)	(1)	n/a	Absent

Catalogue #: 85-01
Sex: M
Age: 35-45

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical			
C3 or C4	(1)	n/a	Absent
C3 or C4 centra only	(1)	n/a	Absent
C6 or C7	(1)	n/a	Absent
Thoracic T1-6	(2)	Pinpoint	Absent
Patella: (R)	(2, 3)	Pinpoint & Co. on more than 2/3 Of surface.	Absent

Catalogue #: 85-02
Sex: F
Age: 25-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical C1 to C7			
C1	(1)	n/a	Absent
C2	(1)	n/a lack pres.	Absent
C3	(1)	Pinpoint	Absent
C4	(1)	Pinpoint	Absent
C5	(1)	n/a	Absent
C6	(1)	n/a	Absent

C7	(1, 2)	n/a	Absent
Thoracic T1- 12			
T1	(1, 2)	Pinpoint around (L) sup. Fa	Absent
3 pieces less 25%	(1)	Coalesced on anterior & lat. Sides	Absent
1 upper T2 or T3	(1, 2)	n/a	Absent
3 pieces T region	(2)	n/a	Absent
Lumbar L1-5			
3 pieces	(1)	n/a	Absent
Sacrum: S1	(2)	n/a	Absent
Humeri: head (R)	(2)	Pinpoint on superior margin	Absent
head (L)	(2)	Pinpoint on superior margin	Absent
Scapulas: (R) glenoid f.	(2)	Pinpoint	Absent
(L) glenoid f.	(2)	n/a	Absent
Clavicle: (R) proximal end.	(2)	Pinpoint & Coa. on 1/3 of sur.	Absent
Radius: (R) distal end	(2)	n/a	Absent
Ulna: (R) proximal end.	(1)	Pinpoint	Absent

General Comments: This individual fractured their forearm severely, as a result of a fall or while defending herself.

Catalogue #: 85-02a
Sex: F
Age: 35-50

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebra: C2	(1)	n/a	Absent

Catalogue #: 85-04
Sex: unknown
Age: 14-19

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: Thoracic 3 pieces T7 - 12			
1st and smallest piece	(3)	n/a	Absent
2nd smallest	(2)	n/a	Absent
3rd	(1)	Coalesced on 1/3 of lat. Sur.	Absent

General Comments: This individual has severe compression of the superior aspect of the third and largest piece present.

Catalogue #: 85-06
Sex: F
Age: 20-24

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 3 pieces upper T	(1)	Coalesced on 1/3 of anterior & lateral sur.	Absent
2 pieces upper (T1-T3)	(2)	Coalesced near rib facet	Absent
1 piece upper Lumbar	(2)	coalesced	Absent
1 piece upper T	(3)	Coalesced	Absent
Lower T or upper L	(3)	pinpoint score 2 in severity	Absent

Catalogue #: 85-08
Sex: unknown
Age: 16-18

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 3 pieces T or L	(1, 2)	Pinpoint on less than 1/3 Of sur.	Absent

General Comments: The second piece has been severely compressed into a wedge like shape, and the inferior margin meets the superior margin. The lipping present appears to be a result of compression. The third and largest piece looks much like the second one, however, it seems to have been compressed in two different directions. The inferior cancellous tissue has responded accordingly suggesting that this occurred antemortem.

Catalogue #: 85-09
Sex: F
Age: 50+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical			
1) C3-5	(3)	n/a	Absent
(R) inf. Facet	(2)	n/a	Absent
Thoracic T6-9	(1)	Pinpoint and Coalesced Score 3 Severity 2/3 of surface.	Absent

General Comments: The cervical vertebra has been severely compressed and therefore the exact number is not clear.

Catalogue #: 85-13
Sex: F
Age: 33-46

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Clavicles: (R) prox. end	(2)	Pinpoint & Coalesced on Greater than 2/3	Absent
(L) prox. end	(2)	Pinpoint & Coalesced on Greater than 2/3	Absent
Vertebrae:C1 (L & R) inf. fa.	(1)	n/a	Absent
T7 - T9	(1)	Coalesced Score 2	Absent

Catalogue #: 85-14
Sex: M
Age: 35-50

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: 1 Cervical	(1)	Coalesced	Absent
2 upper Thor.	(1)	Score 3 Coalesced	Absent

Catalogue #: 85-15
Sex: F
Age: 20-23

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: Thoracic			
T1-3	(1)	Coalesced Score 2 on 1/3 Of centra	Absent
T4-6	(1, 2)	Coalesced Score 1	Absent
T7-12	(1)	Coalesced Score 3 on 1/3 Of lateral surface	Absent
T10-12	(1)	Coalesced on 1/3-2/3 & pinpoint On affected surface	Absent
T11-12	(1)	Coalesced on less than 1/3 of sur. Score 2	Absent
Lumbar L1-5 (3) pieces			
L1-3	(1)	Coalesced Score 3 on 1/3 of sur.	Absent
1 piece	(1)	n/a	Absent
1 posterior arch	(n/a)	Coalesced on left and right inferior Facet Score 1	Absent

Humerus:(R) distal end	(2 & 3)	Coalesced on 2/3	++++ on 25%

General Comments: Due to the young age and severe DJD present, the injury to the elbow was most likely the result of a traumatic injury.

Catalogue #: 85-17
Sex: F
Age: 20-40

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: Cervical: (3)			
C2 less than 25%	(1)	n/a	Absent
C3 50% complete	(2)	Pinpoint	Absent
C5-7 50-75% c.	(1)	n/a	Absent
Thoracic: (5) pieces T6 - 12			
1st smallest piece	(1, 2)	Score 1 Coalesced	Absent
2nd smallest	(1)	Score 1 Coalesced	Absent
3rd	(1)	Score 1 Coalesced	Absent
4th	(2)	Score 2 Coalesced	Absent
5th	(1)	Score 1 Coalesced	Absent
Lumbar: 2 pieces			
L1-3	(1, 2)	n/a	Absent
1 sup. Facet	(2)	Absent	Absent

Catalogue #:85-18a
Sex: F
Age: Adult +

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Radius: Head (side?)	(1)	Coalesced porosity on sup. aspect. Medial side. (1)	Absent

Catalogue #: 85-18a or b
Sex: F
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Hand: (R) 3rd row prox. phalange distal end.	(3)	Pinpoint and Coalesced on more than 2/3 of distal surface.	Absent
(R) 2nd row prox. phalange distal end.	(1)	Pinpoint on less than 1/3 Of surface	Absent
(L) 2nd row middle phalange prox. & dis. End.	(1)	n/a	Absent
(L) 4th row prox. phalange, prox. end.	(1)	n/a	Absent

General Comments: Severe DJD was present, as a result of trauma or perhaps the initial bone changes that occur with RA.

Catalogue #: 85-21
Sex: F
Age: 20-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical			
C2	(1) inf.	n/a	Absent
C4 or C5	(1)	Pinpoint	Absent
Hand:2nd row middle phal. prox.end.	(1)	n/a	Absent

Catalogue #: 85-22
Sex: F
Age: 20-40

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical C3-7 (3) pieces			
C3 25-50%c	(1)	Pinpoint on 75%	Absent
C4 or C5	(1)	Coalesced size	Absent
+ one piece to badly deter. Two badly.			

Thoracic			
3 Pieces T1-6	(1)	Coalesced on less than 1/3	Absent
3 Pieces mid to lower	(1)	Pinpoint and Coalesced Score 3	Absent
T8-12 centra 100%c	(1)	Coalesced score2	Absent

Catalogue #: 85-23
Sex: F
Age: 20-30

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Femur: (R) distal end	(2) ant. & post. margins	Pinpoint on 1/3-2/3 of sur.	Initial wear p
Patella: (R)	(1) med. & inf. (2) sup. Mar	Pin. & Co. 1/3 of med. Fa.	Absent
Vertebrae: 3 Cervical			
C3	(2)	n/a	Absent
C4	(1, 2)	n/a	Absent
C6 or 7	(2)	Absent	Absent
3 pieces of Thoracic	(1)	Co. Score 2 1/3 - 2/3	Absent
2 pieces Thoracic (7 - 12)			
1) T9 or 10	(1)	Coalesced and Pinpoint on 2/3 Of sur.	Absent
2) T11 or 12	(1)	Pinpoint porosity	Absent

General Comments: This individual also appears to have fractured their femur shaft above the distal end.

Catalogue #: 85-25
Sex: F
Age: 35-50

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Ulna: (L) prox. end	(2)	Pinpoint and Coalesced on 1/3 of surface	Present (+) mild

General Comments: The left radius has severe muscle markings on the tuberosity and ridge which corresponds with the heavy muscle strain and stress on the joints.

Catalogue #: 85-26
Sex: F
Age: 45+

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Patella (R)	(1& 2)	Pinpoint & Co. 1/3-2/3	Absent

Catalogue #: 85-27
Sex: F
Age: 20-30

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae:			
C2 to C7	(1 & 2)	1/3 of surface Coalesced	Absent
T1 to T10	(1 & 2)	1/3 - 2/3 of surface Coalesced	Absent
+ 4 Pieces post arch.	(1)	Pinpoint on 1 of surface	Absent

General comments: The right side was affected three times more often than the left. Contained in this burial was the right condyle from a juvenile that showed signs of infection.

Catalogue #: 85-29
Sex: M ( )
Age: 33-42

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: Cervical C6 or 7	(1, 2)	n/a	Absent
Thoracic: T7-12	(1)	Coalesced on less than 1/3 of sur. Score 2	Absent
Hand: (L) 3rd metacarpal distal end	(1)	Pinpoint on 1/3 of surface	Absent
(L) 2nd row middle phalange distal end	(2)	n/a	Absent

Catalogue #: 85-31f
Sex: F
Age: 20-25

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical			
C2	(1)	n/a	+ present on dens Posterior 1/3 of sur.
C3	(1)	n/a	Absent
C4	(1)	n/a	Absent
C5	(1)	n/a	Absent
C6	(1)	n/a	Absent
C7	(1)	Pinpoint on (L) inf. facet.	Absent

Catalogue #: 85-31m
Sex: M
Age: 54-64

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical			
C6	(1)	Pinpoint more than 2/3 And Coalesced on 1/3 of sur.	Absent
C7	(1)	Coalene on ant. & lat. surfaces	Absent
Thoracic T7-12			
T9-10	(1)	Pinpoint on more than 2/3 of (L & R) sup. demi facets	Absent
T12	(1)	Pinpoint on more than 2/3	Absent
Lumbar:			
L4	(1)	n/a	Absent
L5	(2)	Pinpoint on less than 1/3	Absent
Sacrum: S1	(2)	Coalesced 1/3-2/3	Absent
Foot: Navicular (L)	(n/a)	Pinpoint on surface that articulates with Talus.	Absent
(L) 1st row distal Phalange	(1)	Pinpoint along superior margin	Absent

Catalogue #: 85-32
Sex: M
Age: 40+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical 5 pieces			
2 pieces C3 or 4	(1)	n/a	Absent
1 piece C4-7	(2)	Pinpoint porosity 2/3 of sur.	Absent
1 C6 or C7	(1)	Pinpoint porosity 2/3 of sur.	Absent
1 C6 or C7	(1)	Pinpoint porosity 2/3 of sur.	Absent
Thoracic: 9 pieces			
4 pieces (T1-6)			
1st piece	(1, 2)	Pinpoint 2/3 of sur.	Absent
2nd piece	(1)	Pinpoint and Coalesced	n/a
3rd piece	(1)	Pinpoint & Coal. 25-50%	n/a
4th piece	(1)	Coalesced 2/3 of surface	n/a
5 pieces (T7-12)			
1st piece	(1)	Pinpoint 1/3 - 2/3 of sur.	n/a
2nd piece	(1)	Pinpoint and Coal. Severe compression	n/a
3rd piece	(1)	Severe pinpoint & Co. 2/3	n/a
4th piece	(1)	Coalesced Score 2	n/a
5th piece	(1)	4 coalesced severe compression.	n/a
Lumbar: 6 pieces			
1st piece	(1)	Pinpoint (severe) 2/3 Coal. Score 2	Absent
2nd piece	(1)	Pinpoint and Coalesced + unknown pathology	Absent
3rd piece	(1)	Pinpoint & Coa. Score 3	Absent
4th piece	(1)	Pinpoint on superior facets	Absent
5th piece	(1)	Portion 5th lumbar, Pinpoint Severe compression.	Absent
6th piece	(1)	Pinpoint and Coal. 2/3 of sur.	Absent
Femora: Head & neck (L)	(1)	Pinpoint 2/3 on surface & Co. on head.	Absent

		Severe Coalesced in neck	
Head (R)	(1)	Pinpoint and Co. 2/3 50-75%c	Absent
Os Coxae: (R) Ilium	(1)	Pinpoint on 2/3 of surface.	Absent
(R) Ischium	(1)	Pinpoint on_2/3 of surface.	Absent
(L) 5 pieces Ischium	(1)	Pinpoint on 2/3 of surface.	Absent

General Comments: All vertebrae are severely compressed and badly deteriorated. This individual also had the unidentified pathology.

Catalogue #: 85-33
Sex: M
Age: 25-30

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Occipital: (R) facet that articulates with C1	(0)	Pinpoint on 1/3	Absent
Vertebrae: Cervical			
C1	(1)	Pinpoint on ½ of (R) fa.	Absent
C2	(1)	Pinpoint on 1/3-2/3	Absent
C3	(1, 2)	compression of centra. Pinpoint on more than 2/3	Absent
C4	(1, 2)	n/a	Absent
C5	(1, 2)	Pinpoint on 1/3-2/3	Present inf. ant. (L) mar.
C6	(1)	n/a	Absent
C7	(1)	Coalesced on 1/3 of sur.	Absent

* Plus one superior left facet with Score 1 and Coalesced porosity, no eburnation was present.

Thoracic 3 pieces T1-6	(1)	All 3 have severe pinpoint & coa. On their centra.	Absent
1 piece T: L sup. fa.	(1)	Coalesced	Absent

General Comments: The second of three thoracic pieces has + eburnation on the right inferior facet.

Catalogue #: 85-35
Sex: M
Age: 30-40

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: C2	(1)	n/a	Absent
C3 or C4	(1)	n/a	Absent
8 pieces T1- T12	(1)	Pinpoint and Coalesced 1/3- 2/3 on centra	Absent
1 piece Upper T1-4	(1, 2)	Pinpoint 2/3 and Coa. 1/3	Absent
1 T6-12	(1)	Pinpoint & Coa. 1/3 - 2/3	Absent

Burial #: 85-39
Sex: F
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
C2: 75% inferior body and (L) sup. Facet	(1) inf. margin	Coalesced (1) on anterior body	Absent
C3: 50-75% complete centra	(1) inf. & sup. mar.	Absent	Absent
C4: centra 100% com.	(1) inf. & sup. mar.	anterior sup. mar. 1/3 of surface (1)	Absent
C5: 75% complete	(1) inf. & sup. mar.	Absent	Absent
C6: 75% of centra	(1) inf. & sup. mar.	n/a	Absent
T1-6: 3 vertebrae			
1st smallest 50-75% c. com.	(1) inf. & sup. mar.	Coalesced 1/3-2/3 (2)	Absent
2nd smallest 75%< com.	(1) inf. & sup. mar.	Coalesced 1/3-2/3 (2)	Absent
3rd smallest 25% com.	(1) inf. & sup. mar.	Coalesced 1/3-2/3 (1)	Absent

General Comments: Mild osteophytosis and osteoarthritis is present in the neck and upper thoracic regions.

Catalogue #: 85-40
Sex: F
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Patellas: (L)	(1, 2)	Pinpoint more than 2/3 Coalesced less than 1/3	Absent
(R)	(1)	Same as left side	Absent
Femur: (L) distal end	(2 med., 3 lat. & Post.)	n/a	Absent
Tibia: Prox. end	(1)	n/a	Absent
2 pieces distal end.			
1) (L) Medial Maleolus	(1)	n/a	Absent
2) posterior portion of fac.	(1)	Coalesced on 50% of sur.	Absent

Catalogue #: 85-45
Sex:M/F
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Hand: (L) 2nd metacarpal Prox. end	(1)	Pinpoint & Coalesced on less than 1/3 of sur.	Absent

Catalogue #: 85-46c
Sex: F
Age: 20-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical C3-7 (3) Pieces			
1) smallest	(1)	n/a	Absent
2) medium size	(2)	n/a	Absent
3) largest	(1, 2)	n/a	Absent

Catalogue #: 85-52
Sex: F
Age: 20-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 1 piece (T 1-3)	(2)	n/a	Absent
1 piece (T 1-6)	(2)	n/a	Absent
1 piece (T 5-7)	(2)	Pinpoint 1/3 - 2/3	Absent

General Comments: All three vertebrae bodies have been compressed.

Catalogue #: 85-53
Sex: F
Age: 16-23

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Hand:(L) 2nd prox. metac.	(1)	Pinpoint and coa. on less than 1/3 of affected surface.	Absent
Foot: (R) Talus inf.	(1)	Coalesced on less than 1/3	Absent

Catalogue #: 85-62
Sex: F
Age: 20-25

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Cervical C3-7 (2) centra			
both cervical	(1)	Pinpoint	Absent

Catalogue #: 85-64
Sex: F
Age: 50+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae:			
1-piece (T 1-12) (L) superior facet	(2)	Pinpoint & Coalesced 1/3 of surface	Absent
2nd) Piece Lumbar (L) facet	(2)	Pinpoint & Co.1/3 - 2/3	Absent
3rd) Piece Lumbar facet	(1)	Coalesced	Absent

Catalogue #: 85-66
Sex: M
Age: 30-35

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae:			
C2	(1)	Pinpoint porosity on 1/3 Of sur.	Absent
5 pieces (C3-7)	(1)	Pinpoint and Coalesced	Absent
C6 or C7	(1)	Pinpoint on 2/3 of sur.	Absent
Cer. Facet only	(1)	Pinpoint on 1/3 of sur.	Absent

General Comments: The third vertebra listed above shows the same unidentified pathology that destroyed and enlarged the opening to the posterior nutrient foramina.

Catalogue #:85-67a
Sex: M( )
Age: 35-50

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 3 Pieces (T 1-6)			
1) 25% complete	(1, 2)	Coalesced 1/3 of surface	Absent
2) 2nd piece	(1, 2)	Coalesced 1/3 to 2/3 of sur.	Absent
3)3rd piece	(1, 2)	Coalesced 1/3 of surface	Absent
4 pieces (T 7-12)			
1) largest piece 50-75%c.	(1, 2)	Coalesced score 2 on 1/3 of sur.	Absent
2) 2nd largest piece	(1, 2)	n/a	Absent
3) 3rd largest piece	(2, 3)	Coalesced score 2	Absent
4) 4th piece	(2, 3)	Pinpoint on inf. Mar 2/3	Absent
Isolated facet T or L	(1)	Pinpoint	Absent
3 facets:(R) L facet	(1)		
2 pieces inf. Facet	(1)	Coalesced 1/3 of sur.	Absent
Hand: (L) navicular	(1)	Coalesced and pinpoint	Absent

General Comments: This individual has a strange pathology on their spine surrounding the left superior demi-facet.

Catalogue #: 85-69
Sex: F
Age: 20-25

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Clavicle: (R) medial end	(1)	Pinpoint 1/3- 2/3 and Coalesced on less than 1/3	Absent
Vertebrae: Cervical			
C3	(1)	n/a	Absent
C4	(1)	Absent	Absent
C5-7	(1)	Absent	Absent
Thoracic			
4 pieces T1- 6	(1)	Coalesced on 1/3 of sur.	Absent
T6-9	(1)	Coalesced Score 2	Absent
2 pieces mid.- lower	(1)	Pinpoint and Coalesced	Absent
Lumbar 4 pieces			
2 Pieces	(1)	Pinpoint on 1/3- 2/3	Absent
(R) Inf facet	(1)	Coalesced on 1/3 of sur.	Absent
(L) Inf. facet	(1)	Coalesced on 1/3 - 2/3of sur.	Absent

Catalogue #: 85-73
Sex: M
Age: 20-25

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Clavicle: medial (L)	(1)	Pinpoint 100% and Coalesced on 1/3 of the affected surface	Absent
Vertebrae: (T, 2 pieces)	(1,2)	n/a	Absent

Catalogue #: 85-74a
Sex: M
Age: 20-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 1 piece T or L	(1)	n/a	Absent
Lumbar:2 pieces (L) inf. fa.	(1)	Pinpoint 1/3- 2/3 of sur.	Absent
1 post. Arch with (L & R)	(1)	Pinpoint in 1/3 of sur.	Absent

Radii: (R) prox. end	(1)	On 1/3 of superior sur.(Pin.) Absent	
(L) prox. end	(n/a)	Pinpoint & Coa. on 1/3- 2/3	Absent
Ulnas:(R) prox. end	(1)	Pinpoint on less than 1/3	Absent
(L) prox. end	(1)	Pinpoint on less than 1/3	Absent

General Comments: There are two upper thoracic vertebrae with an unidentified pathology present. Nancy Lovell was consulted in attempt to identify it.

Catalogue # :85-76
Sex: Male
Age: Adult +

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Clavicle: (R) distal end	(1, 2)	Co. and Pin. on more than 2/3 Of sur.	Absent
Scapulas: (R) glenoid f.	(1)	n/a	Absent
(L) glenoid f.	(1)	n/a	Absent
Vertebrae: Cervical C1 to C7			
C1 (L) inf. Fa.	(1)	Pinpoint	Absent
C2 (L) sup. Fa	(1, 2)	Pinpoint	Absent
C3	(1, 2)	n/a	Absent
C4	(1, 2)	n/a	Absent
C5	(1, 2)	n/a	Absent
C6	(2)	n/a	Absent
C7	(1)	n/a	Absent
Thoracic (T1)	(1)	n/a	Absent
Lumbar: 1 piece	(2)	n/a	Absent
Innominate: (R) acetabulum	(3)	Pinpoint on 1/3	Absent
(L) in 2 pieces	(2)	Pinpoint 2/3 of sur.	Absent

Catalogue #: 85-76a
Sex: M
Age: 35-40

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: C3	(2)	n/a	Absent

Catalogue #: 85-79
Sex: M
Age: Adult+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Clavicle: (L) medial end	(2)	Pinpoint on 1/4 of surface	Absent

Catalogue #: 85-81
Sex: F
Age: 40+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: Thoracic			
1 piece T1-3	(2)	n/a	Absent
5 pieces T6- 9	(2)	Score 2 Coalesced and Pinpoint	Absent
3 pieces of T post arches	(1, 2)	2 with greater than 2/3	Absent
		1with 1/3- 2/3 pin & coa.	Absent
1 piece T10-12	(2)	n/a	Absent
Lumbar: (L5)inf. Fa.	(3)	Pinpoint on 1/3 of sur.	(R) ++ (L) +++
* Plus one piece Score 3 Location			
Sacrum: S1	(2)	n/a	++ on sup. Med.
Humerus: (R) distal end	(n/a)	Pinpoint on 1/3 of sur.	Mild (+)
Radius: (R) proximal end	(n/a)	Pinpoint on 1/3 of sur.	Initial wear stages.
Innominate: (L & R) p.a..f.	(2)	n/a	Absent
Patella: (L)	(1)	Coalesced on 1/3 of sur.	Absent
Femur: (L)medial distal end.	(1)	Pinpoint on 1/3 of sur.	Absent

Catalogue #: 85-82a
Sex: M
Age: Adult+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Hamate: (R)	(1)	Coalesced on 75%	Absent

Patella: (R)	(2)	Pinpoint & Coa. Score 3 On more than 2/3.	Absent
Fibula: (R) distal end	(1)	Pinpoint on 1/3 of sur.	Absent

General Comments: The fibula also has Periostitis on the last 10th of the shaft.

Catalogue #: 85-82b
Sex: F
Age: 50+

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Patella: (R)	(1, 2)	Co. & Pin. 2/3 of med. Fa.	Absent
Cervical: C3 or C4	(1, 2)	Co on 1/3 of lat. Fa.	Absent

Catalogue #: 85-83
Sex: M
Age: 30-40

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Ulna: (L) Prox. end	(2)	Pinpoint	Absent

General Comments: The lipping that is present may be the result of a green stick fracture or earlier trauma to this region.

Catalogue #: 85-84a
Sex: M
Age: 40+

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Ulna: (R) prox. end	(1)	n/a	Absent
(R) distal end	(n/a)	Pinpoint 1/3 - 2/3 of sur.	Absent

Catalogue #: 85-84a or b
Sex: M
Age: 40+ or 20-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebra: C4 or C5	(1)	n/a	Absent

Catalogue #: 87a or b
Sex: M
Age: 30-40

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 2 Thoracic (2)		Pinpoint	Absent

Catalogue #: 85-93
Sex: F
Age: Adult+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae (T 3 pieces)	(1,2, and 3)	n/a	Absent

Catalogue #: 85-95
Sex: M
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Ulna: (R) distal end	(2)	Coalesced on 1/3 of sur.	Absent

Catalogue #: 85-96
Sex: F
Age: 45+

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Head of (hu.or fe.)	(2)	Pinpoint	Absent

Catalogue #: 85-97
Sex: M
Age: 25-30

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Vertebrae: 5th Lumbar (2)		n/a	Absent
S1 of Sacrum	(1)	Pinpoint on inf. surface 1/3- 2/3	Absent

General Comments: The 5th lumbar vertebra was severely compressed posteriorly giving it a definite wedge shape. An unidentified pathology has created an enlarged area surrounding the posterior nutrient foramina and new bone formation in this area was present.

Catalogue #: 85-98
Sex: M
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
Metacarpal: 1st (L) distal end	(2)	pinpoint and Coalesced	Absent
Metacarpal: 2nd (L) distal end	(1)	Pinpoint on 1/3 of surface	Absent
Metacarpal: 3rd (L) distal end	(3)	n-a	Absent
Prox. Phal.: 4th (L) distal end	(2)	Pinpoint on 2/3 of surface	Absent

General Comments: The thumb has some periosteal infection is present. Amputation and severe atrophy is present. The trauma that was sustained to the left hand, based on the angle, appears to have been accidental and self induced.

Catalogue #: 85- 98a
Sex: M
Age: Adult +

Bone(s) Afflicted	Lipping Score (0-4)	Porosity (Size/Extent)	Eburnation (p or a) and extent
C1 Vertebra	(1)	Pinpoint and Coalesced	Absent
Prox. Phal.: 5th (L) distal end	(2)	Pinpoint 1/3 of distal end.	Absent

Catalogue #: 85-102
Sex: F
Age: 30-35

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae: Cervical C2-7			
C2	(1)	n/a	Absent
C3	(1, 2)	n/a	Absent
C4	(1)	Pinpoint on 1/3 of L & R sup. fa.	Absent
C5	(1)	Pinpoint on 1/3- 2/3 sup. (R) fa.	Absent
C6	(1)	n/a	Absent
C7	(1)	coalesced 1/3 of ssurface	Absent
Thoracic 3 pieces			
1st piece T7-12	(1, 2)	Coalesced on less than 1/3	Absent
2nd piece T7-12	(1, 2)	Coalesced Score 2	Absent
3rd piece T10- 12	(1, 2)	Coalesced on 1/3 of sur.	Absent
(L) sup. facet	(2)	Pinpoint on more than 2/3 of sur.	Absent
Lumbar: 2 pieces	(1, 2)	n/a	Absent
+ 1 pieces Sacrum	(2)	n/a	Absent
Humerus:(L) distal end	(2)	Pinpoint Coalesced_2/3 Of sur.	Absent
Ulna: (L) prox. end	(2)	Pinpoint and Coalesced	Absent

Catalogue #:85-103
Sex: M
Age: 30-40

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Vertebrae:3 pc. Upper T	(1)	Coalesced on 1/3_of sur.	Absent

Catalogue #: 85-105a
Sex: M
Age: Adult +

Bone(s) Afflicted	**Lipping Score (0-4)**	**Porosity (Size/Extent)**	**Eburnation (p or a) and extent**
Ulna: (L) prox. end	(1)	Pinpoint on 1/3 of sur.(+) mild	
Talus: (L) inf. post. Facet	(n/a)	Pinpoint & Coa. on less than 1/3 of surface	Absent

Appendix 4: Signs of Stress in a Skeleton (Larsen 2000:83).

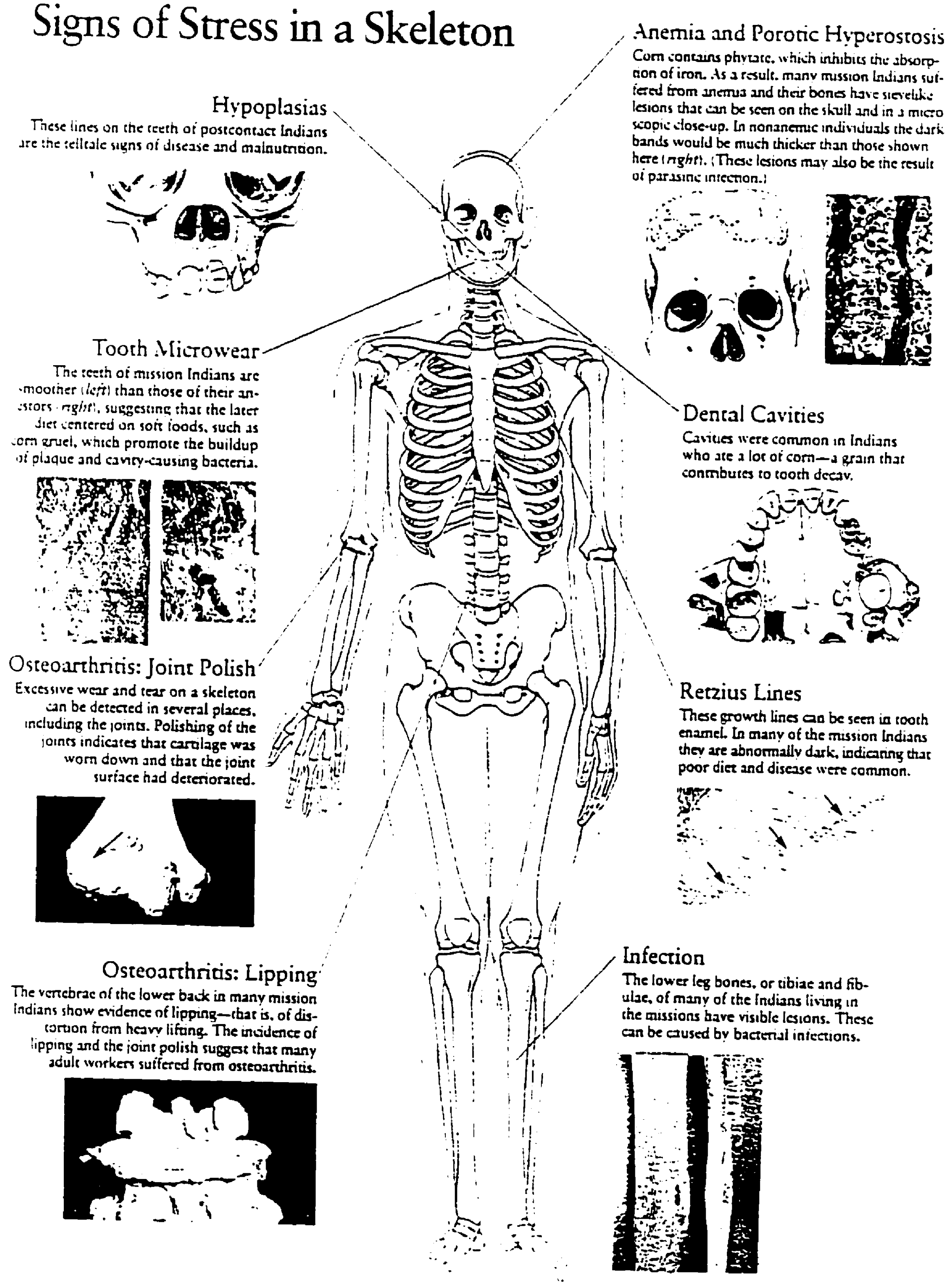


Plate 1: Catalogue # 85-93: Illustrating Scores 1 to 3 (superior to inferior in photo).

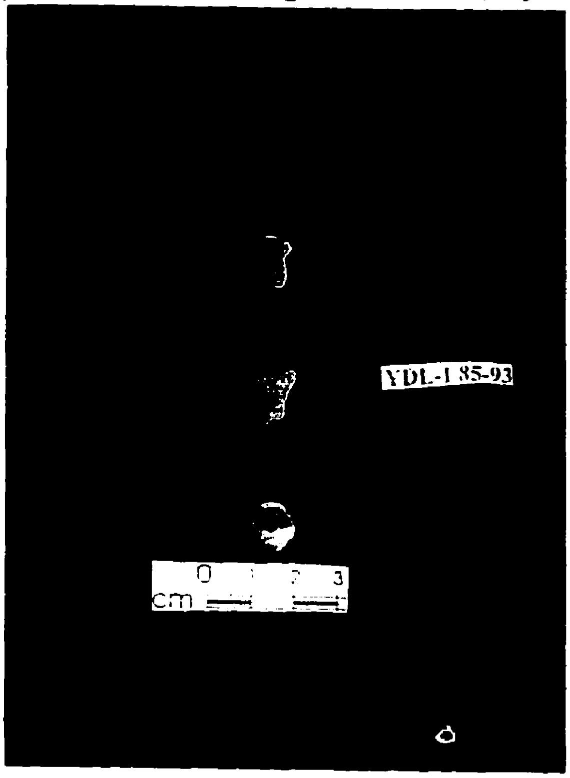


Plate 2: Catalogue # 85-76: Shows unknown etiology on posterior portion of centra.

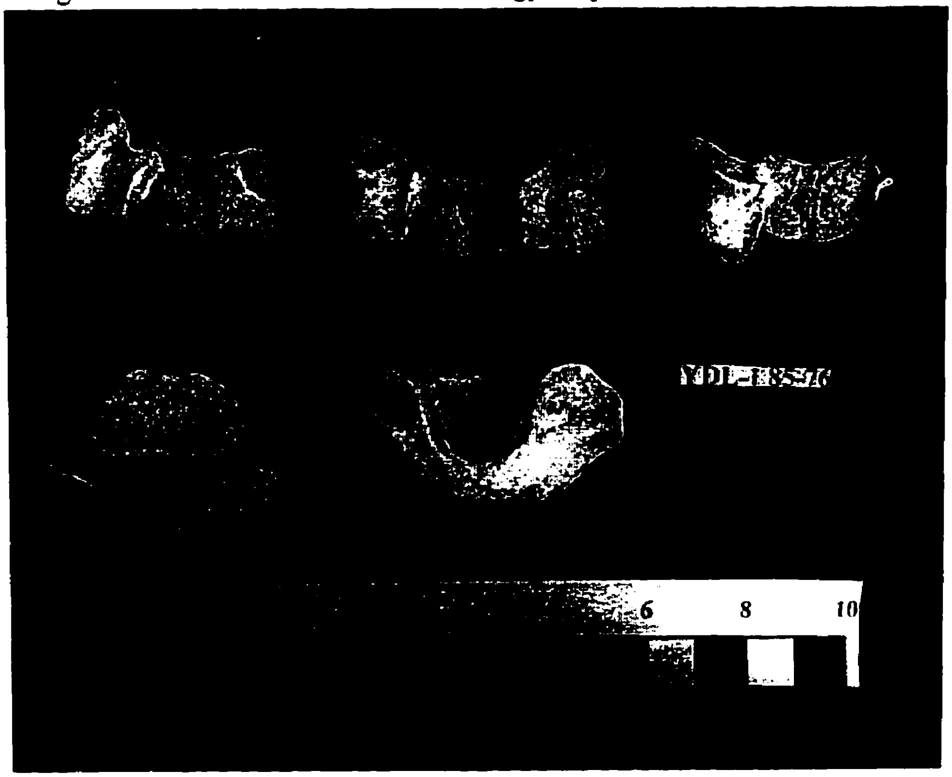


Plate 3: Catalogue # 85-15: Young female with severe eburnation on right elbow.

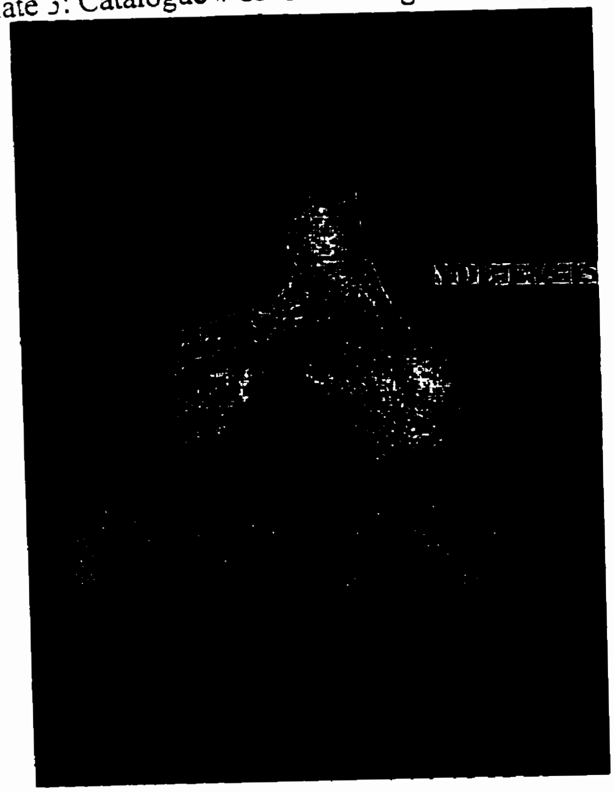


Plate 4: Catalogue # 85-83: Severe Lipping on medial border of left ulna.

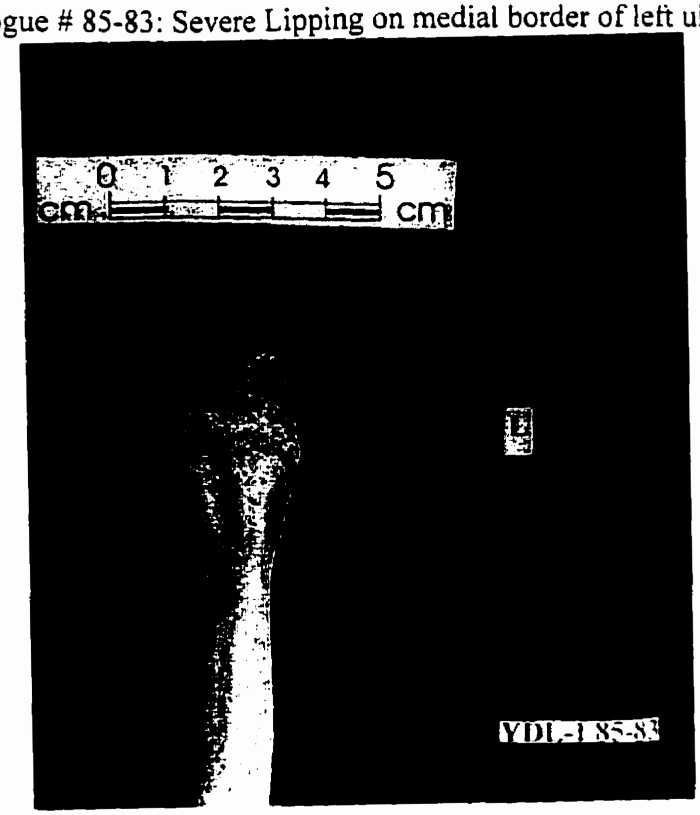


Plate 5: Catalogue # 85-2: Degenerative Joint Disease, caused by trauma to forearm.

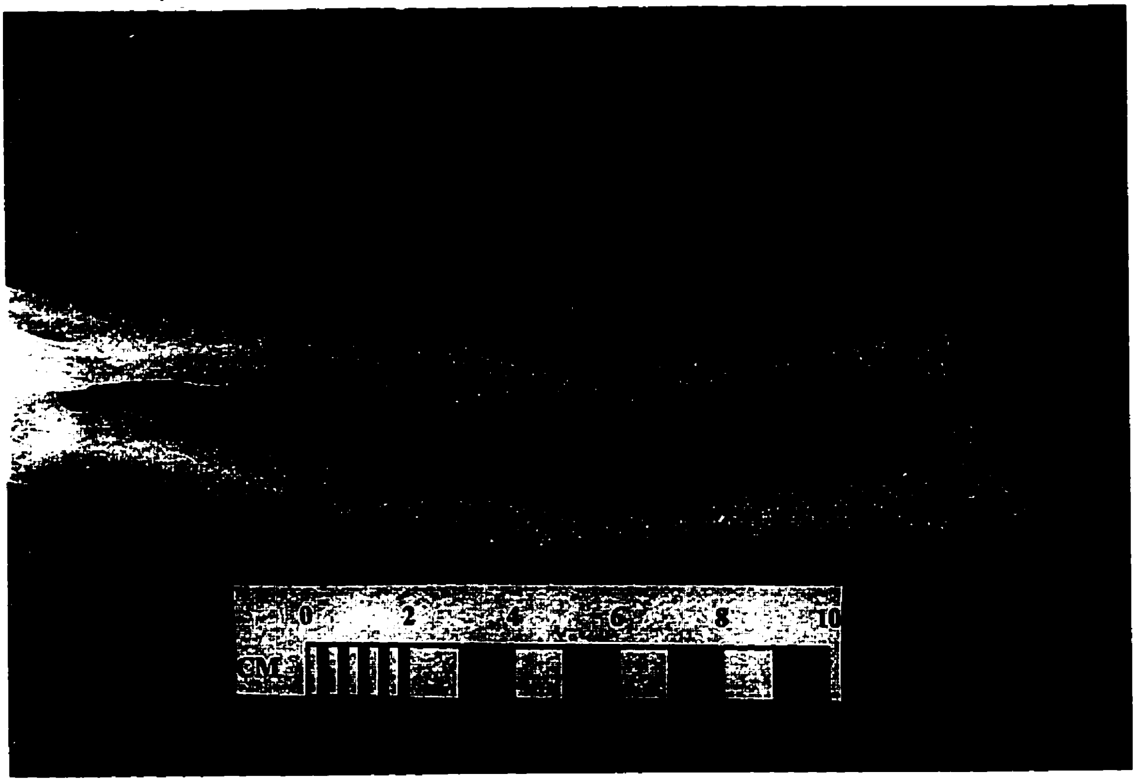


Plate 6: Catalogue # 85-98: Shows amputaion of left digits.

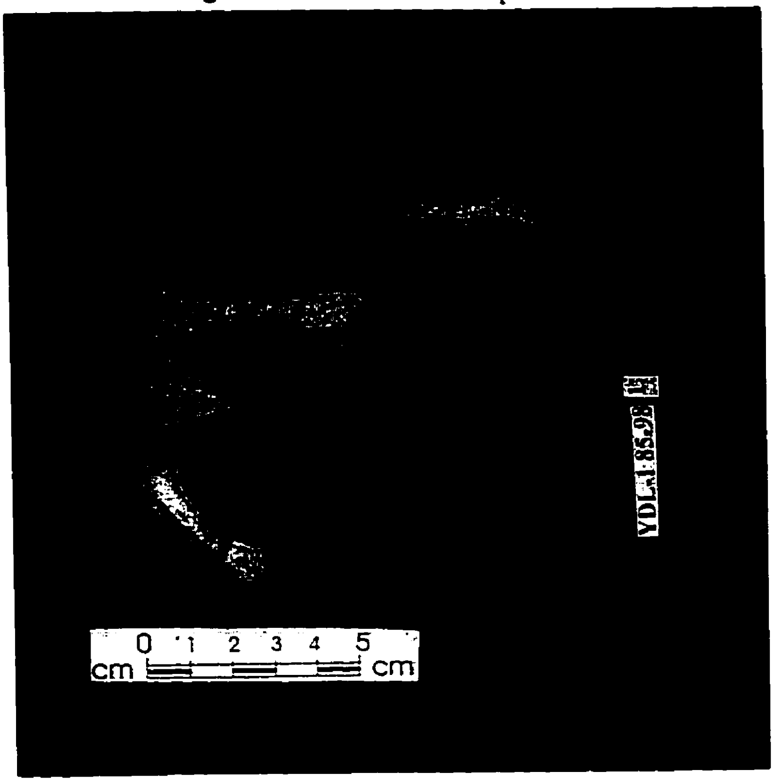


Plate 7: Catalogue #: 85-1: Right Knee with lipping (Lateral) and Porosity (medial facet)

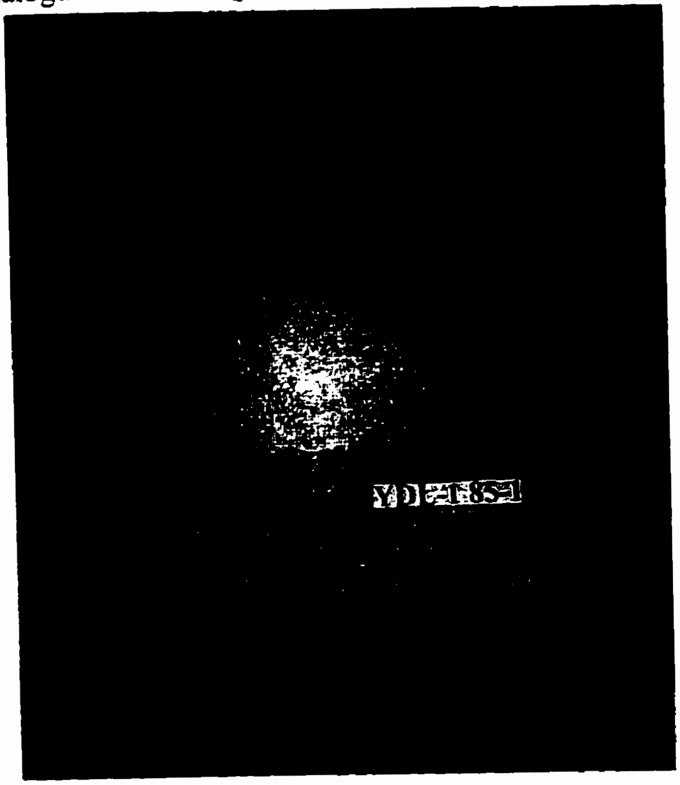


Plate 8: Catalogue #: 85-82a: Shows infection of the right Fibula

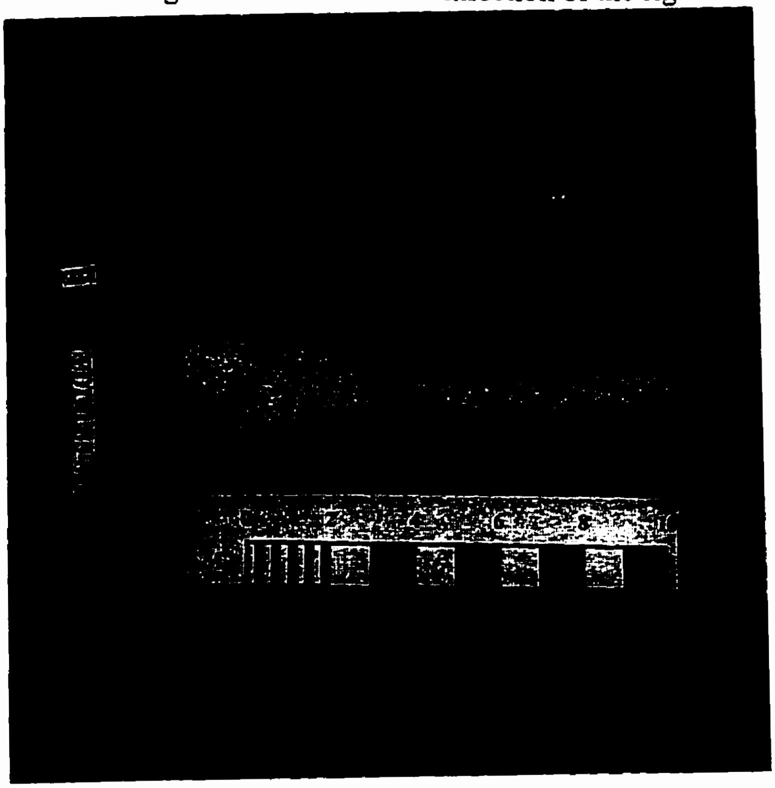


Plate 8: Catalogue # 85-23: Femur with Score 2 Lipping on posterior border.