CITY, TOWN, AND VILLAGE: AN INTER AND INTRA SITE ANALYSIS OF LONG BONE AND RIB FRACTURES AT FIVE SETTLEMENTS IN THE WESTERN ROMAN EMPIRE

CITY, TOWN, AND VILLAGE: AN INTER AND INTRA SITE ANALYSIS OF LONG BONE AND RIB FRACTURES AT FIVE SETTLEMENTS IN THE WESTERN ROMAN EMPIRE

By TAYLOR PEACOCK, B. A. Hons

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements of the Degree Master of Arts

McMaster University MASTER OF ARTS (2019) Hamilton, Ontario (Anthropology)

TITLE: City, Town, and Village: An Intra and Inter Site Analysis of Long Bone and Rib Fractures at Five Settlements in the Western Roman Empire

AUTHOR: Taylor Peacock, B.A., Hon (University of Victoria)

SUPERVISOR: Dr. Megan Brickley

NUMBER OF PAGES: xiii, 177

ABSTRACT

Fractures indicate how an individual has moved through the world. Yet, how an individual navigates their world is also dependent on variables such as age and gender, and the intersection of such variables. This was never more true than during the Roman period, where how one lived was contingent on a number of variables such as class, gender, and age.

The current project analyzed data from 1121 individuals to examine whether one's age, gender, burial treatment and the confluence of these variables related to one's fractures. To capture the diversity of the Roman Empire, the project examined three large settlements: Winchester, UK; Lisieux Michelet, France; and Barcelona, Spain, as well as two smaller settlements: Godmanchester, UK; and Vagnari, Italy. Temporally, the settlements span from the 1st-8th c. CE, the height of the Roman Empire to the Merovingian period.

The results of the current study found that when variables are treated in isolation, there were distinct gendered lifeways at most settlements, with males having more fractures. When the variables are considered together, fractures reflect more complex dynamics of temporal stress, age, and labour within burial communities at the three larger settlements. When settlements were compared to one another, the absence of differences in fracture prevalence between settlements suggest than rather than simple urban/rural divides, settlements are shaped by their economies and lifeways. Further, odds ratios suggest that fracture risk differed for men and women, young and old.

The current study represents the first study to examine multiple large and small settlements outside of Roman Britain, as well as the first to consider fractures in relation to burial treatment. By cross cutting variables, this study expands the current understanding of small, complex communities within cemeteries, and contributes to the discussion on the confluence of identities in the Roman and Merovingian periods.

ACKNOWLEDGMENTS

"I will take the Ring,' he said, 'though I do not know the way."

- *Frodo Baggins, The Red Book of Westmarch*

Rather like Frodo's journey into the heart of Mordor, a thesis is a quest that is not taken alone. Sincere and significant thanks are owed to my supervisor Dr. Megan Brickley, and my committee member Dr. Tracy Prowse, for their never-ending guidance and support throughout this long journey, especially when I didn't know which way to go next. Special thanks are owed to Dr. Shanti Morell-Hart for undertaking the task of being my third reader and supporting my esoteric coursework.

Heartfelt thanks are owed to the Anthropology department, and especially the graduate students who became like family. Never ending gratitude is owed to Madeline, Hana, and Meghan for the endless cups of coffee, beer, chocolate, and supportive talks. Special recognition should be given to Creighton Avery and Brianne Morgan for constant problem solving, references, reading drafts, and being the sounding board for all my work-in-progress ideas. I am begrudgingly grateful to the wizards of math who helped me with my statistics. To Delaney, Geoff, and Rowen at the University of Victoria, thank you. Thank you for answering my emails and my sometimes simple, but often incoherent questions about sample sizes.

This work would not have been possible without the work of numerous graduate students who collected all the data. To Annabelle Schattmann, Joelle Ingram, Laura Lockau, Marissa Ledger, Creighton Avery, Helena Ramsaroop, Sarah Timmins, Lisa Semchuk and Xuan Wei, thank you for all your detailed, carefully recorded data. This would not have been possible without you.

Endless thanks are owed to my family. To my mum, whose long talks served as the best kind of distraction, thank you. To Graham, who came with me all the way to Mordor, and read draft after draft, I cannot thank you enough. As Frodo needed Sam, I would not have made it here if not for you. Last, but not least, thanks are owed to Roxanne Goblin Dogbert (Roxy) for many thought collecting afternoon walks, procrastinating pets, and cheering up.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 2: BACKGROUND

CHAPTER 3: MATERIALS AND METHODS

CHAPTER 4: RESULTS

LIST OF TABLES

CHAPTER 3: MATERIALS AND METHODS

CHAPTER 4: RESULTS

LIST OF EQUATIONS

CHAPTER 3: MATERIALS AND METHODS

LIST OF ABBREVIATIONS

AD – Adult (16+)
AM – Ambiguous
AMP – Carrer Ample 1
AR – Andover Road
AY21 – Lankhills (Booth *et al.* 2010)
BAR – Barcelona
CI – Confidence Interval
CPR – Crude Prevalence
DD – Distal Diaphysis
DE – Distal Epiphysis
DRA – Drassanes
F - Female
HYS – Hyde Street
LH – Lankhills (Clarke 1979)
LM – Lisieux Michelet
M - Male
MA – Middle Adult (35-49.9)
MD – Mid Diaphysis
OA – Old Adult (50+)
OAD – Older Adolescent (16 – 19.9)
OR – Odds Ratio
PD – Proximal Diaphyses
PE – Proximal Epiphysis
PGO – Godmanchester
SAC – Santa Caterina
TPR – True Prevalence
UD - Undetermined
VAG – Vagnari
VMD – Vila de Madrid
WIN – Winchester
YA – Young Adult (20-34.9)

DECLARATION OF ACADEMIC ACHIEVEMENT

The research contained in this thesis dissertation was completed by Taylor Peacock, under the supervision of Dr. Megan Brickley and Dr. Tracy Prowse. Research questions and methodology were developed in consultation with Dr. Brickley and Dr. Prowse. Data for the thesis was provided by Dr. Megan Brickley (SSHRC Project PI) from SSHRC funded study (Insight Grant, File number 435-2013-1006 (ID# 169793)), 'Socio-Cultural Determinants of Community Well-Being in the Western Roman Empire: An Analysis of Vitamin D Status,' collected from 2014-2016, and contained in McMaster University's Bioarch-HDDM Lab. Data was analyzed with permission from Dr. Megan Brickley, and acknowledgements to the various graduate students who completed the osteological analysis can be found in the appropriate section.

CHAPTER 1 INTRODUCTION

1.1 Introduction

In the Roman world, life was not universally the same from one corner of the empire to the next; life for urban individuals was distinct from those in *vici* (settlements) and farms (Gowland 2017). While a diversity of lived experiences is expected between communities, bioarcheologists have demonstrated that the intersection of multiple identities *within* a community is as important (*e.g.* Robb *et al.* 2001; Cucina and Tieslar 2003; Agarwal 2012; Kjellstrom 2014). Clinical and anthropological literature suggests that not only are a person's age, gender, and socio-economic status important, but also that the confluence of these identities dictates how an individual navigates the world (Viruell-Fuentes *et al.* 2012; Agarwal 2017). In the Roman world, the impact of various identities is evident in the early texts, as life was hierarchical, with gender and class determining what one did (Dixon 2004, 56-75).

Fractures, or breaks in bone, are indicative of how an individual moves through the world (Lovell 2008, 341), whether they engage in combat, suffer serious illness, or fall. Studies of medieval samples from Britain, Poland, and Denmark have found that there are significant differences in fracture prevalence between urban and rural communities (*e.g.* Judd and Roberts 1999; Agnew *et al.* 2015; Collier and Primeau 2019); however, Gilmour *et al.*'s (2015) study remains the only one to have compared fractures in urban and rural communities in the Roman world. Likewise, singular facets of identity have been examined in the Roman world, but a combined study of identities such as age, gender, and burial treatment in relation to fractures has yet to be completed (Gowland

2017). As individuals are not one identity at any point in their lives, the consideration of multiple identities simultaneously is required.

The goal of the current study is to examine the intersection of various forms of identity and their impact on lifeways at five settlements in the Roman Empire. The current study investigates how fracture prevalence in the long bones (clavicle, humerus, ulna, radius, femur, tibia and fibula) and ribs differs both *within* and *between* communities across five settlements in the Roman Empire: Winchester, UK: Lisieux Michelet, France; Barcelona, Spain; Godmanchester, UK; and Vagnari, Italy. Fractures are examined *within* a community in relation to sex, age, and burial treatment, and the intersection of age and sex within burial treatment. Fractures are then compared by age and sex *between* three larger and two smaller settlements. The analysis of fractures is guided by the theory of embodiment. Embodiment argues that life is reflected in the body, and the body is reflected in life (Krieger 2005; Gravlee 2009), considering how social processes, social biases, and inequalities shape the skeleton. The current study represents the first large scale examination of fractures in the Roman world, and the first major study to consider cross cutting variables in the Roman period.

Data on the skeletal remains used in the current study come from the records of five settlements, spanning from the 1st c. CE to the 8th c. CE. The records and photographs of 1121 adult individuals (>16 years of age) from the SSHRC-funded study ‘Social-Cultural Determinants of Community Wellbeing in the Western Roman Empire: Analysis and Interpretation of Vitamin D Status’ were evaluated and contextualized through historical, archaeological, and textual evidence. As a large database spread across numerous Roman provinces, the quantity of SSHRC study data allows for the complex analyses of lifeways both *between* and *within* numerous settlements.

1.2 Thesis Organization

The thesis is organized into six chapters with additional appendices. Chapter two provides an overview of the theory of embodiment, as well as social identity in bioarchaeology and the use of cross cutting variables. Included in the chapter is an overview of fracture mechanisms and biocultural studies of fractures, as well as a timeline of the rise and fall of the empire, settlement size, gender, age, status, and death in the Roman world. Chapter three introduces each site under study, and the skeletal materials used in the study. Methods for the analysis of fractures, including healing, are also outlined alongside methods of statistical analysis. The results of the study are presented in chapter four and broken down into *within* and *between* site analyses. Chapter five contextualizes the results using historical, textual, and archaeological sources, and chapter six concludes the thesis by highlighting the key findings and providing areas of future research.

CHAPTER 2 BACKGROUND

2.1 Theoretical Frameworks

The most prominent theoretical approach in bioarchaeology is a biocultural one. Beginning with Goodman and Leatherman's (1998) book, the biocultural approach is one which simultaneously considers biology, society, and culture when investigating life both in the past and present. The biocultural approach transcends disciplinary lines and, in bioarchaeology, borrows heavily from archaeological theory, considering the combined social and cultural forces that are enacted on the body inferred from skeletal evidence (Goodman and Leatherman 1998). Beneath the umbrella of the biocultural approach in bioarchaeology lies the theory of embodiment.

2.1.1 Embodiment

Embodiment is a body-centric approach that examines how the world around the individual shapes the body, and which posits that the body cannot be divorced from its historical and cultural condition (Krieger 2005). However, the body is not passive, rather being how an individual interfaces with the world, and the focal point from which the individual is oriented (Sofaer 2006, 21-22; Wesp 2017, 106-107). Built on the phenomenological concept of "being-in-the-world" or *dasein*, first outlined by Martin Heidegger, a 20th century German philosopher, *dasein* examines the individual's perception and understanding of lived experience; the individual and the body are intertwined with society and the perception of society (Sofaer 2006, 21). Important to the theory of embodiment is the notion of *thrownness*, best summarized by the phrase 'always already,' which argues that individuals are not brought up into Being, but rather, exist and already are interacting with the world and their perception of the world (Large 2008, 125). The world which an individual interfaces with is cultural, historical, and particular, as it does not merely spring into being, but comes from somewhere (Large 2008, 125).

The body and, in bioarchaeology, the skeleton, are simultaneously reflective of social processes and engagements in the social world, and the social world is further shaped by the body (Sofaer 2006, 75; Gowland 2017). In epidemiology, embodiment focuses on how inequalities such as poor diet, access to food, racism, and other social processes become biology, and thus part of the body, and how the body may act as a window into such inequalities (Krieger 2005). Sofaer (2006) argues that when we examine the body as material (as a product of one's social and cultural conditions, upbringings and life, alongside the stand-in for social self), we can consider the skeleton as both cultural and biological (74-75). Other considerations of embodiment examine the interaction of individuals with the world and with other Beings through consciousness, for example (*e.g.* Voestermans and Verheggen 2013). Where bioarchaeology's use differs from previous uses of embodiment is in its body-centric, physicality approach.

While skeletons in bioarchaeology are viewed as either biologically or culturally shaped, embodiment theory as used in bioarchaeology argues that the biological world (the skeleton) and the social world are inseparable (Gravlee 2009; Gowland 2017). Embodiment in bioarchaeology examines how differences within life, such as social standing, are reflected in our biology, and how our biology reflects the lived reality (Krieger 2005). Life is transcribed on the body, and the body bears the marks of life

(Sofaer 2006; Gowland 2017). For Sofaer, the key concept associated with the material body is its plasticity; the notion that bodies are reflective of, conditioned by, and changed in social and cultural conditions, even those of one's predecessors (2006, 74-75). Krieger's (2005) consideration of embodiment in epidemiology argues that the theoretical orientation has three key concepts: (1) bodies cannot be divorced from their conditions; (2) bodies' stories may not reflect the stories of their owners; and lastly, (3) bodies' stories may be the ones that an individual cannot convey themselves. To have a life that is embodied, the body is not merely an object, but an active participant in the structuring and restructuring of self and world, shaped by existing cultural and societal forces.

2.2 Social Identity in Bioarchaeology

2.2.1 Gender in Bioarchaeology

In the current study, sex and gender are used as two distinct terms, as broadly used in the Social Sciences. Sex refers to biological differences between individuals and exists on a spectrum (Geller 2008; Wesp 2017, 107). In bioarchaeology, the common skeletal designations are Male – Female, with Probable and Ambiguous individuals in between (Wesp 2017, 107). Skeletal sex is among the first of several indicators examined by bioarchaeologists; gender, on the other hand, is how individuals interface and engage with the world, and is not routinely examined (Sofaer 2006, 99; Geller 2008). While gender and sex are intertwined, gender is a cultural construction that does not exist in isolation, but in a consistent place of development and reference to the world and body (Wesp 2017, 113-114). Performative in nature, gender is constructed by individuals performing various behaviours that are socially and culturally conditioned, shaped by and given biological and material consequences (Sofaer 2006, 97-98). While sex in bioarchaeology has largely not been challenged and is viewed as inherently stable (Geller 2008), gender and the use of gender has been used cautiously, as researchers begin to unpack the various issues associated with gendering an individual, such as using grave goods and the gender binary (see Agarwal and Wesp 2017).

Traditionally, gender has been attributed to individuals through grave goods or funerary treatment (Sofaer and Sorensen 2013, 530-532). With the rise of post-processual and feminist/queer theory in archaeology, reading gender from grave goods has been challenged (Meskell 2007, 29). The problems with interpreting gender are twofold. First, we cannot assume that the gender binary of male and female was evident in these communities, as more complex identities could be evident (Sofaer and Sorensen 2013, 533-535; Hollimon 2017, 60). Second, gender expression through funerary remains may not be reflective of actual forms of gender expression, but instead the modified and created identity of the deceased (Sofaer and Sorensen 2013, 533-535). For example, if grave goods are broken down into “female” spindle whorls, and “male” knives, the categorisation does not recognize that men may spin, nor that women may carry knives. While gender and bioarcheology have a contested and difficult relationship, researchers have begun to examine gender in relation to sex (*e.g.* Agarwal and Wesp 2017). To circumvent the issues with gendering an individual, Agarwal (2017, 173) opts for a multiscalar approach that examines differences related to sex across the sample as an indicator of gendered action and behaviour, but also considers outliers. Following from this, in the current study, the individuals (skeletons) under study are not gendered, but the actions and behaviours that this thesis seeks to elucidate *are.* When discussing the fracture of an individual, the individual's sex estimation is used but when discussing patterns of behaviour within a sample and a community, the behaviours are gendered using textual and historical evidence.

2.2.2 Burial Treatment and Status

In bioarchaeology, researchers often seek to situate an individual within their social and cultural context, and to compare individuals within a community (*e.g.* Robb *et al.* 2001; Linderholm *et al.* 2008; Griffin *et al.* 2011; Pitts and Griffin 2012). One way is to examine burial treatment; nominally the type of burial, the goods one is buried with, the location of burial, and the position of burial. Influenced heavily by funerary archaeology, the number of grave goods or the type of burial are often used to engage in discussions of status, or socio-economic standing, with the argument that individuals who have greater or grander burials are wealthier and able to mobilize greater resources within a community (Pearce 2016, 342). Processual readings of grave goods began with Saxe's 'hypothesis 8,' which argued that individuals would bury their dead in specific locations based on the availability of resources, alongside lineages and kinship (Saxe 1970, 119 as presented in Chapman 2013, 50). Concurrently, Binford (1971) argued that grave goods are not shaped by one's economic wealth, but rather, social processes such as social standing (as presented in Chapman 2013, 49). Critics of the processual reading of funerary remains have argued that such readings are more complex, and should not be considered in relation to concrete categories, but rather, be reflective of the intermixing and formation of identities (Chapman 2013, 51-54).

Bioarchaeological studies have typically adopted three approaches: consider only the grave goods (*e.g.,* Linderholm *et al.* 2008), consider the grave goods and burial types/funerary architecture (*e.g.,* Cucina and Tieslar 2003), or simply consider burial types (*e.g.,* Redfern and DeWitte 2011). There are advantages and disadvantages to all three in examining social status and wealth, as each present different problems (Keegan 2002). Ignoring grave goods runs the risk of lumping individuals who do not possess grave goods in with those who do. Focusing solely on the grave goods means that absence becomes a determinant for "poverty" or "lower class," which may not be the case (Keegan 2002). Grave good preservation is dependent on taphonomic factors, and the significance attributed to either the category of the item or its materials can heavily favour one metric to the detriment of the other, and therefore interpretations can be ridden with problems (Ekengren 2013, 182). Studies of grave goods and burial practices in medieval and Roman contexts suggest that the quantity of grave goods or their absence is associated with age and gender, rather than a cut-and-dry metric of socio-economic status (*e.g.* Gowland 2006; Griffin *et al.* 2011; Pitts and Griffin 2012). As the interpretation of complete funerary treatment is complex, bioarchaeologists have typically opted for either the simplest approach (*i.e.* just burial type) (*e.g.,* Redfern and Dewitte 2011) or a multivariate exploration that considers burial type and grave goods simultaneously (*e.g.,* Griffin *et al.* 2011; Pitts and Griffin 2012).

While difficult and problem-ridden, at its core funerary treatment can in some instances reflect the social relationships of the living and the deceased, while in others it reflects relationships between living and society, creating a uniquely complex set of data

(Ekengren 2013; Sofaer and Sorenson 2013, 534-535). According to Ekengren (2013, 183) the treatment of the deceased is deliberate, grounded in tradition, and steeped in meaning for the living, as the adage is 'the dead don't bury themselves'. Actions of funerary treatment are deliberate in nature; individuals are buried a particular way with a particular set of goods, or lack thereof, determined by the living. Reading funerary treatment as the differences shaped by an individual's relationships with those around them suggests that burial is reflective of inherent social-cultural differences that are both social and individual (Ekengren 2013, 183). Interpreting funerary treatment, then, especially in relation to health data, must be considered carefully and contextually, with the notion that we are not necessarily measuring the direct socio-economic status of an individual, but rather, the community they inhabited, and the ability to mobilize the resources to bury them, conditioned by cultural values, burial practices, and changing times (Fowler 2013, 522). Further, Keegan (2002) notes that identities are being formed in burial, with the consideration that individual identity is manipulated and moved, exaggerated, or underplayed during burial. In the current study, burial treatment is regarded as the complex negotiation and formation of identities by the community, shaped by the time period, tradition, care, and attention of the living.

2.2.3 Cross Cutting Variables

As studies of social identity have increased in bioarchaeology, researchers have begun to ask more nuanced questions of their data (Agarwal 2017; Gowland 2017). Social identities in the modern world are mixed and malleable, interpreted based on the social sphere one exists in. Bioarchaeologists have sought to consider not just singular identities, but to incorporate that social identities in the modern world are complex forms. Traditionally one form of social identity (*e.g.* sex, status, age) has been privileged over others in bioarchaeology (Agarwal 2017, 168). However, Agarwal (2012) argues that the privileging of one social identity over others means that variables are treated in isolation, rather than as a mixture of intersecting identities.

Bioarchaeologists have sought to combat the privileging of one form of identity over another to examine how a variety of variables intersect (*e.g.* Robb *et al.* 2001; Kjellstrom 2014), and ask questions geared toward social inequalities based on multiple aspects of identity. Any cultural consideration of age and gender demonstrates how the two are linked; how one expresses gender is closely linked to one's age, and gender expression changes throughout the lifecourse. The common practice of sex and age estimation in bioarchaeology as the first assessment of a skeleton makes the initial assumption that these variables of identity remain the most common factors in an individual's health (Agarwal 2012). Borrowing from feminist and gender archaeology, bioarchaeologists have begun using cross-cutting variables to consider age and sex not as separate, but intertwined with one another, thereby examining not how individuals differ by sex or age, but how individuals differ by age and sex simultaneously (*e.g.* Robb *et al.* 2001; Agarwal 2012). Cross-cutting variables are concerned with the differences between elderly females and elderly males, or the differences between young males and middle adult males. Agarwal's (2012) study of osteoporosis and the study of cross-cutting variables initially examined where differences between age and sex existed in medieval Britain, but when the two were combined, the results demonstrated that differences were far more complex than initially presumed. Bone loss differed between urban and rural communities, and when combined with sex and age, suggests that the two communities had differing bone loss trajectories based on age and gender (Agarwal 2012). In considering intersecting identities, the goal is to simultaneously consider differences in access and inequalities. The only study of fractures and multiple identities to date is Kjellstrom's (2014) analysis of cranial and post cranial trauma in Viking age Sweden. As fractures are indicative of how an individual interfaces with the world, whether they fall down or engage in fighting, further analysis of intersecting identities and fractures would allow us to examine the manifestations of embodied life.

2.3 Fractures

In the most literal sense, a fracture refers to a complete or incomplete break in the bone, caused by the inability of the bony material to absorb the force applied to it (Lovell 1997; 2008). In this thesis, fractures are the only type of trauma studied, because while fractures are a type of trauma, not all trauma results in fractures. Lovell defines trauma as "an injury to living tissue that is caused by a force or mechanism extrinsic of the body" (2008, 341). The ability of bones to withstand force before entering the "plastic phase" is dependent on the state of the bone, the type of force, the direction of forces sustained (Zephro and Galloway 2014, 35; Lovell 2008, 386). Factors that affect fracture production include the age and sex of the individual in relation to bone strength as well as the types of force (Zephro and Galloway 2014, 35). In the study of fractures, crucial information includes the location of the fracture on the bone, the apposition (or the alignment of the fractured bone to one another), rotation of elements, and healing, which allow for the determination of fracture types. Critical to the study of fractures is bone biomechanics and healing, or how bone responds to force (Lovell 2008). While fractures are breaks in the bone, these breaks are not always caused by rapidly applied forces, such as falling, but can also be indicative of long-term stress or bone weakness caused by illness (Lovell 2008, 346-347).

2.3.1 Causes of fractures

Fractures can be broken into two distinct categories, complete and incomplete fractures. Complete fractures occur when the bone breaks into two or more segments and can be classified into a number of categories (Lovell 1997; 2008, 347). Incomplete fractures occur when the fracture does not cause the bone to break into two or more fragments. The type of fracture depends on the direction, and in some instances the velocity of the force applied (Zephro and Galloway 2014, 34). Spiral fractures, for example, occur due to the application of rotational forces to the bone, most often in a low velocity setting (Figure 2.1). A number of fractures occur primarily in children, such as torus and greenstick fractures in toddlers, due to the relative elasticity of long bones in children (Galloway *et al.* 2014, 61).

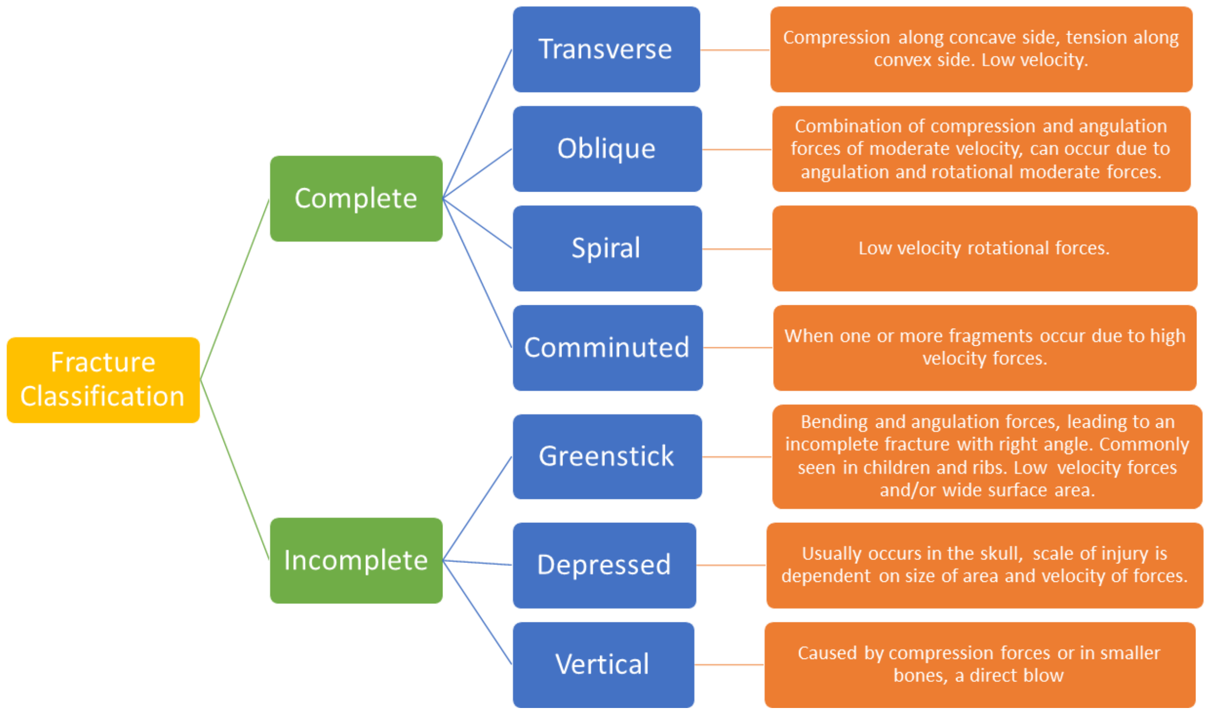


Figure 2.1 Diagram of types of fractures adapted from Galloway *et al.* (2014, 59-71).

One other set of classifications differentiates trauma caused by direct and indirect forces. Direct trauma is defined as forces applied directly to the bone, while indirect trauma is when force is applied to the bone from elsewhere on the body (Figure 2.3.2) (Galloway *et al.* 2014, 68-69).

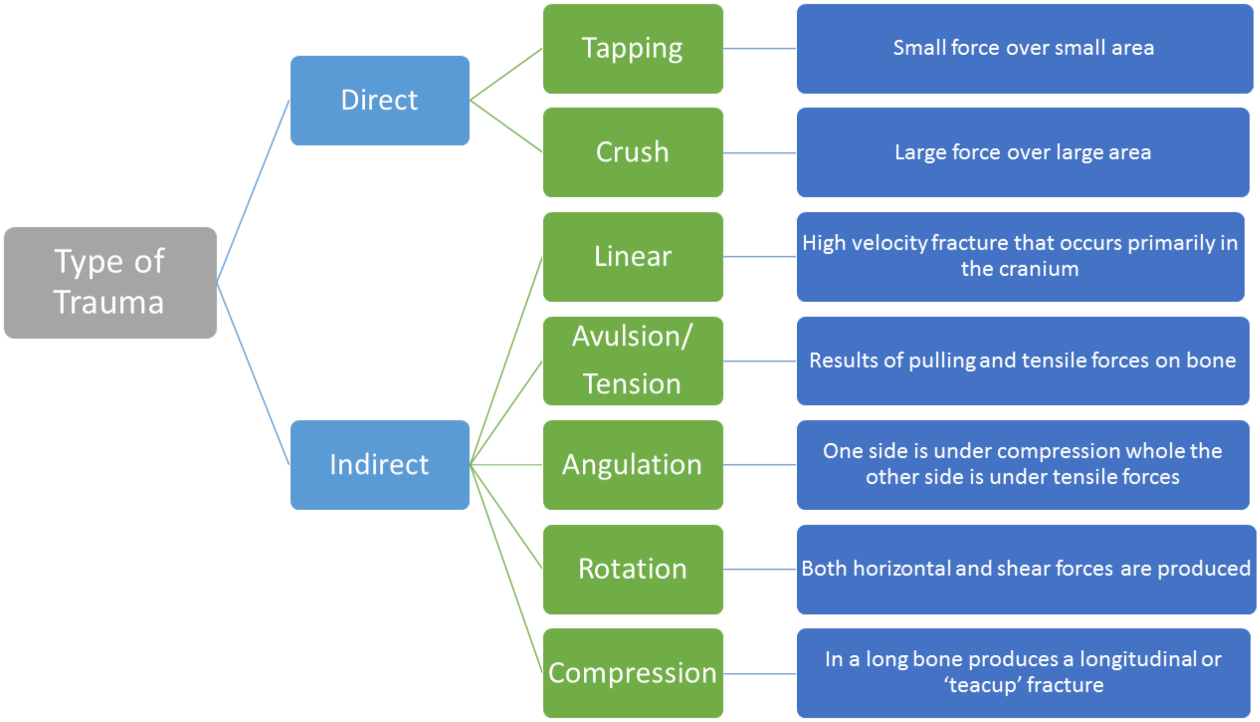


Figure 2.2 Diagram of types of trauma adapted from Galloway *et al.* (2014, 59-71).

While the above section examines bone trauma in the general sense, clinical and experimental literature have examined how specific forces are enacted on specific types of bones, and the associated mechanisms of injury (*e.g.* Egol *et al.* 2015). Clinical literature differentiates between fractures to the upper extremity, lower extremity, and the thorax, discussed in Sections 2.3.2 - 2.3.4.

2.3.2 Fractures to the Upper Extremities

The upper extremity includes the clavicle, humerus, radius, and ulna, as well as injuries to the carpals, metacarpals and phalanges; in the following section, epidemiological data from modern communities is examined in relation to the clavicle, humerus, radius, and ulna.

2.3.2.1 Clavicle

In modern communities, clavicle fractures are relatively common, and occur primarily in young males due to high energy activities such as playing sports (Wiss 2013). Fractures occur primarily in the mid 1/3 of the shaft, and epidemiological studies find that there is a rapid decrease of fractures towards middle age, and then a sharp uptick in elderly women (McKee 2015). According to McKee (2015), mechanisms of injury for most clavicular fractures is a direct blow to shoulder, such as fallings from heights, or sports injuries.

2.3.2.2 Humerus

Humeral fractures are divided into distal, proximal, and shaft fractures in the clinical literature based on the complexity of treatment and the differing mechanisms of injury. Distal humeral fractures are typically associated with falls onto the elbow, the prevalence of which is characterized by a bimodal age distribution with peaks in young adult men and elderly women (Athwal 2015). High energy trauma such as falls onto the shoulder are associated with falls from a height, as well as sports; however, Athwal (2015) notes that most distal humeral fractures are from a simple fall from a standing position. Humeral shaft fractures, comparatively, occur in both men and women equally until old age, where the rate increases for older women (Krieg 2013; Garnavos 2015). Shaft fractures primarily occur due to falls, followed by motor vehicle accidents, although epidemiological evidence suggests that the prevalence of shaft fractures is influenced by geography (Garnavos 2015). According to Garnavos (2015), humeral fractures in Spain and the United States due to motor vehicles accidents are secondary to falls, while in

Sweden and the United Kingdom they are caused by falls from heights, as well as sports. Proximal humeral fractures primarily occur in elderly women who are at risk for osteoporosis, and occur largely due to falls (Gorczyca 2013).

2.3.2.3 Radius and Ulna

McQueen's (2015) study reported that fractures to the distal radius are some of the most common long bone fractures, accounting for around 17.5% of fractures seen in modern populations; these distal radial fractures occur largely in older women. Fractures to the distal radius are caused primarily by falls from standing height and are only rarely associated with high energy impacts (McQueen 2015). The type of distal radius fracture sustained has to do with the position of the hand and velocity of impact. Ulnar involvement is not as common, being related to the severity of the fall and the force of impact. Smith's fractures (or reverse Colle's fractures) have a secondary mechanism of a direct blow to the wrist (McQueen 2015).

In modern clinical studies, diaphyseal fractures to the radius and ulna are less common and occur almost exclusively in young men (25-37 years old) (Streubel and Pesantez 2015). Most occur due to high energy activities such as sports, motor vehicle accidents, and direct trauma. High energy direct trauma of the ulna in modern populations includes gunshots and 'nightstick' or 'parry' fractures; whereas indirect trauma, comparatively, occurs from bending and torsional forces (Streubel and Pesantez 2015). Bending forces often cause breaks in both forearms that fall approximately in line with one another. Common types include a Monteggia fracture, which is a proximal ulnar fracture with radiocapiteller and radioulnar dislocation in the direction of the fracture, and a Galazzeli fracture set, which are fractures at different levels in both the radius and ulna, caused by torsional forces with axial loading (Streubel and Pesantez 2015). Monteggia fractures with anterior dislocation of the radial head are often caused by a fall onto the outstretched hand (Streubel and Pesantez 2015).

2.3.3 Fractures to the Lower Extremities

The lower extremities include the pelvis, femur, tibia, and fibula, as well as the tarsals, metatarsals and phalanges; however, akin to 2.3.2, in the following section, modern epidemiological data is examined in relation to the femur, tibia and fibula.

2.3.3.1 Femur

Femur fractures to the intertrochanteric and neck areas, referred to as hip fractures, are commonly associated with the elderly and occur due to falls alongside osteoporosis, and occur due to a direct impact on the hip (Keating 2015; Russell 2015). Fractures to the neck can also be caused by the rotation of the leg. Russell (2015) reports that these fractures are relatively rare in young individuals and occur only in cases of high energy trauma. Subtrochanteric proximal femur fractures likewise occur in older osteoporotic individuals from falls and in young adults from high energy trauma (Sassoon *et al.* 2015). For young people, high energy trauma includes falls from heights, as well as sports and motor vehicle accidents (Sassoon *et al.* 2015).

Nork (2015) notes that femoral shaft fractures occur due to a variety of causes and across all age groups; yet, they tend to occur more frequently in young men due to high energy activities, while in older women they are typically caused by falls associated with osteoporosis. Distal femur fractures are distinctly less common, and are caused by *varus*, *valgus*, and rotational forces, and have the same bimodal distribution as proximal femur fractures (Collinge and Wiss 2015). In older individuals, Collinge and Wiss (2015) report that falls onto the knee and high energy trauma such as motor vehicle accidents are the most commonly reported causes.

2.3.3.2 Tibia and Fibula

Tibial plateau fractures occur more often in young men from high energy trauma, and in elderly women in association with osteoporosis (Marsh and Karam 2015). Boulton and O’Toole (2015) report that tibial shaft fractures are common and, in some countries, are the most common fracture. In modern day Denmark, tibial shaft fractures occur in 16.9/100,000 people each year (Larsen *et al.* 2015), while tibial fractures overall are the third most commonly treated fracture in the United Kingdom (van Staa *et al.* 2001). Eighty percent of tibial shaft fractures also have an associated fibula shaft fracture (Boulton and O’Toole 2015). In elderly individuals, most tibial shaft fractures are caused by low energy rotational forces caused by falls from a standing height; while in younger, predominantly male individuals, high energy fractures occur primarily due to motor vehicle accidents, direct blows to the shin, and falls from a height (Bolton and O’Toole 2015). Pilon fractures, or fractures to the distal tibial articular surface are a complex fracture caused by high energy trauma such as the falls from heights and motor vehicle accidents, while the pattern of fracture is largely affected by the position of the foot during axial loading (Barei 2015). Finally, ankle fractures, or fractures to the distal tibial and fibula, have similar bimodal age categories of young men and older women, and occur primarily from low energy torsional forces, such as falling (White and Bugler 2015).

2.3.4 Rib Fractures

The mechanisms of injury in rib fractures include local bending and shearing forces. Rib fractures are a relatively common phenomenon in modern populations and can be the result of a simple long-term severe cough to more serious motor vehicle accidents (Cundy and Williams 2018). Rib fractures occur from a variety of causes, but are most commonly and seriously associated with blunt force trauma; while other causes of injury include falls and illness (Sirmali 2003; Sharma *et al.* 2008; Cundy and Williams 2018). As rib fractures can vary from minor trauma (requiring little to no treatment) to a serious illness with increased chance of mortality, the clinical literature is more commonly concerned with the extreme cases (Sharma *et al.* 2008). In serious cases of multiple rib fractures, Sharma et al. (2008) note that the major concerns include 'flail chest', when the rib cage lacks any stability.

2.4 Fractures in Bioarchaeology

Bioarchaeologists often approximate activities from modern communities. In modern populations, numerous occupations are associated with differing rates and risks of fractures, such as farming and other agricultural activities (Redfern 2016, 75-76). The current study of trauma and fractures in bioarchaeology is a result of several shifts in the field. Initially, paleopathologists used a case-study approach, one which favoured the weird and fantastic, rather than the complete sample (Grauer 2012, 3). “Population” studies of long bone fractures begin with Lovejoy and Helpie’s (1981) study of the fractures at the Libben site of Ohio, which shaped further fracture analysis as they called for the standardization of fracture analysis, making fractures comparable between communities. Other notable and influential studies of long bone fractures include Judd’s (2002a) study assessing long bone fractures in a Nubian population, which shaped how long bone fractures were recorded by using segments to account for accuracy. Likewise, Judd’s (2002b) study on injury recidivism created a standard of measurement for multiple fractures in individuals.

While rib fractures are common in archaeological populations, there is a relative dearth of rib fracture studies in bioarchaeology and paleopathology. Brickley (2006) found a crude prevalence (CPR), or number of individuals with fractures (Equation 3.3), of 15.6% and a true prevalence (TPR), or number of elements with fractures compared to elements preserved (Equation 3.4), of 2.3% in 19th c. CE Birmingham, England, while Roberts and Cox (2003) report a crude prevalence of 3.57% for several sites in Late Medieval Britain. Roberts and Cox (2003) remain the only collective analysis of rib fractures from Roman Britain, reporting that rib fractures are the most commonly fractured element (3.4% true prevalence) followed by carpals (2.1%) and clavicles (1.7%) (Roberts and Cox 2003, Table 3.28). However, prevalence reported in Roberts and Cox (2003) may not reflect the changes to paleopathological diagnosis and methods, as much of it was gathered from earlier site reports. In part due to the preservation of ribs, which remains historically lower than long bones due to the relative ratios of trabecular bone, and the complexity of rib bone biomechanics, rib fractures have been overlooked (Brickley 2006; Matos 2009). Ribs, unlike long bones, do not behave in any typical fracture pattern, therefore determining the mechanism of injury is difficult (Love and Symes 2004; Daegling *et al.* 2008). Long bones are often studied in paleopathology, as they are typically well preserved, and break into typical patterns. Long bones also preserve better over time than ribs and the small bones of the hand and foot, making them an excellent tool for analysis. Fracture type analysis such as oblique, comminuted, spiral, and transverse fractures are all based on long bones, as long bones break following specific force patterns, thus bioarchaeologists can determine how the bone was broken (Lovell 2008).

2.4.1 Biocultural Approaches to Fractures

Determining the etiology of fractures not only requires the basic analysis of fracture types, but consideration of the historical and social conditions in which individuals lived (Lovell 2008, 341). In bioarchaeology, studies of fractures aim to discover whether something was caused by accident or intention.

2.4.1.1 Violence and Interpersonal Violence

A large portion of the bioarchaeological literature on fractures is on violence, often demarcated by the presence of weapons in burial and/or a known history of conflict, in combination with ‘parry fractures,’ cranial or facial trauma, or perimortem trauma (Judd and Redfern 2012, 365). Violence was as much a reality for past populations as it is today, with the consideration of violence encompassing warfare, mass graves, or brawls in the streets; all existed and have been documented (Knusel 2014, 4; Martin and Harrod 2015). The study of violence is not limited to skeletal analysis, but rather extends to the integration of grave goods and the associated contextual findings, requiring a biocultural approach (*e.g.* Robbins Schug *et al.* 2012; Kjellstrom 2014; Redfern 2016). The Robbins Schug *et al.* (2012) study of violence at Harappa (3300-1300 BCE), for example, combined the social organisation of society across time periods to examine whether there were significant differences in the risks of sustaining cranial trauma between groups of individuals. The results suggest that in Harappan society, the risk of violence was dependent on both gender and community, with marginalized people being more likely to sustain cranial trauma (Robbins Schug *et al.* 2012).

Based on clinical literature, studies of violence are focused on the expected findings of multiple rib fractures, cranial fractures, and the distinctive 'parry fracture,' but differential diagnoses of interpersonal violence without evidence of sharp force trauma must be carefully considered, as fractures to the ulnae, ribs, and cranium can all occur without interpersonal violence (Judd and Redfern 2012, 365-366). Judd (2008) posed that there were significant issues with the determination of "parry" ulnar fractures, and that ulnar fractures must be analyzed using strict guidelines and four criteria. Judd (2008) refines the criteria of 'parry' fractures to only consider those that occur below the midshaft, with minimal apposition and rotation and no radial involvement. When considering lower limbs, no studies of violence in past populations have considered violence as a mechanism of injury to fractures of the tibia, fibula, and femur. In the clinical literature, violence has rarely been recorded in the lower limbs, with injuries primarily involving the feet and ankles. Wladis *et al.*'s (1999) modern study of assault across eight years in Sweden found that ankle fractures accounted for 1.3% of the trauma recorded, and 1% associated with the tibia. However, Wladis *et al.* (1999) defined assault to include beatings, brawls, and rape in their definition, meaning that fracture prevalence could be affected by the manner of violence endured. Likewise, Shepherd *et al.*'s (1990) examination of patterns of assault in modern day United Kingdom found that lower limb fractures accounted for 2% of all the sustained fractures. When considering and interpreting violence in past populations, the difficulties of assuming mechanism of injury in relation to violence mean that most often, evidence of weapons, graves of communities who would have sustained trauma such as battlegrounds, and clear indications of sharp force trauma become the only reliable indicators.

2.4.1.2 Lifeways and Activities

Few bioarchaeological studies examine activities or lifeways directly, as determining exactly what individuals did in the past, as interpreted from fractures, is impossible. Bioarchaeological studies of lifeways contemplate differences in rural and urban populations (e.g., Judd and Roberts 1999; Agnew *et al.* 2015), or transhumance (e.g., Gilmour 2017). Activity-based studies have been primarily concerned with the conditions surrounding rurality, with the assumption that harder labour occurred in rural settings (*e.g.* Judd and Roberts 1999; Djuric *et al.* 2006). When engaging in the rural versus urban debate, much of what is being interrogated are the agricultural behaviours of individuals (*e.g.* Collier and Primeau 2019). In Grauer and Roberts' (2017) analysis of fractures and gender in Medieval Britain, for example, the authors found that the crude prevalence of fractures in rural settings (particularly in females) was higher than in their urban counterparts. Likewise, Agnew *et al.* (2015) found that there were significant differences in the types of fractures sustained between urban and rural Medieval Poland. In the rural community, individuals had significantly more vertebral and long bone fractures associated with agricultural lifeways (Agnew *et al.* 2015). For the Roman world, the consideration of rurality and urbanism is often tied to the rise of urbanism and the association with migration and mobility, changing diets, and shifting societal structures (Redfern *et al.* 2015).

2.4.2 Fractures Studies in the Roman World

Fractures have been documented across the Roman world, but very few published studies have engaged directly and solely with fractures. Notable long bone studies in the Roman world include Gilmour *et al.*'s (2015) study on Roman Hungary, which compared male and female long bone fractures to examine gendered activities in the Roman Provinces. The authors found that there were differences between males and females, with males having more high energy fractures. Gilmour *et al.* (2015) is also the only study to compare rural and urban sites in different Roman provinces with a focus on sites outside of Roman Britain. The fractures from *Aquincum*, a major urban centre, was most similar to that of rural continental Croatia, suggesting that in the case of Roman border communities, individuals had similarly difficult lifeways regardless of sample sizes (Gilmour *et al.* 2015). In looking at violence in the Roman period, Šlaus *et al.* (2012), found that violence in the Adriatic region (Croatia; Bosnia and Herzegovina) generally increased from the 2nd c. CE onward. With respect to fracture healing and treatment, Redfern *et al.*'s (2010) study of fracture treatment in Iron Age and Roman Dorset found that overall fractures were treated with minimal difficulties, and no sex differences existed in fracture treatment. Similarly, Gilmour *et al.*'s (2019) study of biomechanics and fractures in Roman Ancaster (UK) and Roman Vagnari (Italy) found that there was very little function lost when fractures healed.

2.4.3 Limitations to Fracture Studies in Bioarchaeology

The relative growth of fracture studies in bioarchaeology has allowed for comparison between numerous populations; however, there are several problems associated with 'population' studies and trauma. Foremost is the issue of preservation. To address the differences in preservation between individuals, true prevalence has been used as a metric for calculating prevalence within a skeletal sample. Most commonly, studies of fracture analysis have used crude prevalence, a measure common in epidemiology (Waldron 1994, 44-45). Crude prevalence measures the individual and examines the number of individuals with fractures against the total number of individuals (Waldron 1994, 45). In contrast, true prevalence measures the number of elements with fractures against the number of elements present, meaning that elements that are not present are not counted. Further, archaeological samples are not true "samples" akin to those used in epidemiology, as they are biased in age, sex, and preservation, therefore individuals found are not representative (Waldron 1994, 62; Milner and Boldsen 2017). The prevalence of age and sex in samples affects how we see fractures in populations (Waldron 1994, 62; Klaus 2014). To account for differences in crude prevalence, preservation, age, and sex, proposed methods by Klaus (2014) include the presentation of prevalence in as many ways as possible, the use of other metrics of association, and accounting for age. In interpreting fractures, much of what is found in archaeological samples is healed, which makes estimating the age at incident nearly impossible (Glencross 2011).

More critical than a population approach is the interpretation of trauma itself. Interpreting the *why* of fractures is a key question, though without doubt one of the most difficult. For example, in considering the Wladis *et al.* (1999) results and how they might be reflected in the archaeological record could mean that ankle fractures are being routinely considered with normal and everyday lifeways. Further, in interpreting interpersonal violence, our own Western understanding of violence often influences how violence is gendered in the past; evidence of parry fractures on female skeletons is viewed as "domestic violence" rather than military defensive fractures, while the opposite is interpreted in male individuals (Hollimon 2011, 159). The study of violence in bioarchaeology involves our modern Western assumptions that certain individuals are more at risk of violence than others, while in the past, this may not be true (Hollimon 2011, 159). Jurmain's (1999) *Stories from the Skeleton* highlights how interpreting activity-based trauma is notoriously problematic, as we cannot determine what individuals did or did not do, but merely suggest activities known about the population. The adoption of "lifeways" as a term in bioarchaeology by authors such as Agnew *et al.* (2015) is an attempt to counter the direct assumption that a specific type of fracture is associated with a specific action.

2.5 The Western Roman Empire

It is outside of the scope of the current study to provide a comprehensive history of the Roman Empire, but it is prudent to situate the settlements examined in this thesis within their historical contexts.

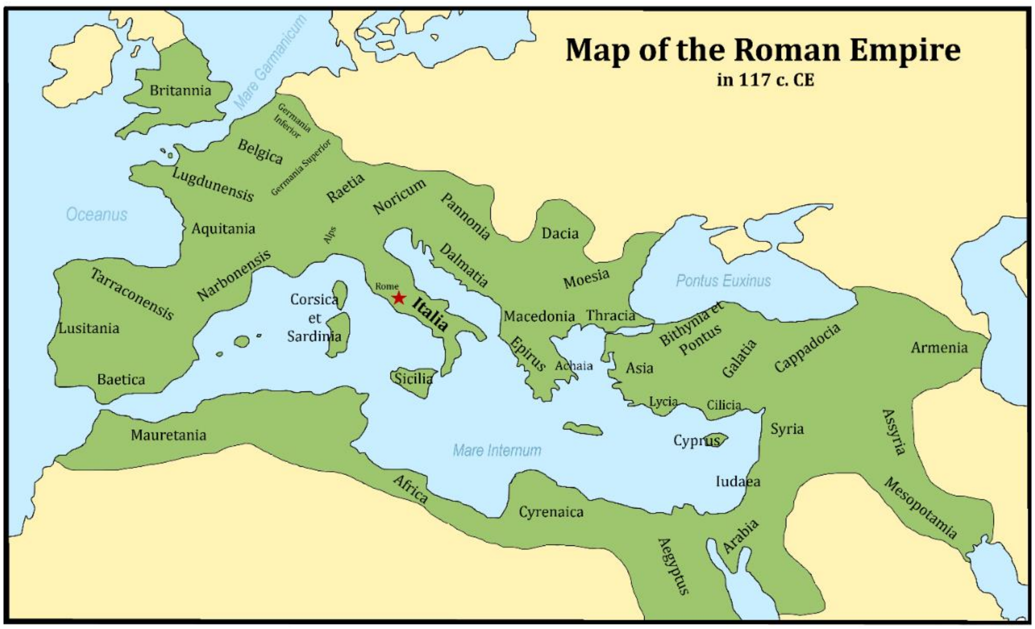


Figure 2.3 Map of the extent of the Roman Empire at its peak in 117 c. CE. Provinces are labelled, while star indicates Rome. Adapted from https://www.ancient.eu/uploads/images/266.png?v=1485680721. Accessed February 15th, 2019.

2.5.1 The Roman Conquest and the Provinces of Britain, Spain and France

The history of the Romans begins in the 8th c. BCE in Italy with the founding of the Roman kingdom, followed by the rise of the Republic and a two-man consul system, after the overthrow of the kingship in the late 6th c. BCE (Adkins and Adkins 1994, 3). It was not until 206 BCE, however, that Spain would become an official Roman province after a period of intense turmoil and civil war (Richardson 1996, 41; Adkins and Adkins 1994, 6). After the conquest of Gaul in 54 BCE (nominally France, Luxembourg, Belgium, Switzerland and Northern Italy), Julius Ceasar turned his attention to Britain (Millett *et al.* 2016, xxix). The death of Ceasar led to the appointment of Octavian, and in 27 BCE Augustus; it is here that the Roman Empire was born (Adkins and Adkins 1994; Figure 2.3).

With the rise and spread of the Roman Empire came increased diversity associated with migration and the subsequent Romanisation of the provinces (Pitts 2016, 731). Romanisation, or the adoption of Roman religion, values, governance, and hierarchy was not a simple one-way avenue, however, as each conquered people had a subsequent influence on Roman life, both in Rome itself, and in the conquered lands (Kaey and Terranato 2001). Romanisation is made up of numerous elements such as economy, religion, law, migration, and warfare; however, the key points in relation to the current study are the adoption and growth of Roman burial rites (Weekes 2016) as well as the expansion and urbanisation of the Roman provinces (Pitts 2016; Roger 2016).

The migration of individuals and subsequent diversity of communities, whether through slavery, military service, or trade, is important to understanding the health and age/sex structure of urban settlements (Eckardt *et al.* 2009; Gowland 2017). The avenues for studying Roman life are numerous, whether textual (such as Pliny the Elder and the writings of Galen), epigraphic, or archaeological (see Barchiesi and Scheidel 2010, for example). While the overthrow of King Romulus in 476 CE by the Osigoth Odavacer is often viewed as the beginning of the fall of the Roman Empire, as he was the last of the emperors (Adkins and Adkins 1994, 36), most historians argue the decline began around

100 years earlier, as wars between various barbarian tribes broke out and the Roman Empire increasingly lost control of various provinces (Esmonde Cleary 2012, 17; 2016, 135-136). Gradually, the provinces were divided among various leaders and independent kingdoms. In Spain, the Romans were replaced by the Osigoths in 406 CE, while in France and Britain the dates vary depending on the region (Adkins and Adkins 1994, 7-8). The fall of the Roman Empire was not the end of "Roman" ways of life, and the period classified as Late Antiquity allowed for continuation under new rule (Esmonde Cleary 2016, 135-136).

2.5.2 The Individual in Roman Society

Life in Roman society was dependent on who you were, to whom you were born, and what part of the empire you lived in. Life in Roman society was hierarchical in nature, and status was organized based on the level of Roman citizenry held; full citizens had the highest status, and slaves had the lowest (Schumacher 2011, 590). Life was also gendered, as women had significantly fewer rights in the eyes of the law than men. Milnor (2011, 610) highlights, however, that Roman life was written from the perspective of men, as men were the individuals in power. In Roman law, women were constricted individuals whose lives were nominally under the control of men; however, legal documents present a single view of women's lives in the Roman Empire (Dixon 2004, 59). In considering the occupations and activities that women engaged in, Gardner (1986, 274) examines textual evidence that suggests that women of highborn status were not to engage in physical labour, but that women made appearances as bankers, moneylenders, midwives and general practitioners in history. While women are often assumed to belong in the domestic sphere, the notion has been challenged in the case of the lower class, as very little is known about the activities of these individuals. Women's jobs likely included working in markets, tending to cattle and engaging in other trade-based activities (Gardner 1986, 233-256). While males would take on military services, engage in agricultural practices and other higher intensity activities, as well as participate in politics and engage in common rule, women of the higher status were domestically limited (Gilmour *et al.* 2015). One example of the standard for the 'dutiful' wife comes from an epigraph from Rome:

> Corpus Inscriptionum Latinarum 6.11602 = Inscriptiones Latinae Selectae 8402 = Carmina Latina Epigraphica 237 (Rome, Hadrianic period):
>
> > "Here is buried Amymone, [wife] of Marcus, best and most beautiful, a worker-in-wool, devoted, modest, frugal, chaste, a stay-at-home [*domiseda*]." (Parkin and Pomeroy 2007, 92)

In interpreting women's lives in the Roman period, Milnor (2011, 609-612) highlights lower status women being absent, and the interpretation of women's lives from the writings of men, such as the wives Galen visits. While two genders are apparent in the writings and epigraphic information of the Roman world (Milnor 2011, 609-612), further gender expression is not known.

While Roman citizens had the highest forms of status, followed by non-Roman individuals, slaves and freedmen made up a significant proportion of the labour force (Parkin and Pomeroy 2007, 5). While freedmen, individuals who were freed from slavery, were individuals who lacked the capacity to vote or hold any real political office, they could marry and move beyond their station (Andreau 1993, 81). According to Hunt

(2018, 14-15), slaves were a fixture of Roman society from the early stages of the Republic, but their number and treatment changed throughout time. While slaves are present in the literature, such as in plays, (Hunt 2018, 16) it is only in epigraphic data that we can identity individuals as slaves. Redfern (2018) argues, however, that in bioarchaeology, we must not ignore slaves in the Roman period, even though they are the least obvious and most complex portions of Roman society.

While social identity and status in the Roman world are often divided into the extremes of slavery and elite, Whittaker (1993, 279) argues that the reality of the Roman world is that most individuals existed along a spectrum from poverty to wealth. One's occupation was reflective of status, and the classes' relative stability. For example, farmers and rural working Romans, along with crop prices, were often at the whim of the harvest and their ability to produce crops (Kolendo 1993, 212). When discussing Roman social classes, Parkin and Pomeroy (2007, 5) make two points: first, they were not absolute in their creation, as we have records of individuals who garnered and maintained wealth, thus moving between social classes; second, that the social classes were not necessarily fluid either. Individuals may have moved up in social status, or have remained in place, thus inferring that status in the Roman world cannot be considered a static category, but one that could change throughout the lifetime, and be as elastic as any other social condition (Parkin and Pomeroy 2005, 5).

Age was an important part of the Roman world, demarcated by various rites of passage. Unlike Western aging, which is viewed as primarily chronological, age in the Roman period was also associated with one's wisdom, physical appearance, behaviour, and capabilities. Age was gendered, as ageing was different for boys and men, and women and girls (Harlow and Laurence 2002, 16). Varro in the 1st c. BCE (as listed in Harlow and Laurence 2002, 16), presents a chronological five stage age categorization to aid in census classification: at birth, infants had to survive nine days to be named, prior to which they were not considered individuals. From birth to the age of seven, individuals were labelled as *infantia*, or infants. At around age seven, individuals became *puertia*, with the accompanying changes in status, and schooling for individuals who could afford it. From fourteen, boys and girls transcended into *adolescentia*, with girls likely being betrothed and married post menstruation. Boys in the Roman period would be classified as *adolescentia* (and not responsible, but learning) until thirty, upon which they were considered *juventus*. After *juventus* men became *seniores* at around forty-five, and then later *senectus* at around sixty. For men, the period of *seniores* is further extended if the individual belonged in the army and served to protect the city. Age was also related to status, as individuals of higher status in Roman society had distinctly different aging customs than those of lower or slave status, but little is written about the lower classes of society (Harlow and Laurence 2002).

2.5.3 Settlements in the Roman Empire

2.5.3.1 Roman Towns

Cities were the founding and basis of much of the Roman Empire, often considered a domain of cities and urbanism (Goodman 2007). Much has been written about the Roman city, as cities differed widely based on size and character (*eg.* Wacher 1995; Goodman 2007; Roger 2016; Laurence *et al.* 2011). Cities in the Roman Empire were determined by the type of governance allowed. *Civitas* were cities which were nominally allowed self-governance, found in Gaul, Spain, Italy, and Britain, and were the loosely designated administrative centres of the *civitates* found in the Western Empire (Adkins and Adkins 1994, 133; Goodman 2007, 9). According to Adkins and Adkins (1994, 132-133), *coloniae* were towns that were formed on state-owned land that were self-administrating, and which individuals had been sent to conquer, while *municipae* were towns that were governed by administrative centres, and whose citizens were Roman, but had no voting rights. In Roman law, there was no distinction between urban and rural citizens, although cities were viewed as the centre of all things political, while the villa and the country were romantically viewed as places of agricultural labour (Goodman 2007, 10). Goodman (2007, 10) suggests that cities were also symbols of wealth and prosperity in the empire, as the elite could demonstrate their status, and the empire could demonstrate its strength. Elis (2018, 9) notes that cities represented the greatest diversity in activity and economy, with the forefront of those being *tabernae* (or shops), so much less is known about what individuals did, and what activities they likely engaged in. Much of what we know about Roman provincial cities is from Roman Britain, where evidence has been well recorded (Bonsall 2013). In urban Roman Britain lifeways and occupations would have included agricultural labour, market work, pottery, glass making, and smithing (Bonsall 2013). In Roman Barcelona, for example, further activities include quarrying, wine making, and amphora production (Kaey 1988, 97; 112).

Small towns and other nucleated settlements represent a distinct entity in the Roman world, as they were not quite cities, but were not quite the country either (Burnham and

Wacher 1990, 44; Bonsall 2013). Small towns often had public buildings, and were a mixture of city life and rurality, with production centres and their associated shops but a higher rate of agriculture (Burnham and Wacher 1990, 44-45). Small towns like Godmanchester, which grew out of a small hillfort, represent the connection to country life in the Roman Empire, as they engaged in agricultural practices and contained public buildings. Comparisons between the city and the smaller towns of Roman Britain in discussions of health include Redfern and DeWitte (2011) and Pitts and Griffin (2012).

2.5.3.2 The Roman Village, Farm, and Villa

The countryside in the Roman world was not homogenous across the empire, as soil dictated what labour and activities looked like (Millet 2016, 700). Rural structures, however, included the *vicus* or village, farms, as well as the traditional Roman *villa*. The archaeological evidence for *villas* shows that the wealthy often inhabited these places, and likely lived in the *villas* full time (Millet 2016, 704). Partially due to the realities of excavations and the smaller nature of cemeteries, fewer individuals have been found from *villas*, and much of the bioarchaeological literature has been focused on urban life (McCarthy 2013, 34). *Vici,* or villages, have been studied much less, and are archaeologically defined by a collection of buildings (Millet 2016, 706). Villages were often carried over from initial Iron Age settlements, and often had an administrative centre. The relative scarcity of such findings certainly makes the bioarchaeological study of rurality significantly more difficult (McCarthy 2013, 34). Archaeologically, little remains of the Roman countryside where a significant proportion of the Roman Empire lived (Dyson 2003, 74). Villages and *villas* were considered production centres for the surrounding urban centres, typically associated with a well-to-do estate, and the primary functions included pastoralism, farming, and agriculture (Dyson 2003, 23; Millet 2016, 703-704).

2.5.4 Death in the Roman Empire

In the early Roman Empire, burials reflected the desire to send individuals into the afterlife prepared; burials were associated with the pagan gods, and the deceased were given gifts to take into the afterlife (see Toynbee 1971 and Morris 1992). Pottery, jewelry, glass vases and other types of grave goods were found in burials (see Morris 1992 for a complete study of Late Antiquity). Style of burials were also regional, with a variety of differences associated with where one lived and died in the empire (Philpott 1991; Weekes 2016). In central and northern Italy, cremation was the primary form of burial until the 2nd c. CE when inhumations begin to appear more frequently (Hope 2007, 110; Morris 1992, 54). Comparatively, in Western Europe, inhumation is the primary type of burial from 475 to 200 BCE, then reappearing in the 1st century CE interspersed with cremations (Morris 1992, 47). Memorials to the deceased such as *stelae* and *cupae* are located at the edge of cities and towns as part of the Twelve Tables, but likely also for hygienic and economic reasons (Hope 2007, 130). Carroll (2011, 128-148) notes that memorials to individuals in the Roman world are often an indicator of who the individuals buried were, but also who buried them, as cases have found that freedmen buried former slaves, and vice versa. Memorials were erected so that a passerby might look upon the dead and remember them (Hope 2007, 141-142). Studies of Roman burial practice are numerous, with some focusing on the textual sources (*e.g.* Hope 2007), the epigraphic and memorial aspects (*e.g.* Carroll 2011), or the archaeological evidence (*e.g.* Philpott 1991; Weekes 2016). Relatively few have considered the body, both the person interred during the act of burial, and the later osteological evidence, although bioarchaeologists have sought to change that. Significant to the study of Roman burial is the decline of elaborate burials in the later periods of the Empire. In the 4th century CE, burial practices changed, cemeteries adopted an East-West orientation and the use of grave goods and tile-based burials declined (Philpott 1991, 225-226; Weekes 2016). Minimal coffin burials are the most prevalent forms of burial in many of the late Roman sites (Philpott 1991, 226; Petts 2016, 672).

2.6 Summary

In the current chapter, the theoretical orientation of embodiment is detailed, as it provides a basis for the analysis of fractures in the current study. An overview of clinical studies of fracture patterns in modern populations reveals that there are age and sex-based variations in the type and frequency of patterns experienced. Research on fracture patterns in past populations also reveals variation associated with age and sex, but little bioarchaeological research has been undertaken on fractures and trauma in the Roman Empire. The chapter also highlighted that studies of fractures in bioarchaeology focus on key areas of violence and urban/rural distinctions, with the latter being notably absent from the Roman period. While the archaeological evidence for various identities and lifeways in the Roman period are numerous, such as a detailed analysis of age, gender, and funerary treatment, considering how these variables intersect on the skeleton, with the consideration of cross-cutting variables will be beneficial to the study of life during the Roman period.

CHAPTER 3 MATERIALS AND METHODS

3.1 Introduction

The current chapter provides a detailed breakdown of the data and materials used in the study, collected from the Bioarch-HDDM lab at McMaster University as part of the SSHRC funded study 'Socio-cultural determinants of community well-being in the Roman Empire: An Analysis of Vitamin D Status," collected from 2014-2016. Data has previously been published in Brickley *et al.* (2018) and Mays *et al.* (2018). Section 3.2 provides a summary archaeological, geographic and historical information for each of the sites while Section 3.3 examines the methods of sex and age estimation used in the SSHRC study. Section 3.3 further provides a summary of the age and sex distribution at each of the sites, along with the burial treatment recorded. Methods for fracture location analysis from the photographs taken as part of the study, prevalence and healing as well as statistics used in the current study are provided in Section 3.4.

3.2 Materials

Records from a total of 1121 older adolescent and adult (16+) individuals from five sites (Winchester, UK; Lisieux Michelet, France; Barcelona, Spain; Godmanchester, UK; and Vagnari, Italy) and 3 regions in the Western Roman Empire were analyzed from 1732 available records from the SSHRC project. The five sites were chosen based on the availability of funerary treatment data, and to enable a comparison of urban and rural living in the Roman Empire (Figure 3.1). The time period spans from the 1st to 8th century CE, from the height of the Roman Empire to the Merovingian period (Figure 3.1). Four sites (Drassanes, Carrer Ample 1, Vila de Madrid, and Santa Caterina) from the area of Roman *Barcino* (modern Barcelona) within this thesis are classified as Barcelona, as all are associated with the Roman *civitas*. Likewise, the sites of Andover Road and Hyde Street are included under the heading of Winchester as both belong to the *civitas* of Roman Winchester.

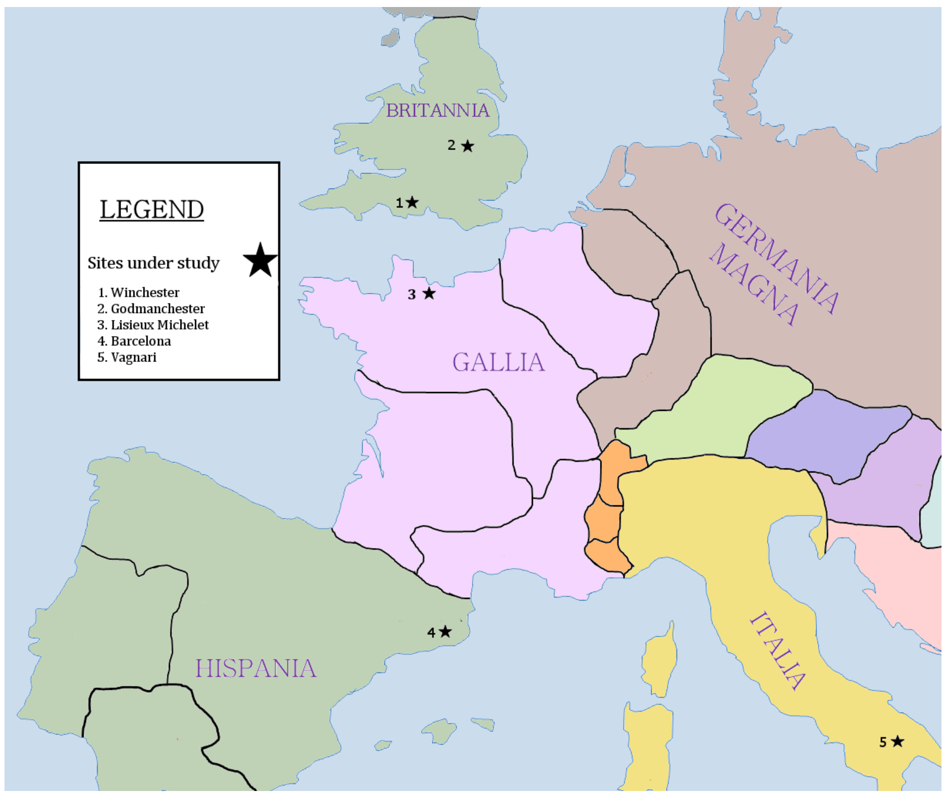


Figure 3.1 Map of the Roman Empire, with sites under study listed. Map adapted from the Ancient History Encyclopedia, (https://www.ancient.eu/image/266/). Accessed August 12th 2018.

3.2.1 Lisieux Michelet, France (LM)

Lisieux is in northern France, was settled by the Romans in the 1st century CE, and was named *Noviomagus Lexoviorum* after being taken from the *Lexovii* people of the region (Paillard 2006). The Michelet necropolis was active during the 3-8th centuries CE, from the late Roman period into the Merovingian period. A total of 970 total inhumations were excavated between 2000 and 2007, and are from two key periods, 4th-5th century and 6th-8th century, with the earliest inhumation dating to the mid-4th century CE (Paillard 2006). Information on funerary treatment at Lisieux Michelet is incomplete, as during excavation pottery was not recorded and researchers chose to only include significant finds when small finds (e.g., metal) were discovered (Paillard 2006). As not all grave goods were collected, the dating of Lisieux Michelet is considered an estimate. Timmins *et al.* (2017) study of cranial trauma in subadults found that the four individuals with cranial injuries were between the ages of 2 and 6 years old, and these injuries could be related to the stress associated with periods of turmoil at the Michelet.

3.2.2 Barcelona, Spain (BAR)

Barcelona in the current study refers to data collected from four separate sites: Santa Caterina (SC), Vila de Madrid (VMD), Drassanes (DRA), and Carrer Ample 1 (AMP).

3.2.2.1 Santa Caterina (SC)

The market square of Santa Caterina stands just outside the markings of the Roman city of *Barcino* (modern day Barcelona) and has been under study since 1997 (Mas *et al.* 2005). Excavations of Santa Caterina found 130 individuals in a cemetery dated to the 4th century CE. Burials were within a demarcated space excavated in the ground, as well as large funeral structures (Mas *et al.* 2005). Many of the graves and individuals were disturbed by the building of a large medieval convent over the cemetery.

3.2.2.2 Vila de Madrid (VMD)

Vila de Madrid is in the centre of modern Barcelona and remains an active tourist attraction due to the preserved *cupae* (rounded monuments with inscriptions) that line the sides of walking streets. Excavated from 1954 to 1957 and then revisited from 2000-2003, Vila de Madrid was a burial site from the 1st to 3th centuries CE (Beltrán 2007). Individuals included in the current study predominantly came from the 2000-2003 excavations (Jordana and Malgosa 2007).

3.2.2.3 Carrer Ample 1 (AMP)

The site of Carrer Ample 1 is located on Carrer Ample Road outside of Roman Barcelona and located on the water's edge, dated from the 1st-4th centuries CE (Rissech *et al.* 2016). Twenty-four individuals were excavated from 2007-2008, with a variety of grave types and an absence of grave goods. Studies of Carrer Ample 1 have argued that stature, evidence of growth disruption from hypoplasia, and an absence of grave goods point to low socio-economic status individuals (Pujol-Bayona *et al.* 2011). A bioarchaeological study of stable isotopes at Carrer Ample 1 found that there was no fish in the diets of these individuals even though Barcelona was a significant centre for *garum* production (Rissech *et al*. 2016).

3.2.2.4 Drassanes (DRA)

The Barcelona Royal Shipyard (Drassanes Reials de Barcelona) is in the Port of Barcelona, and contains the Barcelona Maritime Museum (Nadal 2015). The current dockyard has been in use since the 13th century CE, when textual and archaeological evidence point to the existence of a structure that was later built over in the 16th century

CE. Excavations in 2012 found a Roman cemetery that dated from the 1st to 6th centuries CE (Nadal 2015).

3.2.3 Vagnari, Italy (VAG)

The cemetery at Vagnari is associated with a *vicus* at Vagnari located in modern day southern Italy near Gravina in Puglia. The site has had ongoing excavations since 2002, when tombs were identified below the surface (Small *et al.* 2007). Since the initial find, excavations have discovered 130 individuals, dated from the 1st to 4th centuries CE (Gilmour 2017). The suggestion of individuals belonging to slave and lower classes in Roman society are tied to the presence of the *villa* (Small *et al.* 2007); however, there is no epigraphic evidence to support these suggestions. At Vagnari, life was agricultural in nature (Small 2014; Carroll 2013), as the land was more heavily forested than in the current day. Archaeobotanical remains indicate that milling was a common activity, as well as baking (Carroll 2013). Evidence from animal remains suggest that equines such as donkeys were used for hauling and draught. Sheep were also present for the collection of wool (Carroll 2013). Previous work has been conducted by Gilmour *et al.* (2019) on long bone fractures at Vagnari, examining the long-term consequences of fracture healing.

3.2.4 Godmanchester, UK (PGO)

Excavated from 1997 to 1998 ahead of a housing development, Roman Godmanchester (*Durovigutum*) was a small Roman town that began as two military forts, and has since been extensively researched (Jones 2003; Green and Malim 2017). The excavated cemeteries of Godmanchester are made up of two parts; the Parks, located on the northern edge of modern Godmanchester, and London Road, located on the southern edge of modern Godmanchester (Jones 2003). Individuals from the current study come from the Parks, a cemetery that contained 2nd century cremations, and 4th century inhumations (Jones 2003). From the Parks, a total of 62 individuals, including two double burials, were excavated. Prior to the cemetery, part of the Parks included kilns for pottery production, with many 2nd century CE pottery fragments excavated (Green and Malim 2017).

3.2.5 Winchester, UK (WIN)

Located in southwest Britain, excavations at Roman Winchester began in 1967. The total excavated individuals (>1000) at Roman Winchester come from several smaller sites which make up the Northern and Western Cemeteries. The current study examined 770 individuals from three sites in the Northern Cemetery only, as these were the data available through the SSHRC project. Several studies of Winchester have been completed, including examinations of migration and mobility (*e.g.* Eckardt *et al*. 2009; 2014) as well as grave goods and inequality (Pitts and Griffin 2012).

3.2.5.1 Lankhills Booth (2010) and Clarke (1979) (LH)

Included in the current study is the most thoroughly documented site within the Northern Cemetery, Lankhills School, which consists of over 700 individuals excavated from 1967-1972 by Clarke (1979), and then from 2000-2005 by Booth *et al.* (2010). The dating of Lankhills was proposed to be around the 4th and 5th centuries CE by Clarke (1979). Grave goods from the Clarke excavation (1979) suggest that activity ranged from the 4th to 5th centuries. Booth *et al.'s* (2010) expansion excavation also found burials dating to the 4th century CE; however, usage of the cemetery into the 5th century is still unknown.

3.2.5.2 Hyde Street (HYS) and Andover Road (AR)

Other smaller sites include Hyde Street and Andover Road, both of which are included in the current study. Hyde Street was excavated in 1979, with a total of 27 burials fully excavated, five that were not fully recorded, and that were not available for study (Ottaway *et al.* 2012). The Hyde Street site's minimal grave goods make dating the site difficult, although a coin dated from 388-402 CE and a comb indicate activity between the mid-4th and 5th centuries CE. Andover Road was excavated relatively quickly in 1998, with 48 Roman graves recorded and 37 excavated (Ottaway *et al.* 2012). The grave goods at Andover Road suggest site activity from the early 4th and 5th century CE (Ottaway *et al.* 2012).

3.3 Individuals Included in the Current Study

One thousand one hundred and twenty-one individuals of the 1732 available records were included in the current study (Table 3.1). Individuals were included based on age, information on funerary architecture and preservation. As this study only looks at adults and older adolescents, 533 were excluded as infants, juveniles, and adolescents (Figure 3.2). Younger individuals were excluded from this study as the timing, typology, and consideration of fracture mechanisms is difficult in children and infants and requires radiographs (Verlinden and Lewis 2015), which is beyond the scope of this thesis. Of the remaining individuals, a further 15 were excluded for lack of available grave information. To be counted in the current study, individuals had to have complete records for funerary treatment. A total of 64 individuals with <25% preservation of proximal rib heads or one long bone segment with <75% were also excluded (Figure 3.2).

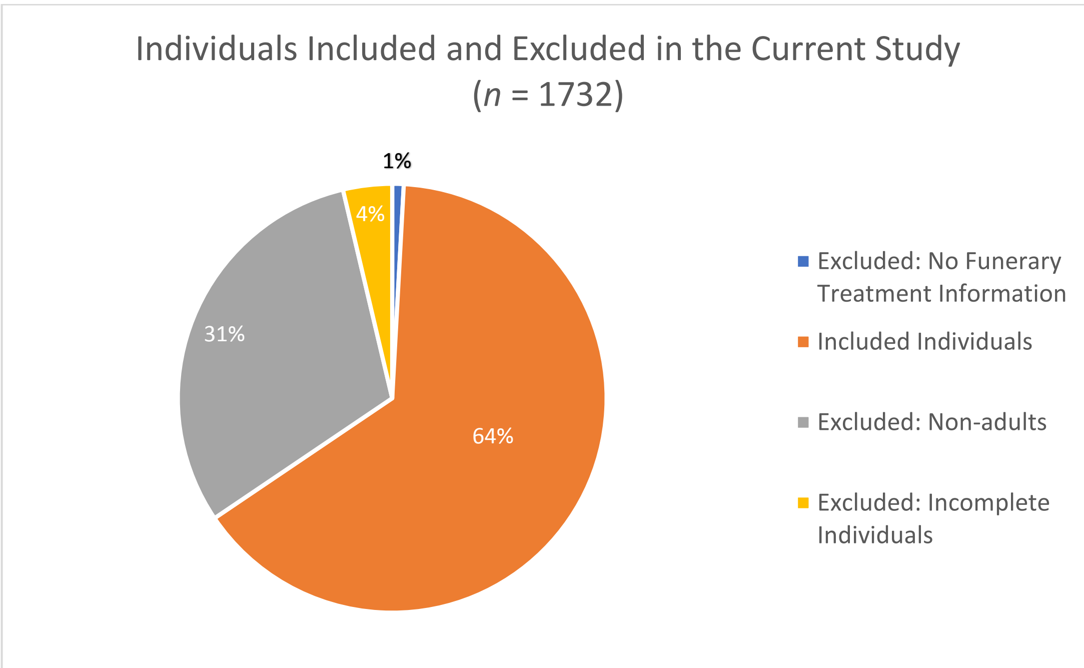


Figure 3.2 Individuals Excluded and Included From the Data Available for All Sites. The total percentage of individuals included is 64%.

Table 3.1 Individuals Used in This Study.

Site	Time Period	Site Code[1]	Site Code Combined[2]	Number of Individuals[3]
Lisieux Michelet	3-8th c. CE	LM	LM	392
Hyde Street	4-5th c. CE	HYS	WIN	22
Andover Road	4-5th c. CE	AR	WIN	24
Lankhills Clarke	4-5th c. CE	LH	WIN	288
Lankhills Booth	4-5th c. CE	AY21	WIN	199
Godmanchester	4th c. CE	PGO	PGO	40
Vagnari	1-4th c. CE	VAG	VAG	64
Drassanes	1-6th c. CE	DRA	BAR	10
Vila de Madrid	1st–3rd c. CE	VMD	BAR	18
Santa Caterina	4th-6th c. CE	SAC	BAR	53
Carrer Ample 1	4th c. CE	AMP	BAR	11

[1]Site codes were collected from each of the archaeological reports, see the appropriate section for each report. [2]Combined site reports are based on the location of each of the sites and ease of analysis. [3]Number of individuals indicates the number of individuals included in the study, not the number of individuals collected for the SSHRC study (Insight Grant, File number 435-2013-1006, ID# 169793).

3.3.1 Age and Sex Estimation Methods Used in the SSHRC Study

3.3.1.1 Age at Death Estimation

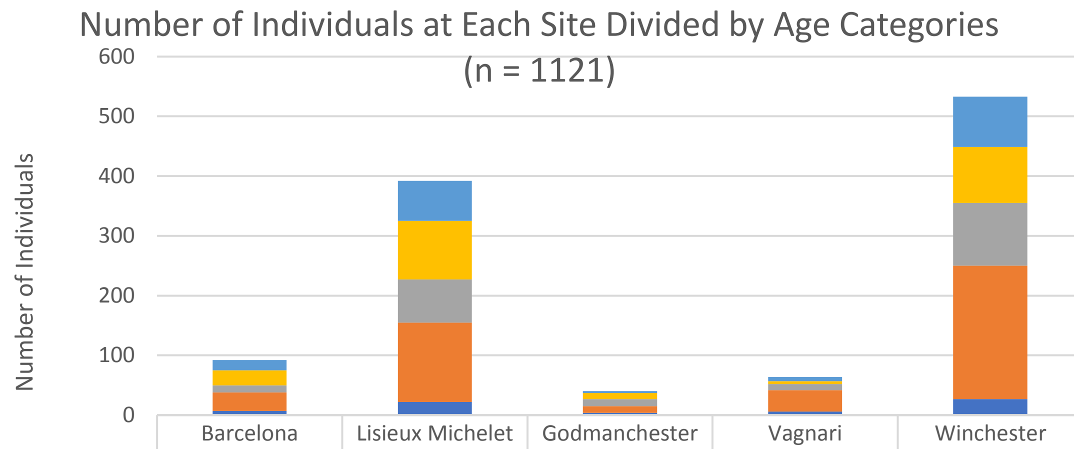
Age estimation for all individuals was completed by various students during data collection between 2014-2016 and used multiple methods to overcome preservation issues (see Brickley *et al.* 2018 and Mays *et al.* 2018 for complete methods). Data was collected from the lab and compiled into Excel spreadsheets. The SSHRC study's methods for age estimation included examining epiphyseal fusion following Cardoso (2008a; 2008b), dental eruption (Gustafson and Koch 1974) and tooth wear (adapted from Brothwell 1963), transition analysis of the sacroiliac joint (Boldsen *et al.* 2002), and pubic symphysis morphology (Suchey-Brookes 1990; Katz and Suchey 1986). Sex was recorded on the forms presented in Appendix A created for the SSHRC project. Age categories used in the current study are listed in Table 3.2.

Table 3.2 Age Categories Used in this Study

Age Categories[1]		***N* – Total Number of Individuals in Each Category and Percentage**
Older Adolescent (OAD)	16-19.9	66 (5.9%)
Young Adult (YA)	20-34.9	434 (38.7%)
Middle Adult (MA)	35-49.9	211 (18.8%)
Old Adult (OD)	50+	232 (20.7%)
Adult Undetermined (AD)	16+	178 (15.9%)

[1]Age categories were based on those from Buikstra and Ubelaker (1994) but were modified for the SSHRC study.

The number of individuals in each age category from each of the sites are summarized in Figure 3.2. At four of the five sites, the greatest proportion of individuals were young adults, while older adolescents make up a notably small proportion. At Godmanchester, the proportion of middle adults and young adults is equal.



	Barcelona	Lisieux Michelet	Godmanchester	Vagnari	Winchester
Adult (16+)	17	67	3	7	84
Old Adult (50+)	25	98	10	5	94
Middle Adult (35-49.9)	12	72	12	10	105
Young Adult (20-34.9)	31	133	11	36	223
Older Adolescent (16-19.9)	7	22	4	6	27

Figure 3.3 Number of Individuals from Each Site in Each Age Category. Raw data is provided in the table below.

3.3.1.2 Sex Estimation

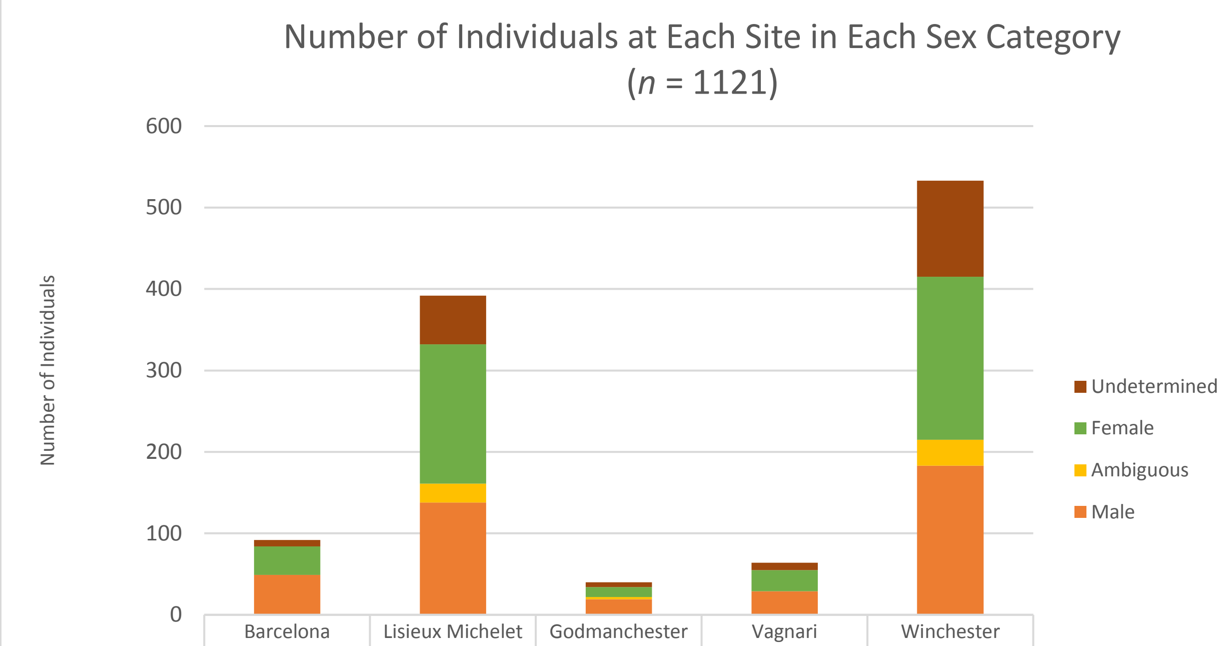
Sex estimation was completed during the 2014-2016 study seasons by scoring features on the cranium and innominates for all individuals over 17 years of age (after Buikstra and Ubelaker 1994). The cranial features examined were the nuchal crest, mastoid process, supraorbital margin, glabella, and mental eminence. The greater sciatic notch and the preauricular sulcus on the innominate were graded on a five-point scale, while the ventral arc, subpubic concavity, and ischiopubic ramus were graded on a three-point scale (Buikstra and Ubelaker 1994). Sex was recorded on the forms in Appendix A created for the SSHRC project, and complete methods are described in Mays *et al.* (2018) and Brickley *et al.* (2018). Sex categories of Probable Female and Probable Male were later collapsed into their respective categories to allow for larger samples (Table 3.3).

Table 3.3 Sex Categories Used in This Study.

Sex Categories[1]		***N* - Total Number of Individuals in Collapsed Categories and Percentage**
Male	M	418 (37.3%)
Possible Male (collapsed)	M	
Ambiguous	AM	58 (5.2%)
Possible Female (collapsed)	F	444 (39.6%)
Female	F	
Undetermined	UD	201 (17.9%)

[1]Sex categories were based on the standards put forth by Buikstra and Ubelaker (1994) but collapsed following Gilmour (2017).

Figure 3.4 summarizes the number of individuals from each site in all four sex categories. At Barcelona, Lisieux Michelet and Winchester, there are more females than males, while at Godmanchester and Vagnari, there are more males than females. Ambiguous individuals are only present at three of the five sites (Figure 3.4).



	Barcelona	Lisieux Michelet	Godmanchester	Vagnari	Winchester
Undetermined	8	60	6	9	118
Female	35	171	12	26	200
Ambiguous		23	3		32
Male	49	138	19	29	183

Figure 3.4 Individuals in Each of the Sex Categories at All Five Settlements. Raw data is provided in the table below.

3.3.2 Burial Treatment

In the current project, funerary treatment and burial treatment are used interchangeably. Archaeologically, burial treatment refers to the complex treatment associated with burial, such as the individual's burial position in the cemetery, their body positioning, the burial container, and any finds associated within the grave (Philpott 1991; Pearce *et al.* 2000). Compilation of funerary treatment followed the work already done on Winchester and Godmanchester, as well as the study by Brent and Prowse (2014) on the Vagnari cemetery. Grave goods were treated as typologies instead of counts to prevent over- and underweighting of small finds, such as nails. Funerary treatment was recorded following the sheets outlined by Dr. Michele George and Dr. Tracy Prowse of the SSHRC project, in Appendix A. While a large set of data that included burial goods, positioning, temporal date, container and disturbance was collected, not all such data was used for analysis. While other materials were available, the only method used to compare burial treatment to health in this thesis is the type of burial or burial architecture. In keeping with the extended time period, differences in geography, and the minimal analysis of grave goods at sites such as Barcelona, and Lisieux Michelet, it was determined that burial types were the most appropriate measure to compare against health.

3.3.2.1 Burial Type

Burial types were categorized based on the designations outlined by the SSHRC recording form (Appendix A). Burial type or funerary architecture refers to the structure and type of burial container, such as coffin, pit, or tile burials. The current study found that there were ten different burial types across all sites, but the categories present at each site differed (Figure 3.5). Categories included examining the materials, such as tile, or cist (stone lined), as well as coffin enclosures, which would have been made of wood (Avery 2016). Burial containers were also identified based on the shape and formation of the container, such as *cappuccina*, which is the use of tile in an inverted V shape, or libation burials, which creates a funnel for beverages to be passed along to the deceased (Brent and Prowse 2014). Information on burial containers was collected from site reports and follow the specifications set by the archaeologists (following Avery 2016;

Brent and Prowse 2014). In instances where more information was given, such as packing (shale, flint *etc.*), the overall container was considered. As coffins and other burial methods utilizing biodegradable material are often assessed based on the presence of nails, the categorization of burial containers was based on the suggestion of existing site reports. One set of burial treatment was classified outside of the existing sheets provided, as there was no adequate category. Thirty-one burials from Clarke's (1979) excavation were listed as burial type 'unknown' based on the size of pit, but no other evidence of burial material. Clarke (1979) stated that the pit was too large to suggest a simple pit burial, but the lack of archaeological evidence for coffins makes the inference of coffins impossible. These burials were classified as "Possible Coffin" to designate the archaeologist's design and were included in the study as there was also grave good data available.

The proportion of individuals in each type of burial is summarized in Figure 3.5. At each site, the highest proportion of burial type varies. At almost all sites, coffins are present, as well as pits. Tile burials were made of *tegulae*, that had no fundamental shape, except at Vagnari were they were classified as *cappuccina* or *libation*. The number of individuals in each type of burial is found in Table 3.4.

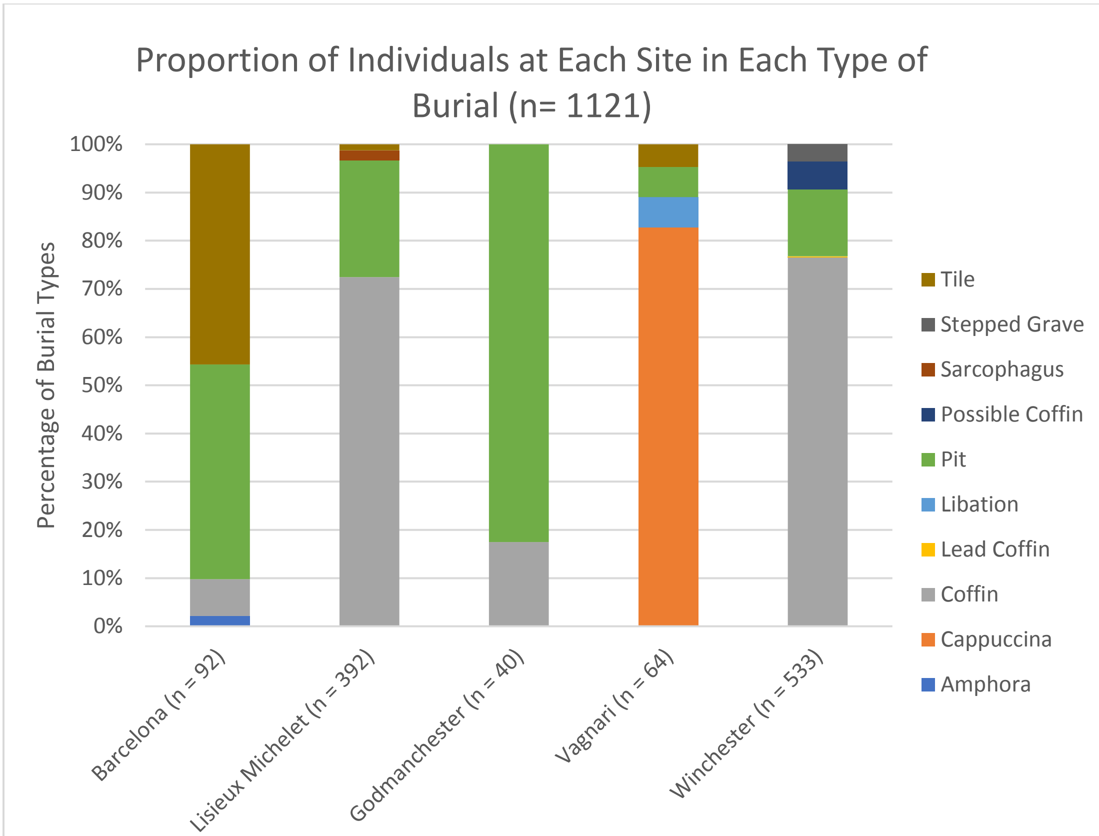


Figure 3.5 Proportion of Individuals in Different Types of Burial at Each Site.

Table 3.4 Number of Individuals in each Burial Type at All Sites.

Winchester	**Coffin**	**Pit**	**Lead Coffin**	**Possible Coffin**	**Stepped Grave**	**Total**
	408	74	1	31	19	533
Lisieux Michelet	**Coffin**	**Pit**	**Sarcophagus**	**Tile**	**Total**	
	284	95	8	5	392	
Barcelona	**Coffin**	**Pit**	**Tile**	**Amphora**	**Total**	
	8	40	42	2	92	
Vagnari	**Tile/ Disturbed**	**Pit**	**Cappuccina**	**Libation**	**Total**	
	3	4	53	4	64	
Godmanchester	**Coffin**	**Pit**	**Total**			
	7	33	40			

3.4 Methods

3.4.1 Preservation of Long Bones and Ribs

For the purpose of the current study, long bones include the clavicle, humerus, radius, ulna, femur, tibia, and fibula. Preservation of long bones for the SSHRC project was recorded following Judd (2002a). All long bones were divided into 5 segments, and preservation calculated following the four scale preservation categories (>25%, 25-50%, 50-75%, >75%) proposed by Buikstra and Ubelaker (1994). Segments included a proximal (PE) and distal epiphysis (DE), and a proximal (PD), distal (DD) and mid (MD) diaphysis, yielding 70 segments per individual (Equation 3.1).

$$\textbf{Equation 3.1}\ \boldsymbol{Segment\ Calculation}: 14\ elements\ x\ 5\ segments\ per\ element = 70\ segements\ per\ individual$$

The use of the five-segment method for all elements allows for a more complete analysis of total preservation and accounts for the fragmentary nature of archaeological samples (Gilmour *et al.* 2015; Judd 2002a). Long bones were calculated as complete/incomplete and included in the analysis of true prevalence (TPR) based on the presence of at least one segment at greater than 75% following Gilmour *et al.* (2015). See Equation 3.4 for the calculation of true prevalence. Ribs were calculated as present or absent based on the presence of the proximal heads, for a possible total of 24 per individual (Brickley 2006).

Following Judd (2002a), a preservation index was completed by calculating the total number of complete segments against the total number of expected segments

(Equation 3.2). Segments were considered complete if they were greater than >75% preserved. For ribs, the number of expected segments were the 24 possible rib heads, and segments observed were the number of proximal heads counted.

$$\boldsymbol{Equation\ 3.2\ Survival\ Index} = \frac{number\ of\ segments\ observed\ at\ >75\%}{number\ of\ segments\ expected\ at\ >75\%}\ x\ 100$$

To be considered categorical data and computed for preservation using chi-square following Judd (2002a), each segment observed at >75% for an individual was classified as ‘present,’ while any segment with <75% was classified as ‘absent’ which prevents nesting of various categories into one another.

3.4.2 Fracture Assessment

Long bone and rib fractures were recorded by various researchers on the sheet listed in Appendix A as part of the SSHRC funded project from 2014-2016. Fractures were recorded as part of the overall paleopathological analysis of the individuals. The recording sheets required researchers to record the presence/absence of fracture, location, state of healing, and state of union. Healing was classified by the presence of new bone formation (spiculated, woven, and lamellar) for all fractures. Location of the fracture by segment was also recorded, as well as the state of union (united, ununited). Fractures were photographed by the students, and the photographs were used in the current study.

In this study, photographs of all fractures were assessed macroscopically independent of the collection notes and then compared to the sheets recorded during data collection. In cases where photographs were not available or could not be located, fractures were included given enough information taken by the researchers. Fractures were assessed based on the following criteria as determined by Lovell (1997; 2008) to be the crucial information for fractures. First, the bone was sided, and in the case of ribs, the estimated rib number and location in the chest (upper, middle, lower) was recorded in an Excel spreadsheet. Next, the fracture was identified from the photos, and location was recorded. Healing was assessed based on the criteria provided later in the current chapter. Notes were collected on the evidence of healing, and union based on "union, non-union, and mal-union" criteria put forth by Lovell (2008, 371-372). Notes were then compared to the SSHRC classification of union/non-union as described on the pathology sheets provided in Appendix A. Further information is provided in the sections below.

3.4.2.1 Perimortem, Antemortem, and Postmortem

As archaeological collections suffer from a variety of taphonomic events, fractures must first and foremost be determined to have occurred during the individual's life and not after burial. Antemortem fractures are fractures that demonstrate signs of healing, evident either macroscopically or in radiographs, indicating that the individual lived long enough after the fracture occurred to begin regenerating bony material (Wedel and Galloway 2014). The appearance of macroscopic healing is generally assumed to be around 13 days (Sauer 1998). Perimortem fractures, for bioarchaeologists, reflect the most problematic of fractures, as they often show no signs of healing, but are determined to have occurred around time of death, in the window before bone completely behaves as dry bone. The assessment of perimortem fractures is based on the behaviour of the fractures, whether they reflect dry or wet fracture patterns, as well as bone discolouration and fracture texture (Sauer 1998; Ubelaker and Adams 1995). The perimortem time interval is noted to be highly variable after death, which suggests that individuals can sustain fractures sometimes months after death and exhibit wet bone fracture patterns (Ubelaker and Adams 1995; Wheatley 2008; Cappella *et al.* 2014). In this study, only fractures that show healing were included, as perimortem fractures could not be independently and adequately assessed. Fractures that exhibited minimal healing were assessed carefully macroscopically, and the notes included by the researchers who assessed the bones were consulted. Fractures that showed ongoing healing were assessed macroscopically following the methods and time frame described in Lovell (1997; 2008). Following the criteria outlined in Table 3.5, age of fracture was estimated based on the evidence of healing. Fractures with calluses that had long solidified were classified as remodeling. Fractures that showed evidence of callus formation were classified as such, based on the evidence of periosteal reaction and woven bone.

Table 3.5 Age of Healing of Fractures taken from Lovell (2008, 369-371).

Stage		**Time Period**	**Macroscopic Appearance**
Cellular	Tissue Destruction	24hrs	Not visible on either radiographs or macroscopically
	Cellular Proliferation	48hrs – 3 or 4 weeks	Osteoid is formed and fracture is bridged
	Callus Formation	2-3 weeks to 8-9 weeks	Callus of woven bone is evident
Metabolic	Consolidation	Weeks to months (dependent on element)	Mature lamaller bone overtakes woven bone, solidly united fracture
Mechanical	Remodeling	Months to years	Fracture is solidly united

3.4.2.2 Fracture Location

Fracture location, the element itself, and fracture location on the element are important points of information, as they are often indicative of types of force and the mechanism of injury. Fracture location was determined based on the element, side, and segment following the five-segment designation used in preservation by Judd (2002a). Segmentation of bone into proximal and distal epiphysis, proximal, mid, and distal thirds of the diaphysis allows for more accurate and standardized recording of fracture location (Glencross 2003; Judd 2002a; Gilmour *et al.* 2015). Fracture locations were identified through photographs in this study were then compared to the recording sheets completed by the SSHRC student researchers to ensure accuracy. In instances where fractures overlapped into two segments, or where the original and the independent recordings were at odds, the category in which the majority of the fracture occurred was chosen.

3.4.2.3 Fracture Type

Fracture type is one of the most important indicators of the mechanism of injury, as type indicates the direction of force that was sustained by the bone (Lovell 1997; 2008). Fracture type, however, is exceptionally difficult to determine when dealing with archaeological bone solely through macroscopic analysis, and radiographs have become the standard tool for assessment (Lovell, 2008). Radiographs allow researchers to analyze the line of fracture based on the lamellar and trabecular bone. Fractures in archaeological collections are often healed, which obscure the original fracture line; cortical bone preservation is also varied. Types of fractures assessed include those discussed in Section 2.3, include penetrating, crush, comminuted, oblique, transverse, spiral, torus, impacted, greenstick, and avulsion fractures (see Figure 2.1). While fracture types were kept in mind, no accurate assessment of fracture type could be completed, as this study was limited to photographs of fractures. Assessments of type by the researchers who collected the information were considered as well; however, without radiographs, types could only be suggested and not confirmed. Nevertheless, the consideration of location as well as possible fracture types can often highlight the possible mechanisms of injury and are therefore useful. For this reason, the study considered fracture types where clear fracture lines suggested distinctive types, but the primary focus was on location.

3.4.2.4 Pathological Fractures

As the primary goal of the SSHRC study was to understand vitamin D deficiency, pseudofractures were assessed as an indicator associated with vitamin D deficiency, along with other indicators such as the bending of long bones (following Brickley *et al.* 2005; 2010). Psuedofractures are minor cracks on the surface of bone that first begin as lucent bands on radiographs, caused by the buildup of poorly mineralized osteoid. As the unmineralized osteoid accumulates on the surface of the bone, the weakened state then leads to minor cracks under regular or stressful loading, which if not treated can result in full blown fractures (Jennings *et al.* 2018). Individuals who were determined to have vitamin D deficiency were included in the study, however, any healing fractures that showed spiculated bone were listed as pathological and were not included in any parts of the results or analysis, as they were likely associated with bone insufficiency. Only one individual contained a pathological long bone fracture, to the distal third of the right ulna (MIC 767). When individuals had healed fractures as well as psuedofractures, the healed fractures were counted in the fracture assessment, as there is no way to determine whether the fracture was pathological in nature or caused by other factors.

3.4.3 True Prevalence and Crude Prevalence

Within each sample, calculating fracture prevalence permits assessment of how widespread injury is within a sample. Prevalence allows for pattern-based assessments, such as the differences between age and sex groups. In bioarchaeology, studies have traditionally analyzed the crude prevalence (CPR) of fractures across samples (Gilmour *et al.* 2015; Judd 2002a). Crude prevalence approximates individuals with and without fractures and treats individuals as whole and complete (Equation 3.3).

$$\textbf{Equation 3.3}\ \boldsymbol{Crude\ Prevalence} = \frac{number\ of\ individuals\ with\ fractures}{number\ of\ individuals\ within\ the\ sample}\ x\ 100$$

True prevalence, however, examines the number of elements preserved instead of the individual as a whole (Equation 3.4). True prevalence accounts for varying levels of preservation across individuals and provides a more accurate picture of elements that were analyzed compared to the elements that were fractured (Judd 2002a). True prevalence was calculated by the presence of at least one segment at >75% for long bones. Ribs were calculated as individual elements based on the evidence of proximal heads.

$$\boldsymbol{Equation\ 3.4\ True\ Prevalence} = \frac{Number\ of\ Fractured\ Elements}{Number\ of\ Elements\ with\ a\ Segment\ at\ {>}75\%}\ x\ 100$$

3.4.3.1 Prevalence Comparisons between Samples

Archaeological data suffers from a variety of issues, such as sample size and structure (Klaus 2014). When comparing frequencies and prevalence between samples these issues must be accounted for and addressed accordingly, where possible (Glencross and Sawchuck 2003; Klaus 2014). Differences in age and sex can affect the how prevalence is interpreted and displayed. To account for, this there have been several proposed measures, described by Klaus (2014), such as weighting of age and sex, the use of odds ratios, and person-years, all used to varying degrees.

As the primary function of this study is to compare five different samples from five different sites, two different methods were adopted to combat the differences between age and sex structures in the skeletal samples. To accompany 2 x 2 chi-square tests, odds ratios were employed to test the strength of this relationship and were calculated by hand following Equation 3.5 (Klaus 2014; Gilmour *et al.* 2019).

$$\textbf{Equation 3.5}\ \boldsymbol{Odds\ Ratio} = \frac{a * d}{b * c}\ OR\ \frac{a/b}{c/d}$$

Odds ratios, like other measures of association, account for the variability of data and allow for differences within a sample between males and females, such as a high proportion of females, or a higher proportion of males (Klaus 2014; Collier and Primeau 2019). While not a test of statistical significance, odds ratios allow researchers to examine the strength of differences without engaging in reweighting the data (Klaus 2014; Szumilas 2010). Odds ratios were initially proposed by Waldron (1994) to combat the differences between data structures, but the method has rarely been applied. Table 3.6

lists how to interpret odds ratios in this study. Additionally, rather than compare whole communities with different structures, communities were divided into age and sex categories when significant, and these were then compared.

Table 3.6 Table to Interpret Odds Ratio Values*

Odds Ratio Value	Significance
OR = 1	The odds of either group are equal and do not increase or decrease
OR = <1	The odds for exposure/event are lower based on the factor
OR = >1	The odds for exposure/event are greater based on the factor

*taken from Szumalis (2010).

3.4.4 Statistical Tests

Statistics for this study were run using IBM SPSS 24.0 and socialsciencestatistics.com. Fracture frequency and preservation were compared using chi-square, following the methods of Gilmour *et al.* (2015) and Judd (2002a). Chi-square (X^2) was deemed appropriate as a non-parametric test that requires categorical data. In samples with less than 1 in the expected count, or less than 5 in over 20% of the cells listed, Fisher's Exact Test (P_{FET}) was used in place of the Chi-Square, as it provides a true count and is useful for smaller sample sizes (Agresti and Franklin 2013). A Yates (X^2_{YATES}) continuity correction was applied to small sample sizes when a 2x2 contingency table was compared (Gilmour *et al.* 2015). The p-value for all tests was set at .05 significance.

The p-values on all post-hoc tests and subsampling were corrected with a hand-calculated Bonferroni correction (Equation 3.6). The size of the p-value required for significance is provided below each of the tables. Corrections were used when samples were tested multiple times to correct for family-wise (Type 1) errors (Agresti and Franklin 2013). While conservative, the Bonferroni correction ensures no data is deemed statistically significant due to multiple tests (Agresti and Franklin 2013).

$$\textbf{Equation 3.6 } \boldsymbol{Bonferroni\ Correction} = \frac{0.05}{\#\ of\ tests\ performed} = reduced\ p - value$$

To account for sample size in preservation analysis, Cramer's *V* was applied as a post-hoc measure to all preservation statistics. Cramer's *V* was hand-calculated following the equation below (Equation 3.7), then interpreted following the strength of association provided in Table 3.7, and was determined to be necessary as preservation samples exceeded 5000 segments (Cohen 1988). Chi-square can be influenced by sample size, and with large sample sizes results can be designated as significant when only minute changes have occurred (Gingrich 1992). A measure of association in this case allows for researchers to see how the two variables being examined (long bone present/absent and age, for example) are associated, and is considered an effect size measure.

$$\textbf{Equation 3.7 } \boldsymbol{Cramer's\ V} = \sqrt{\frac{Chi - Square\ Value}{Sample\ Size\ (Smaller\ Degree\ of\ Freedom - 1)}}$$

Table 3.7 Table of Cramer's V Interpretation Used in this Study*

Cramer's V Value	Degree of Freedom	Interpretation
.10	1	Small effect (weak association)
.30	1	Medium effect (moderate association)
.50	1	Large effect (great association)
.07	2	Small effect (weak association)
.21	2	Medium effect (moderate association)
.35	2	Large effect (great association)

*Taken from Cohen (1988)

CHAPTER 4 RESULTS

4.1 Introduction

This chapter presents the results of fracture analysis on 1121 skeletons from one Roman *vicus* (Vagnari), one Roman small town (Godmanchester), and three urban *civitas* (Winchester, Barcelona, and Lisieux Michelet). The chapter begins with an overview of the preservation of long bones and rib segments and whether they differ in each of the key variables (age, sex, and burial treatment). The crude prevalence (CPR) of fractures and multiple fractures are examined using the same key variables, followed by an examination of the confluence of burial and age, and burial and sex at each site. The crude prevalence of fractures and multiple fractures are then compared between large and small settlements, divided by age and sex. Finally, the location and elements with fractures are explored at each of the sites. Statistical results and prevalence data are provided throughout the chapter, and each individual with fractures is provided in Appendix B.

4.2 Preservation

In this section, the overall preservation of long bones and ribs is compared within a site by sex, age, and burial type to consider how fracture prevalence is related to prevalence. To account for sample size and provide a measure of association, a Cramer's V is presented along with the Chi-Square statistic using Equation 3.7, with the scale of weak, moderate, and strong association taken from Cohen (1988) as presented in Chapter 3, Table 3.7. The survival index is calculated following Judd (2002a), using Equation 3.2.

4.2.1 Long Bone Preservation

The long bone survival index for each sample is as follows: Lisieux Michelet 55.7%; Winchester 46.9%; Barcelona 58.8%; Vagnari 43.1%; and Godmanchester 65.4%. The number of long bones present and absent for each sample is displayed in Figure 4.1

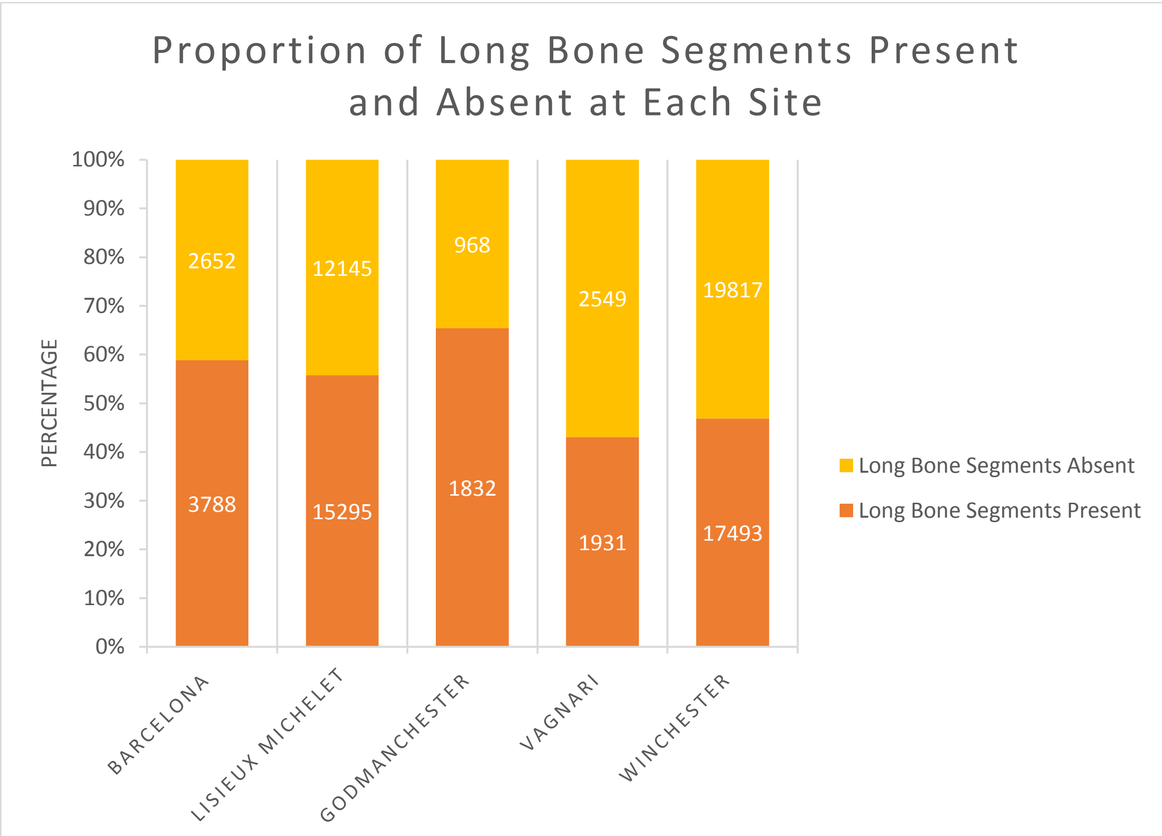


Figure 4.1 Proportion of Long Bones Preserved at Each Site. Raw data is listed in the associated bars.

4.2.1.1 Long Bone Preservation by Age

Long bone preservation differed between age categories in all samples, with data provided in Table 4.1. At all sites, preservation was the lowest in Adult Undetermined individuals. At Lisieux Michelet and Godmanchester, long bone preservation decreased as age categories increased, with the greatest preservation occurring in older adolescent individuals and the least in Old Adults (Table 4.1). In the Barcelona, Vagnari, and Winchester skeletal samples, preservation was the greatest in differing age categories (Table 4.1). Differences in preservation between age categories were significant at all sites, but moderately associated at only Lisieux Michelet and Godmanchester (Table 4.2).

Table 4.1 Long Bone Segment Preservation at Each Site by Age Categories.

Site	**Older Adolescent**	**Young Adult**	**Middle Adult**	**Old Adult**	**Adult Undetermined**	**Total**
Lisieux Michelet	1112/1540* (72.2%)	6178/9310 (66.4%)	3317/5040 (65.8%)	3709/6860 (54.1%)	979/4690 (20.9%)	**15295/27440 (55.7%)**
Winchester	1093/1890 (57.8%)	7296/15610 (48%)	4485/7350 (61%)	3585/6580 (54.5%)	1034/5880 (17.6%)	**17493/37310 (46.9%)**
Barcelona	267/490 (54.5%)	1495/2170 (68.9%)	528/840 (62.9%)	902/1750 (51.5%)	596/1190 (50.1%)	**3788/6440 (58.8%)**
Vagnari	252/420 (60%)	1003/2520 (39.8%)	405/700 (57.9%)	180/350 (51.4%)	91/490 (18.6%)	**1931/4480 (43.1%)**
Godmanchester	212/280 (75.7%)	578/770 (75.1%)	632/840 (75.2%)	379/700 (54.1%)	31/210 (24.3%)	**1832/2800 (65.4%)**
Combined	**2936/4620 (63.5%)**	**16550/30380 (54.5%)**	**9367/14770 (63.4%)**	**8755/16240 (53.9%)**	**2731/12460 (21.9%)**	**40339/78470 (51.4%)**

[1]Percentages on the bottom indicate the prevalence of the segments preserved.
*Ratio presented is the segments present versus the segments calculated following Judd (2002a).

Table 4.2 Results of Long Bone Preservation Comparison Between Age Categories.[1]

Site	Chi - Square (X^2)	Degrees of Freedom (df)	*p* value	Cramer's V^2	Cramer's V Degrees of Freedom[2]	Cramer's *V* Interpretation
Lisieux Michelet	3120.055	df = 4	0.000	.331	df =1	Moderate Association
Winchester	2860.366	df = 4	0.000	.246	df =1	Weak Association
Barcelona	176.118	df = 4	0.000	.165	df = 1	Weak Association
Vagnari	252.36	df = 4	0.000	.237	df = 1	Weak Association
Godmanchester	359.188	df = 4	0.000	.357	df = 1	Moderate Association

[1]Light blue cells indicate moderate association
[2]Refer to Equation 3.7

4.2.1.2 Long Bone Preservation by Sex

Apart from Barcelona, male skeletons were better preserved in all samples. At Barcelona, females had a higher overall survival index than males (Table 4.3). Undetermined individuals had the lowest preservation at four of the five sites; at Godmanchester, ambiguous individuals had the lowest preservation. The differences in preservation between males and females were statistically significant for all sites but weakly associated, indicating that statistically significant differences were small (Table 4.4).

Table 4.3 Long Bone Preservation at Each Site by Sex Categories.

Site	**Male**	**Ambiguous**	**Female**	**Undetermined**	**Total**
Lisieux Michelet	6435/9660* (66.6%)	825/1610 (51.2%)	7295/11970 (61.2%)	275/840 (32.7%)	**15295/27440 (55.7%)**
Winchester	7679/12810 (59.9%)	954/2240 (42.6%)	7413/14000 (53%)	1447/8260 (17.5%)	**17493/37310 (46.9%)**
Barcelona	2063/3430 (60.1%)	0/0 (0%)	1569/2450 (64%)	156/560 (27.9%)	**3788/6440 (58.8%)**
Vagnari	1075/2030 (53%)	0/0 (0%)	720/1820 (39.6%)	136/630 (21.6%)	**1931/4480 (43.1%)**
Godmanchester	1096/1330 (82.4%)	61/210 (29%)	540/840 (64.3%)	135/420 (32.1%)	**1832/2800 (65.4%)**
Combined	**18348/29260 (62.7%)**	**1840/4060 (45.3%)**	**17537/31080 (56.4%)**	**2149/10710 (20.1%)**	**40339/78470 (51.4%)**

[1]Percentages below indicate the overall prevalence of the segments preserved
*Ratio presented is the segments present versus the segments calculated following Judd (2002a).

Table 4.4 Results of Long Bone Preservation Comparison Between Males and Females.

Site	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	***p* value**	**Cramer's *V*[1]**	**Cramer's V Degrees of Freedom**	**Cramer's *V* Interpretation**
Lisieux Michelet	73.909	df = 1	0.000	.058	df =1	Weak Association
Winchester	73.662	df = 1	0.000	.052	df =1	Weak Association
***Barcelona*[2]**	*68.704*	*df = 1*	*0.000*	*.221*	*df = 1*	*Weak Association*
Vagnari	65.68	df = 1	0.000	.13	df = 1	Weak Association
Godmanchester	91.48	df = 1	0.000	.2038	df = 1	Weak Association

[1]Refer to Equation 3.7
[2]Italicized cells indicate females have greater preservation than males.

4.2.1.3 Long Bone Preservation by Burial Type

At Winchester, the best preservation occurred in individuals in lead coffins (67.1%), while at Lisieux Michelet, Godmanchester, and Barcelona, individuals in coffin burials had the best preservation, and at Vagnari it was individuals in pit burials (Table 4.5). Not all types of burial were found at each site, however. Differences between burial types at four of the five sites were significant, while at Vagnari the difference in preservation between burial types was not significant (Table 4.6). While differences were significant at all four sites, it was only at Lisieux Michelet that preservation was moderately associated with burial type.

Table 4.5 Preservation of Long Bones at Each Site by Burial Type.[1]

Site						
Winchester	**Coffin**	**Pit**	**Lead Coffin**	**Possible Coffin**	**Stepped Grave**	**Total**
	12464/28560 (43.6%)	3179/5180 (61.4%)	47/70 (67.1%)	1155/2170 (53.2%)	648/1330 (48.7%)	17493/37310 (46.9%)
Lisieux Michelet	**Coffin**	**Pit**	**Sarcophagus**	**Tile**	**Total**	
	12900/19880 (64.9%)	1988/6650 (29.9%)	208/560 (37.1%)	199/350 (56.9%)	15295/27440 (55.7%)	
Barcelona	**Coffin**	**Pit**	**Tile**	**Amphora**	**Total**	
	325/490 (66.9%)	1793/2870 (62.5%)	1684/2940 (57.3%)	66/140 (47.1%)	3788/6440 (58.8%)	
Vagnari	**Tile/ Disturbed**	**Pit**	**Cappuccina**	**Libation**	**Total**	
	96/210 (45.7%)	128/280 (45.7%)	1580/3710 (42.6%)	127/280 (45.4%)	1931/4480 (43.1%)	
Godmanchester	**Coffin**	**Pit**	**Total**			
	578/770 (75.1%)	1467/2310 (63.5%)	1832/2800 (65.4%)			

[1]Percentages on the bottom indicate the overall true prevalence of preserved segments.

Table 4.6 Results of Long Bone Preservation Comparison Between Burial Types.[1]

Site	Chi - Square (X^2)	Degrees of Freedom (df)	*p* value	Cramer's V^2	Cramer's V Degrees of Freedom	Cramer's *V* Interpretation
Lisieux Michelet	2476.58	df = 4	0.000	.305	df =1	Moderate association
Winchester	605.497	df = 4	0.000	.127	df =1	Weak association
Barcelona	16.440	df = 3	0.001	.05	df = 1	Weak association
Vagnari[3]	2.344	df = 3	0.504	-	-	-
Godmanchester	21.026	df = 2	0.000	.086	df = 1	Weak association

[1]Light blue cells indicate moderate association
[2]Refer to Equation 3.7
[3]Light pink indicates no statistical significance.

4.2.2 Rib Preservation

Rib preservation varied between sites. Ribs were best preserved at Godmanchester and least preserved at Vagnari. Rib preservation is summarized in Figure 4.2 and Table 4.7.

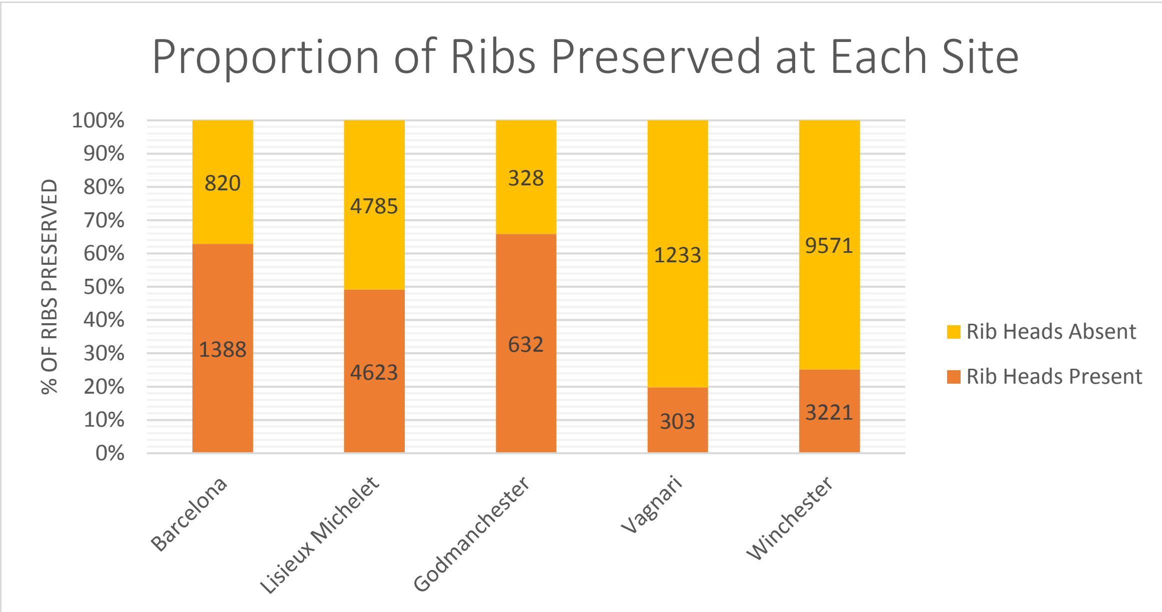


Figure 4.2 Proportion of Ribs Preserved at Each Site. Raw data is provided in the figure bars.

4.2.2.1 Rib Preservation by Age

Middle adults have the greatest rib preservation at Winchester (37.8%), Barcelona (80.9%), and Godmanchester (74.7%). At Vagnari (60%) and Lisieux Michelet (83.7%), older adolescents have the greatest preservation. Adult undetermined individuals have the least preservation at all sites; however, at Barcelona, this is a difference of 0.4% (Table 4.7). At all sites, the differences between age categories and rib preservation are significant; however, only at Lisieux Michelet is preservation and age moderately associated (Table 4.8).

Table 4.7 Rib Preservation at Each Site by Age.[1]

Site	**Older Adolescent**	**Young Adult**	**Middle Adult**	**Old Adult**	**Adult Undetermined**	**Total**
Lisieux Michelet	442/528 (83.7%)	1874/3192 (58.7%)	1075/1728 (62.4%)	1039/2352 (44.2%)	193/1608 (12%)	**4623/9408 (49.1%)**
Winchester	222/648 (34.3%)	1278/5352 (23.8%)	952/2520 (37.8%)	699/2256 (31%)	70/2016 (3.4%)	**3221/12792 (25%)**
Barcelona	93/168 (55.4%)	472/744 (63.4%)	233/288 (80.9%)	365/600 (60.8%)	225/408 (55.1%)	**1388/2208 (62.9%)**
Vagnari	252/420 (60%)	143/864 (16.6%)	89/240 (37.1%)	20/120 (16.7%)	14/168 (8.3%)	**303/1536 (19.7%)**
Godmanchester	62/96 (64.6%)	193/264 (73.1%)	215/288 (74.7%)	129/240 (53.8%)	33/72 (45.8%)	**632/960 (65.8%)**
Combined	**1071/1860 (57.8%)**	**3960/10416 (38%)**	**2564/5064 (50.6%)**	**2252/5568 (40.4%)**	**535/4272 (12.5%)**	**10167/26940 (37.7%)**

[1] Percentages below indicate the overall prevalence of segments present.

Table 4.8 Results of Rib Preservation Comparison Between Age Categories.[1]

Site	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	***p* value**	**Cramer's V^2**	**Cramer's V Degrees of Freedom**	**Cramer's *V* Interpretation**
Lisieux Michelet	1207.231	df = 4	0.000	.358	df =1	Moderate Association
Winchester	807.148	df = 4	0.000	.251	df =1	Weak Association
Barcelona	55.771	df = 4	0.001	.158	df = 1	Weak Association
Vagnari	68.881	df = 4	0.000	.211	df = 1	Weak Association
Godmanchester	44.617	df = 4	0.000	.21	df = 1	Weak Association

[1]Light blue cells indicate moderate association
[2]Refer to Equation 3.7

4.2.2.2 Rib Preservation by Sex

At all sites, males had the greatest number of proximal ribs heads, while undetermined individuals had the least (Table 4.9). Differences between males and females were only statistically significant at Lisieux Michelet and Winchester and were weakly associated, indicating that differences which were statistically significant were likely small (Table 4.10).

Table 4.9 Rib Preservation at Each Site by Sex.[1]

Site	**M**	**AM**	**F**	**UD**	Total
Lisieux Michelet	2015/3312 (60.8%)	204/552 (37%)	2273/4104 (55.4%)	131/1440 (9.1%)	**4623/9408 (49.1%)**
Winchester	1644/4392 (37.4%)	97/768 (12.6%)	1436/4800 (29.1%)	44/2832 (1.5%)	**3221/12792 (25%)**
Barcelona	800/1176 (68%)	0/0 (0%)	541/840 (64.4%)	47/192 (24.5%)	**1388/2208 (62.9%)**
Vagnari	154/696 (22.1%)	0/0 (0%)	135/624 (21.6%)	14/216 (6.5%)	**303/1536 (19.7%)**
Godmanchester	328/456 (71.9%)	48/72 (66.7%)	190/288 (66%)	66/144 (45.8%)	**632/960 (65.8%)**
Combined	**4941/10032 (49.3%)**	**348/1392 (25%)**	**4575/10656 (42.9%)**	**302/4824 (6.3%)**	**10167/26904 (37.8%)**

[1]Percentages below indicate the overall preservation of each category.

Table 4.10 Results of Rib Preservation Comparison Between Males and Females.[1]

Site	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	***p* value**	**Cramer's V^2**	**Cramer's V Degrees of Freedom**	**Cramer's *V* Interpretation**
Lisieux Michelet	**24.789**	df = 1	0.000	0.051	df =1	Weak association
Winchester	**57.59**	df = 1	0.000	0.079	df =1	Weak association
Barcelona	2.72	df = 1	0.0986	-	-	-
Vagnari	.02	df = 1	0.881	-	-	-
Godmanchester	2.68	df = 1	0.1011	-	-	-

[1]Light pink cells indicate no statistical significance.
[2]Refer to Equation 3.7

4.2.2.3 Rib Preservation by Burial Type

At Lisieux Michelet, the individuals in the eight sarcophagi had the least preservation (20.8%). At Winchester, individuals in coffin burials had ribs with the lowest preservation (21.1%), while at Barcelona, individuals in tile burials had the least preserved ribs (61.3%) (Table 4.11). At all sites, differences in the preservation of ribs according to burial type were statistically significant but had a weak association, indicating that differences which are statistically significant were small (Table 4.12).

Table 4.11 Rib Preservation at Each Site by Burial Type.[1]

Site						
Winchester	**Coffin**	**Pit**	**Lead Coffin**	**Possible Coffin**	**Stepped Grave**	**Total**
	2059/9792 (21.1%)	760/1776 (42.8%)	20/24 (83.3%)	225/744 (30.2%)	157/456 (34.4%)	3221/12792 (25%)
Lisieux Michelet	**Coffin**	**Pit**	**Tile**	**Sarcophagus**	**Total**	
	3977/6816 (58.3%)	546/2280 (22.8%)	60/120 (50%)	40/192 (20.8%)	4623/9408 (49.1%)	
Barcelona	**Coffin**	**Pit**	**Tile**	**Amphora**	**Total**	
	139/168 (82.7%)	631/984 (64.1%)	618/1008 (61.3%)	0/48 (0%)	1388/2208 (62.9%)	
Vagnari	**Tile/ Disturbed**	**Pit**	**Cappuccina**	**Libation**	**Total**	
	17/72 (23.6%)	5/96 (5.2%)	272/1272 (21.38%)	9/96 (9.4%)	303/1536 (19.7%)	
Godmanchester	**Coffin**	**Pit**	**Total**			
	193/264 (73.1%)	489/792 (61.7%)	632/960 (65.8%)			

[1]Percentages below indicate the preservation of the category

Table 4.12 Results of Rib Preservation Comparison Between Burial Types.[1]

Site	Chi - Square (X^2)	Degrees of Freedom (df)	*p* value	Cramer's V^2	Cramer's V Degrees of Freedom	Cramer's *V* Interpretation
Lisieux Michelet	843.527	df = 3	0.000	.29	df =1	Weak Association
Winchester	437.062	df = 4	0.000	.184	df =1	Weak Association
Barcelona	93.144	df = 3	0.001	.205	df = 1	Weak Association
Vagnari	22.16	df = 3	0.000	.120	df = 1	Weak Association
Godmanchester	32.651**	df = 1	0.000	.184	df = 1	Weak Association

[1]Light blue cells indicate moderate association
[2]Refer to Equation 3.7
**Corrected with a Yates Correction for Continuity (X^2YATES).

4.3 Fracture Prevalence Within Sites

In this section, the crude prevalence of fractures is presented for each sample based on age, sex, and burial type categories to consider how fractures prevalence varied in relation to aspects of social identity. Pairwise comparisons were completed for statistically significant results to examine which categories had the greatest difference, with a Bonferroni correction applied to the *p*-value to account for multiple tests. For sex category comparisons, ambiguous and undetermined individuals are included in the overall prevalence tables; however, only males and females are compared statistically to present clear results. Complete fracture data can be found in Appendix B.

Table 4.13 Crude Prevalence of Individuals with Fractures at Each Settlement by Age and Sex.[1]

Sample		Male	Ambiguous	Female	Undetermined	Combined
Lisieux Michelet	**Older Adolescent**	0/5	0/0	2/17 (11.8%)	0/0	**2/22 (9%)**
	Young Adult	9/47 (19.1%)	1/9 (11.1%)	1/68 (1.5%)	0/9	**11/133 (9.7%)**
	Middle Adult	6/42 (14.3%)	0/5	2/22 (9%)	1/3 (33.3%)	**9/72 (12.5%)**
	Old Adult	10/40 (25%)	2/6 (33.3%)	6/49 (12.2%)	0/3	**18/98 (18.4%)**
	Adult	0/4	0/3	0/15	0/45	**0/67**
	Combined	**25/138**	**3/23**	**11/171**	**1/60**	**40/392**

		(18.1%)	(13%)	(6.4%)	(1.7%)	(10.2%)
Winchester		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/6	0/2	0/15	0/4	**0/27**
	Young Adult	7/78 (9%)	0/10	7/97 (7.2%)	2/38 (5.3%)	**16/223 (7.2%)**
	Middle Adult	17/58 (29.3%)	2/6 (33%)	2/27 (7.4%)	0/14	**21/105 (20%)**
	Old Adult	7/27 (26%)	2/10 (20%)	11/56 (19.4%)	0/1	**20/94 (21.3%)**
	Adult	2/14 (14.3%)	0/4	0/5	4/61 (6.6%)	**6/84 (7.1%)**
	Combined	**33/183 (18%)**	**4/32 (12.5%)**	**20/200 (10%)**	**6/118 (5.1%)**	**63/533 (11.8%)**
		Male	**Ambiguous**	**Female**	**Undetermined**	**Combined**
Barcelona	**Older Adolescent**	0/5		0/2		**0/7**
	Young Adult	4/18 (22.2%)		3/11 (27.2%)	0/2	**7/31 (22.6%)**
	Middle Adult	2/7 (28.6%)		1/5 (20%)		**3/12 (25%)**
	Old Adult	5/14 (35.7%)		3/10 (30%)	0/1	**8/25 (32%)**
	Adult	2/5 (40%)		2/7 (28.5%)	0/5	**4/17 (23.5%)**
	Combined	13/49 (26.5%)		9/35 (25.7%)	0/8	**22/92 (23.9%)**
Vagnari		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/1		0/4	0/1	**0/6**
	Young Adult	1/16 (6.25%)		2/15 (13.3%)	1/5 (20%)	**4/36 (11.1%)**
	Middle Adult	3/8 (37.5%)		1/2 (50%)		**4/10 (40%)**
	Old Adult	1/2 (50%)		0/2	0/1	**1/5 (20%)**
	Adult	0/2		0/3	0/2	**0/7**
	Combined	**5/29 (17.2%)**		**3/26 (11.5%)**	**1/9 (11.1%)**	**9/64 (14.1%)**
Godmanchester		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/1		0/2	0/1	**0/4**
	Young Adult	0/7	0/1	0/2	0/1	**0/11**
	Middle Adult	3/7 (42.9%)	1/1 (100%)	0/4		**4/12 (33.3%)**
	Old Adult	0/4	0/1	0/4	1/1 (100%)	**1/10 (10%)**
	Adult				0/3	**0/3**
	Combined	**3/19 (15.8%)**	**1/3 (33.3%)**	**0/12**	**1/6 (16.7%)**	**5/40 (12.5%)**

---

[1]Percentages below indicate the prevalence of fractures in each age/sex category.

4.3.1 Fracture Prevalence Between Age Categories

At Winchester (21%), Barcelona (32%), and Lisieux Michelet (18.1%), old adults have the highest prevalence of fractures. In the same three samples, fractures increase as age increases, while at Godmanchester and Vagnari, fracture prevalence peaks in middle adults (Table 4.13). At Winchester, the differences between the crude prevalence of fractures between age categories is statistically significant (Table 4.14), and further pairwise comparisons of crude prevalence show that the differences between young adults and middle adults (**X^2= 11.3, *p*=.000615, OR = 3.23, CI 1.6-6.5**) as well as young adults and old adults (**X^2= 13.06, *p*=.000302, OR = 3.69, CI 1.81-7.52**) are statistically significant. At Lisieux Michelet, the differences in crude prevalence between age categories were statistically significant (Table 4.14). However, further pairwise comparisons had a nonsignificant *p*-value following a Bonferroni correction (Equation 3.6). Complete pairwise comparisons for both Winchester and Lisieux Michelet can be found in Appendix C. Differences of crude prevalence between age categories at Barcelona, Godmanchester, and Vagnari are not significant (Table 4.14).

Table 4.14 Results of Comparison of Crude Prevalence of Fractures Between Age Categories at Each Settlement.[1]

Site	Chi -Square (X^2)	Degrees of Freedom (df)	Fisher's Exact (P_{FET})	*p* value
Lisieux Michelet*	**-**	**df = 3**	**0.001**	**-**
Winchester*	**24.80**	**df = 3**	**-**	**0.000**
Barcelona	-	df = 3	0.588	-
Vagnari	-	df = 2	0.067	-
Godmanchester	-	df = 1	0.323	-

[1]Blue shaded cells and bold are statistically significant.
*Pairwise comparisons of crude prevalence can be found in the Appendix C.

4.3.2 Sex Differences in Fracture Prevalence

At Winchester (18%), Lisieux Michelet (18.1%), Vagnari (17%) and Barcelona (27%), males have a higher crude prevalence of fractures than females. At Barcelona, this is a marginal difference of 27% versus 26% (Table 4.13). Ambiguous individuals have a greater prevalence of fractures at Godmanchester (33%) than either males or undetermined individuals; no females had fractures. Complete crude prevalence of fractures at each site are presented in Table 4.13.

Differences between males and females are only significant at Lisieux Michelet and Winchester (Table 4.15). At Lisieux Michelet, males are 3.218 times more likely to have sustained a fracture than females, while at Winchester the males are only 1.98 more likely to have sustained a fracture (Table 4.15). As Godmanchester had no females with fractures, sex comparisons were not performed.

Table 4.15 Results of Comparisons of Crude Prevalence Between Males and Females at Each Settlement.[1]

Site	Chi -Square (X^2YATES)	Degrees of Freedom (df)	Fishers Exact (PFET)	*p* value	Odds Ratio A*D/B*C
Lisieux Michelet	**9.024**	**df = 1**	-	**0.002**	**3.218**
Winchester	**4.5198**	**df = 1**	-	**0.033**	**1.980**
Barcelona	-	df = 1	0.292	-	1.04
Vagnari	-	df = 1	0.704	-	1.59
Godmanchester*	-	-	-	-	-

[1]Light blue shaded cells indicate statistically significant tests
*Sex comparisons were not completed for Godmanchester as no females had fractures.

4.3.3 Fracture Prevalence Between Burial Types

At Lisieux Michelet the individuals with the highest prevalence of fractures are buried in tile burials (20%) and the lowest prevalence occurred in individuals in pit burials (6.5%). At Winchester, individuals in pit burials have the greatest prevalence of fractures (22.7%), while those in stepped graves have the least (5.3%) (Table 4.16). Individuals with fractures were found only in libation (50%) or *cappuccina* burials (13.2%) at Vagnari. At Godmanchester, there are only two types of burials (pits and coffins), and fractures were only found in individuals buried in pits (15.1%). Apart from Winchester, differences in crude prevalence of fractures between burial types were not significant (Table 4.17).

Pairwise comparisons at Winchester show the differences between pit and coffin burials to be statistically significant (**X^2YATES = 8.7, *p*=.003182, OR = 2.67, CI 1.42-5.01**), with individuals in pit burials 2.67 times more likely to have a sustained a fracture, while all other pairs are not. Complete pairwise comparisons for Winchester can be found in Appendix C.

Table 4.16 Crude Prevalence of Individuals with Fractures at Each Settlement by Burial Types.

Winchester	**Coffin**	**Pit**	**Lead Coffin**	**Possible Coffin**	**Stepped Grave**	**Total**
	41/408 (10%)	17/74 (22.7%)	0/1 (0%)	4/31 (12.1%)	1/19 (5.3%)	63/533 (11.8%)
Lisieux Michelet	**Coffin**	**Pit**	**Sarcophagus**	**Tile**	**Total**	
	32/284 (11.3%)	6/95 (6.3%)	1/8 (12.5%)	1/5 (20%)	40/392 (10.2%)	
Barcelona	**Coffin**	**Pit**	**Tile**	**Amphora**	**Total**	
	1/8 (12.5%)	10/40 (25%)	11/42 (26.2%)	0/2 (0%)	22/92 (23.9%)	
Vagnari	**Tile/ Disturbed**	**Pit**	**Cappuccina**	**Libation**	**Total**	
	0/3 (0%)	0/4 (0%)	7/53 (13.2%)	2/4 (50%)	9/64 (14.1%)	
Godmanchester	**Coffin**	**Pit**	**Total**			
	0/7 (0%)	5/33 (15.1%)	5/40 (12.5%)			

Table 4.17 Results of Comparisons of Crude Prevalence Between Burial Types at Each Settlement.[1]

Site	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (*P*FET)**	***p* value**
Lisieux Michelet	-	df = 4	.248	-
Winchester*	**-**	**df = 3**	**.032**	**-**
Barcelona	-	df = 1	.927	-
Vagnari	-	df = 2	.113	-
Godmanchester	-	df = 2	.564	-

[1]Significant results are bold and in blue shaded cells
*Pairwise comparisons were performed and found in Appendix C.

4.4 Cross Cutting Variables with Burial

To consider how fracture prevalence differs when comparing the intersection of identities, in this section, age and sex are compared with crude prevalence within all types of burials for each of the sites using Chi-Square and Fisher's Exact Test to examine how the prevalence of fractures changes between age and sex categories when examined from within types of burials versus the overall sample. All *p*-values are adjusted using a Bonferroni Correction (Equation 3.6) to account for subsampling, with the reduced *p*-value provided below the table.

4.4.1 Lisieux Michelet

While old adults have greater fractures in the total sample (Table 4.13) at Lisieux Michelet, older adolescents (66.6%) have greater prevalence in pit burials; however, differences between age categories are not significant (Tables 4.18 and Tables 4.19). The difference in fracture prevalence between males and females is greater for individuals in coffin burials (19.3% versus 5.2%), and is statistically significant, with males 4.33 times more likely to have sustained a fracture (Table 4.19) while for individuals in pit burials, the difference is .5% and is not statistically significant. Cross cuts of sarcophagus and tile burials were not performed as each type of burial had a single individual.

Table 4.18 Prevalence of Fractures in Cross Cutting Burial Types at Lisieux Michelet.

Coffin		Males	Ambiguous	Females	UD	Total
	Older Adolescent	0/4 (0%)	0/0	0/14 (0%)	0/0	**0/18 (0%)**
	Young Adult	8/39 (20.5%)	1/7 (14.3%)	1/58 (1.7%)	0/6 (0%)	**10/110 (9%)**
	Middle Adult	6/39 (15.4%)	0/5 (0%)	2/18 (11.1%)	0/0	**8/62 (12.9%)**
	Old Adult	8/31 (25%)	2/6 (33.3%)	4/34 (11.8%)	0/1 (0%)	**14/72 (19.4%)**
	Adult Undetermined	0/1 (0%)	0/3 (0%)	0/10 (0%)	0/8 (0%)	**0/22 (0%)**
	Total	**22/114 (19.3%)**	**3/21 (14.3%)**	**7/134 (5.2%)**	**0/15 (0%)**	**32/284 (11.2%)**
Pit		**Males**	**Ambiguous**	**Females**	**UD**	**Total**
	Older Adolescent	0/0	0/0	2/3 (66.6%)	0/0	**2/3 (66.6%)**
	Young Adult	1/7 (14.3%)	0/2 (0%)	0/8 (0%)	0/3 (0%)	**1/20 (5%)**
	Middle Adult	0/3 (0%)	0/0	0/4 (0%)	1/1 (100%)	**1/8 (25%)**
	Old Adult	1/8 (25%)	0/0	1/10 (10%)	0/2 (0%)	**2/20 (10%)**
	Adult Undetermined	0/3 (0%)	0/0	0/5 (0%)	0/36 (0%)	**0/44 (0%)**
	Total	**2/21 (9.5%)**	**0/2 (0%)**	**3/30 (10%)**	**1/42 (2.4%)**	**6/95 (6.3%)**

Table 4.19 Results of Comparison of Crude Prevalence Within Burial Types Between Age and Sex Categories at Lisieux Michelet.[1]

	Age Comparisons				*Sex Comparisons*				
Burial Type	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (P_{FET})**	***p* value**	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (P_{FET})**	***p* value**	**Odds Ratio**
Coffin	4.1	df = 2	-	.128	**10.49***	**df = 1**	**-**	**.001**	**4.33**
Pit	-	df = 3	.054	-	-	df = 1	1	-	1.05

[1]P-value was adjusted to .0125 using Equation 3.6.
*Blue cells indicate statistically significant results.

4.4.2 Winchester

At Winchester, in pit and possible coffin burials, middle adults have the greatest prevalence of fractures (36% and 25%), which is different than the overall sample, in which old adults have the greatest overall prevalence by a difference of 1% (Table 4.13). Differences between age categories were only significant between individuals in coffin burials. (Table 4.21). While the differences between males and females was not significant in each type of burial, the odds of males having fractures increases in coffin burials (Table 4.21), when compared to the overall sample (Table 4.20) As stepped graves and lead coffins only had one individual with fractures, they were not examined.

Table 4.20 Prevalence of Fractures in Cross Cutting Burial Types at Winchester.

Coffin		**Males**	**Ambiguous**	**Females**	**UD**	**Total**
	Older Adolescent	0/5 (0%)	0/1	0/11 (0%)	0/4	**0/21 (0%)**
	Young Adult	6/64 (9.4%)	0/8	4/76 (5.3%)	2/34 (6.7%)	**12/182 (6.7%)**
	Middle Adult	9/39 (23.1%)	0/4 (0%)	1/14 (7.1%)	0/14	**10/71 (14.1%)**
	Old Adult	6/20 (30%)	1/6 (16.7%)	8/37 (21.6%)	0/1	**15/64 (23.4%)**
	Adult Undetermined	2/10 (20%)	0/4	0/5	2/51 (3.9%)	**4/70 (5.7%)**
	Total	**23/138 (16.7%)**	**1/23 (4.3%)**	**13/143 (9.1%)**	**4/104 (3.8%)**	**41/408 (10%)**
Pit		**Males**	**Ambiguous**	**Females**	**UD**	**Total**
	Older Adolescent	0/1 (0%)	0/0	0/3 (0%)	0/0	**0/4 (0%)**
	Young Adult	1/8 (12.5%)	0/0	2/10 (20%)	0/2 (0%)	**3/20 (15%)**
	Middle Adult	7/14 (50%)	1/1 (100%)	1/10 (10%)	0/0	**9/25 (36%)**
	Old Adult	0/5 (0%)	1/3 (33%)	3/12 (25%)	0/0	**4/20 (20%)**
	Adult Undetermined	0/2 (0%)	0/0	0/0	1/3 (33%)	**1/5 (20%)**
	Total	**8/30 (26.7%)**	**2/4 (50%)**	**6/35 (17.1%)**	**1/5 (20%)**	**17/74 (23%)**
Possible Coffin		**Males**	**Ambiguous**	**Females**	**UD**	**Total**
	Older Adolescent	0/0	0/1 (0%)	0/1 (0%)	0/0	**0/2 (0%)**
	Young Adult	0/4 (0%)	0/0	0/4 (0%)	0/2 (0%)	**0/10 (0%)**
	Middle Adult	1/5 (20%)	1/1 (100%)	0/2 (0%)	0/0	**2/8 (25%)**
	Old Adult	1/1 (100%)	0/0	0/5 (0%)	0/0	**1/6 (16.7%)**
	Adult Undetermined	0/1 (0%)	0/0	0/0	1/4 (25%)	**1/5 (20%)**
	Total	**2/11 (18.2%)**	**1/2 (50%)**	**0/12 (0%)**	**1/6 (16.7%)**	**4/31 (12.9%)**

Table 4.21 Results of Comparison of Crude Prevalence Within Burial Types Between Age and Sex Categories at Winchester.[1]

	Age Comparisons				*Sex Comparisons*				
Burial Type	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (*P*FET)**	***p* value**	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (*P*FET)**	***p* value**	Odds Ratio
Coffin	**16.89**	**df = 3**	**-**	**.0007**	2.22	df = 1	-	.135	2.19
Pit	-	df = 3	.406	-	-	df = 1	.385	-	1.76
Possible Coffin	-	df = 2	.999	-	-	-		-	

[1]P-value was adjusted to .00625 using Equation 3.6, and blue shaded cells indicate significant tests.

4.4.3 Barcelona

In the overall sample, males have marginally more fractures than females (27% vs 26%) (Table 4.13), in tile burials, females have more fractures than males (31.5%); however, they are only 1.38 times more likely to possess a fracture (Table 4.23). Likewise, while old adults have the greatest number of fractures in the overall sample, in middle adults in pit burials (50%) have a greater prevalence of fractures; however, this is likely due to small sample size (n=4) (Table 4.22). While differences in crude prevalence based on age and sex are evident, none are statistically significant (Table 4.23). As coffin burials only had one individual with fractures, and amphora contain none, differences were not examined.

Table 4.22 Prevalence of Fractures in Cross Cutting Burial Types at Barcelona.

Tile		**Males**	**Females**	**UD**	**Total**
	Older Adolescent	0/2 (0%)	0/2 (0%)	0/0	**0/4 (0%)**
	Young Adult	2/9 (22.2%)	1/5 (20%)	0/0	**3/14 (21.4%)**
	Middle Adult	0/3 (0%)	0/2 (0%)	0/0	**0/5 (0%)**
	Old Adult	2/3 (66%)	3/6 (50%)	0/0	**5/9 (55.5%)**
	Adult Undetermined	1/3 (33.3%)	2/4 (50%)	0/3 (0%)	**3/10 (30%)**
	Total	**5/20 (25%)**	**6/19 (31.5%)**	**0/3 (0%)**	**11/42 (26.2%)**
Pit		**Males**	**Females**	**UD**	**Total**
	Older Adolescent	0/3 (0%)	0/0	0/0	**0/3 (0%)**
	Young Adult	2/8 (25%)	2/4 (50%)	0/2 (0%)	**4/14 (28.6%)**
	Middle Adult	2/3 (66.6%)	0/1 (0%)	0/0	**2/4 (50%)**
	Old Adult	3/9 (33.3%)	0/3 (0%)	0/1 (0%)	**3/13 (23.1%)**
	Adult Undetermined	1/2 (50%)	0/3 (0%)	0/2 (0%)	**1/7 (14.3%)**
	Total	**8/25 (32%)**	**2/11 (18.2%)**	**0/5 (0%)**	**10/41 (24.4%)**

Table 4.23 Results of Comparison of Crude Prevalence Within Burial Types Between Age and Sex Categories at Barcelona.[1]

	Age Comparisons				**Sex Comparisons**				
Burial Type	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (PFET)**	**p value**	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (PFET)**	**p value**	**Odds Ratio**
*Tile**	-	*df = 2*	*.239*	-	-	*df = 1*	*.731*	-	*1.38*
Pit	-	df = 3	.680	-	-	df = 1	.688	-	2.11

[1]*P*-value was adjusted to .0125 following Equation 3.6
*Italicized sections indicate females had more fractures than males.

4.4.4 Vagnari

When a cross cutting analysis of burial types was applied to Vagnari, differences were noted in *cappuccina* burials. While middle adults have the highest crude prevalence of fractures in the overall sample (Table 4.13), in *cappuccina* burials, fracture rates are the same between old adults (33.3%) and middle adults (33.3%) (Table 4.24). Differences between age and sex within *cappuccina* burials were not significant; males and females have equal odds of sustaining a fracture (Table 4.25). As no fractures were recorded for individuals in disturbed burials, these were not compared.

Table 4.24 Prevalence of Fractures in Cross Cutting Burial Types at Vagnari.

Cappuccina		**Males**	**Females**	**UD**	**Total**
	Older Adolescent	0/1 (0%)	0/4 (0%)	0/1 (0%)	**0/6 (0%)**
	Young Adult	0/12 (0%)	2/13 (15.4%)	1/4 (25%)	**3/29 (10.3%)**
	Middle Adult	2/7 (28.6%)	1/2 (50%)	0/0	**3/9 (33.3%)**
	Old Adult	1/1 (100%)	0/2 (0%)	0/0	**1/3 (33.3%)**
	Adult Undetermined	0/1 (0%)	0/3 (0%)	0/2 (0%)	**0/5 (0%)**
	Total	**3/22 (13.6%)**	**3/24 (12.5%)**	**1/7 (14.3%)**	**7/53 (13.2%)**
Libation		**Males**	**Females**	**UD**	**Total**
	Older Adolescent	0/0	0/0	0/0	**0/0**
	Young Adult	1/2 (50%)	0/0	0/1 (0%)	**1/3 (33.3%)**
	Middle Adult	1/1 (100%)	0/0	0/0	**1/1 (100%)**
	Old Adult	0/0	0/0	0/0	**0/0**
	Adult Undetermined	0/0	0/0	0/0	**0/0**
	Total	**2/3 (66.6%)**	**0/0**	**0/1 (0%)**	**2/4 (50%)**

Table 4.25 Results of Comparison of Crude Prevalence Within Burial Types Between Age and Sex Categories at Vagnari.[1]

	Age Comparisons				Sex Comparisons				
Burial Type	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (PFET)**	**p value**	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (PFET)**	**p value**	**Odds Ratio**
Cappuccina	-	df = 2	.141	-	-	df = 1	1.00	-	1.10
Libation	-	df = 1	1.00	-	-	-	-	-	

[1]P-value was adjusted to .0125 following Equation 3.6.

4.4.5 Godmanchester

At Godmanchester, the crosscut analysis by age only reduced the prevalence of fractures in both middle and old adults (Table 4.26). The complete crosscut of pit burials is found in Table 4.26; cross cuts of coffin burials were not completed as no individuals had fractures. The differences between age categories within pit burials are not statistically significant (Table 4.27).

Table 4.26 Prevalence of Fractures in Cross Cutting Burial Types at Godmanchester.

Pit		**Males**	**Ambiguous**	**Females**	**UD**	**Total**
	Older Adolescent	0/1 (0%)	0/0	0/1 (0%)	0/1 (0%)	**0/3 (0%)**
	Young Adult	0/5 (0%)	0/1 (0%)	0/2 (0%)	0/1 (0%)	**0/9 (0%)**
	Middle Adult	3/7 (42.9%)	1/1 (100%)	0/3 (0%)	0/0	**4/11 (36.4%)**
	Old Adult	0/3 (0%)	0/0	0/3 (0%)	1/1 (100%)	**1/7 (14.3%)**
	Adult Undetermined	0/0	0/0	0/0	0/3 (0%)	**0/3 (0%)**
	Total	**3/16 (18.8%)**	**1/2 (50%)**	**0/9 (0%)**	**1/6 (16.7%)**	**5/33 (15.2%)**

Table 4.27 Results of Comparison of Crude Prevalence Within Burial Types Between Age and Sex Categories at Godmanchester.[1]

	Age Comparisons				Sex Comparisons			
Burial Type	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (P_{FET})**	**p value**	**Chi - Square (X^2)**	**Degrees of Freedom (df)**	**Fisher's Exact (P_{FET})**	**p value**
Pit	-	df = 2	.595	-	-	-	-	-

[1]P-value was adjusted to .025 following Equation 3.6

4.5 Multiple Fracture Prevalence Within Sites

This section examines the crude prevalence of individuals with multiple fractures within each of the sites to consider how multiple fracture prevalence differs within sites in relation to aspects of social identity. Overall, the sample from Barcelona had the highest number of individuals with multiple fractures (14.1%), while Vagnari had the least (1.6%) (Figure 4.3).

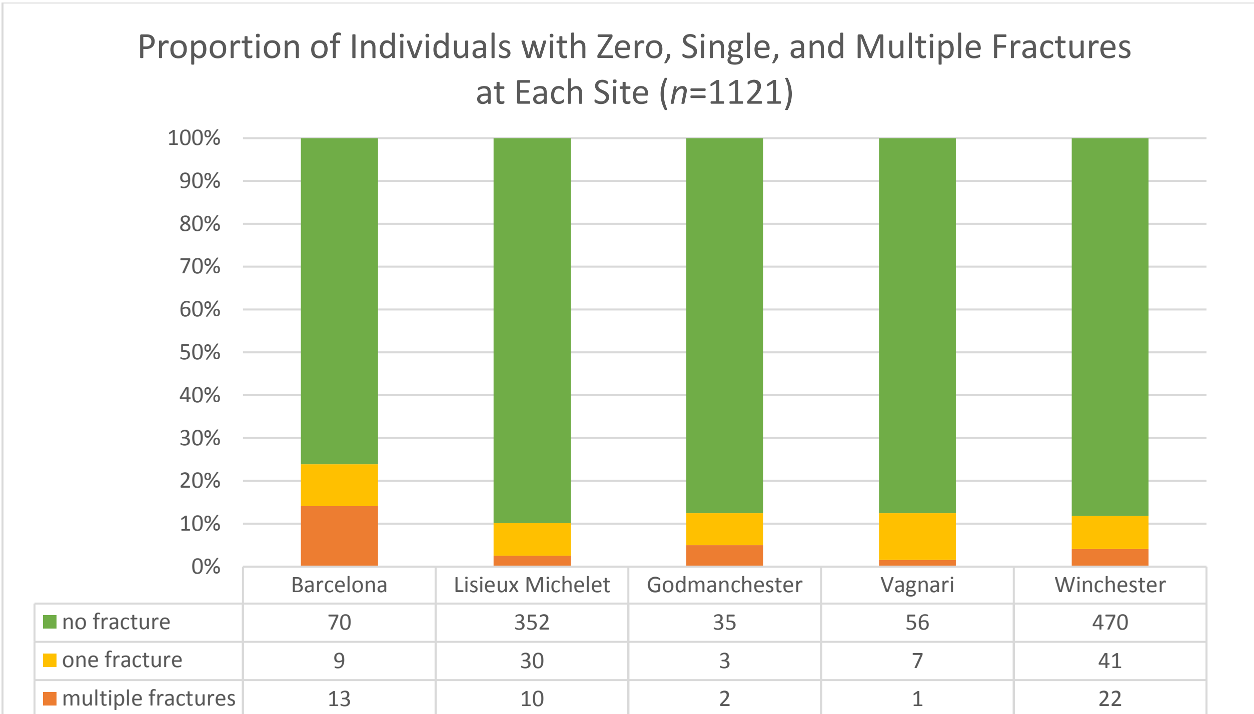


Figure 4.3 Proportion of Individuals with Zero, Single, and Multiple Fractures at Each Settlement. Raw data is provided in the table below the graph.

Table 4.28 Crude Prevalence of Multiple Fractures at Each Settlement by Age and Sex.[1]

Sample		Male	Ambiguous	Female	Undetermined	Combined
Lisieux Michelet	**Older Adolescent**	0/5	0/0	0/17	0/0	**0/22 (0%)**
	Young Adult	1/47 (2.12%)	1/9 (11.1%)	0/68	0/9	**2/133 (1.5%)**
	Middle Adult	2/42 (4.8%)	0/5	1/22 (4.5%)	1/3 (33.3%)	**4/72 (4.6%)**
	Old Adult	3/40 (7.5%)	0/6	1/49 (2%)	0/3	**4/98 (4.1%)**
	Adult	0/4	0/3	0/15	0/45	**0/67**
	Combined	**6/138 (4.3%)**	**1/23 (4.3%)**	**2/171 (1.2%)**	**1/60 (1.7%)**	**10/392 (2.6%)**
Winchester		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/6	0/2	0/15	0/4	**0/27**
	Young Adult	3/78 (3.8%)	0/10	1/97 (1%)	1/38 (2.6%)	**5/223 (2.2%)**
	Middle Adult	7/58 (12.1%)	1/6 (16.7%)	1/27 (3.7%)	0/14	**9/105 (8.6%)**

	Old Adult	4/27 (14.8%)	0/10	3/56 (5.4%)	0/1	**7/94 (7.4%)**
	Adult	1/14 (7.1%)	0/4	0/5	0/61	**1/84 (1.2%)**
	Combined	**15/183 (8.2%)**	**1/32 (3.1%)**	**5/200 (2.5%)**	**1/118 (.8%)**	**22/533 (4.1%)**
Barcelona		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/5		0/2		**0/7 (0%)**
	Young Adult	3/18 (16.7%)		2/11 (18.2%)	0/2	**5/31 (16.1%)**
	Middle Adult	0/7		1/5 (20%)		**1/12 (8.3%)**
	Old Adult	2/14 (14.3%)		3/10 (30%)	0/1	**5/25 (20%)**
	Adult	0/5		2/7 (28.5%)	0/5	**2/17 (11.8%)**
	Combined	5/49 (10.2%)		8/35 (22.9%)	0/8	**13/92 (14.1%)**
Vagnari		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/1		0/4	0/1	**0/6 (0%)**
	Young Adult	0/16		1/15 (6.7%)	0/5	**1/36 (2.8%)**
	Middle Adult	0/8		0/2		**0/10 (0%)**
	Old Adult	0/2		0/2	0/1	**0/5 (0%)**
	Adult	0/2		0/3	0/2	**0/7 (0%)**
	Combined	**0/29 (0%)**		**1/26 (3.8%)**	**0/9 (0%)**	**1/64 (1.6%)**
Godmanchester		**Male**	**Ambiguous**	**Female**	**Undetermined**	**Combined**
	Older Adolescent	0/1		0/2	0/1	**0/4 (0%)**
	Young Adult	0/7	0/1	0/2	0/1	**0/11 (0%)**
	Middle Adult	1/7 (14.3%)	1/1 (100%)	0/4		**2/12 (16.7%)**
	Old Adult	0/4	0/1	0/4	0/1	**0/10 (0%)**
	Adult				0/3	**0/3 (0%)**
	Combined	**1/19 (5.3%)**	**1/3 (33.3%)**	**0/12 (0%)**	**0/6 (0%)**	**2/40 (2.5%)**

[2]Percentages below represent the overall prevalence within each sample age and sex category.

4.5.1 Multiple Fractures by Age

At Godmanchester, Winchester, and Lisieux Michelet, middle adults have the greatest prevalence of multiple injuries, at 16.6%, 8.6%, and 5.5% respectively (Table 4.28). At Vagnari, the only individual with multiple fractures is a young adult. At Barcelona, old adults have the greatest prevalence of multiple fractures (20%). No older adolescent individuals in any of the samples had multiple fractures. The differences between age categories for multiple fractures were only significant at Winchester (Table 4.29).

Table 4.29 Results of Crude Prevalence Comparisons of Multiple Fractures at Each Settlement Between Age Categories.[1]

Site	Chi -Square (X^2)	Degrees of Freedom (df)	Fisher's Exact (*P*FET)	*p* value
Lisieux Michelet	-	df = 2	.243	-
Winchester	**-**	**df = 3**	**.014**	**-**
Barcelona	-	df = 3	.900	-
Vagnari	-	df = 1	1	-
Godmanchester	-	df = 1	1	-

[1]Statistically significant results are in blue shaded cells

4.5.2 Multiple Fractures by Sex

At Winchester, males have the greatest prevalence of multiple fractures (8%), while at both Barcelona and Vagnari, females have greater prevalence of multiple fractures (22.9% and 3.8%, respectively) (Table 4.28). While differences in sex categories were only significant at Winchester, males at both Lisieux Michelet and Winchester are over 3 times more likely to have sustained a fracture, while at Barcelona, females are 2.6 times more likely to have a fracture (Table 4.30).

Table 4.30 Results of Crude Prevalence Comparisons of Multiple Fractures at Each Settlement Between Males and Females.[1]

Site	Chi -Square (X^2)	Degrees of Freedom (df)	Fishers Exact (P_{FET})	*p* value	Odds Ratio
Lisieux Michelet	-	df = 1	.146	-	3.84
Winchester	**-**	**df = 1**	**.0194**	**-**	**3.482**
Barcelona*	-	*df = 1*	*.208*	-	*2.607*
Vagnari*	-	*df = 1*	*1*	-	
Godmanchester	-	-	-	-	

[1]Blue shaded cells indicate statistically significant results.
*Italicized sites indicate females had more multiple fractures than males.

4.5.3 Multiple Fractures by Burial

A complete summary of individuals with multiple fractures is provided in Table 4.31. At Lisieux Michelet, individuals in coffin burials have the greatest overall prevalence of multiple fractures (3.3%) (Table 4.31). At Winchester, coffin and possible coffin burials have the same prevalence of multiple fractures (3.3%). At Vagnari, the lone individual with multiple injuries was in a *cappuccina* burial, while at Barcelona, the highest prevalence is in tile burials. At Godmanchester, both individuals with multiple fractures were found in pit burials (Table 4.31). At all sites, fracture prevalence between individuals in different burial types were not statistically significant (Table 4.32).

Table 4.31 Crude Prevalence of Multiple Fractures at Each Settlement by Burial Types.

Winchester	**Coffin**	**Pit**	**Lead Coffin**	**Possible Coffin**	**Stepped Grave**	**Total**
	13/395 (3.3%)	8/66 (1.2%)	0/1 (0%)	1/30 (3.3%)	0/19 (0%)	22/511 (4.3%)
Lisieux Michelet	**Coffin**	**Pit**	**Tile**	**Sarcophagus**	**Total**	
	9/276 (3.3%)	1/94 (1.1%)	0/5 (0%)	0/8 (0%)	10/392 (2.6%)	
Barcelona	**Coffin**	**Pit**	**Tile**	**Amphora**	**Total**	
	1/7 (14.3%)	3/41 (7.3%)	9/42 (21.4%)	0/2 (0%)	13/92 (14.1%)	
Vagnari	**Cappuccina**	**Pit**	**Tile/ Disturbed**	**Libation**	**Total**	
	1/53 (1.9%)	0/4 (0%)	0/3 (0%)	0/4 (0%)	1/64 (1.6%)	
Godmanchester	**Coffin**	**Pit**	**Total**			
	0/7 (0%)	2/33 (6%)	2/40 (5%)			

Table 4.32 Results of Crude Prevalence Comparisons of Multiple Fractures at Each Settlement Between Burial Types.

Site	**Chi -Square (X^2)**	**Degrees of Freedom (df)**	**Fishers Exact (P_{FET})**	***p* value**
Lisieux Michelet	-	df = 1	.460	-
Winchester	-	df = 2	.059	-
Barcelona	-	df = 2	.324	-
Vagnari	-	df = 1	1	-
Godmanchester	-	df = 1	1	-

4.6 Fractures Prevalence Between Sites

In this section, the crude and true prevalence of fractures are compared between sites using Chi-Square or Fisher's Exact tests to examine how fracture prevalence differed between different sized settlements or *between* sites. Small settlements are first compared to each other, then large settlements to each other, and finally small settlements to large settlements.

4.6.1 Fracture Prevalence Between Small Settlements

Crude prevalence was compared between the small sites of Godmanchester and Vagnari to examine whether there were differences between them. As age and sex were not significantly associated with fractures at either site, all ages and sexes were collapsed. Differences in the prevalence of fractures between the two samples were not significant; however, individuals at Vagnari were 1.5 times more likely to have fractures (Table 4.33).

Table 4.33 Results of Crude Prevalence Comparisons Between Small Settlements.

	Chi Square X^2	**Degrees of Freedoms (df)**	**Fisher's Exact (PFET)**	**P – Value**	**Odds Ratios**
		df = 1	.739		1.55

4.6.2 Fracture Prevalence Between Large Settlements

The crude prevalence was compared between the three large *civitas* to examine the differences between each. As age and sex had been statistically significant at Winchester and Lisieux Michelet, the sites were divided by sex and age categories and these groups were compared. Of the three sites, Barcelona had the greatest overall CPR fractures (22/92 individuals), while Lisieux Michelet had the least (40/392 individuals) (Table 4.13). Differences in the fracture prevalence of female young adults at the three sites was statistically significant (Table 4.34).

Table 4.34 Results of Crude Prevalence Comparison Between Large Settlements.[1]

	Chi Square (X^2)	**Degrees of Freedom (df)**	**Fisher's Exact (*P*FET)**	**P – Value**
Female YA[2]	**-**	**df = 2**	**0.01**	**-**
Female MA		df = 2	0.615	
Female OA	2.21	df = 2	-	.331
Male YA	3.68	df = 2	-	.1588
Male MA	3.18	df = 2	-	.20
Male OA	.63	df = 2	-	.72

[1]Shaded light blue cells are statistically significant
[2]Abbreviations for age categories is as indicated: YA = Young Adult, MA = Middle Adult, OA = Old Adult,

4.6.3 Comparisons Between Large and Small Settlements

Large towns were collapsed into one grouping, and small settlements were likewise collapsed to test the differences between the two categories. Sites were divided by sexes, and then compared by age group to account for the differences in age and sex distribution between sites. While there were no statistically significant differences between the small and large settlements, odds ratios show that the odds of fracture differed between age and sex category (Table 4.35). Females from small sites were more likely to sustain fractures than large town females, while young and old males were more likely to possess a fracture if they were from a large town (Table 4.35).

Table 4.35 Results of Crude Prevalence Comparison Between Large and Small Settlements.[1]

	Chi Square X^2	**Degrees of freedom**	**Fishers Exact (*P*FET)**	**P-Value**	**Odds Ratio**
Female YA[2]	.750	Df = 1	-	.386	*2.00**
Female MA	-	Df = 1	.999		*1.96*
Female OA	-	-	-	-	-
Male YA		Df = 1	.313		3.57
Male MA		Df = 1	.250	-	*2.18*
Male OA	-	Df = 1	.681	-	1.86

[1]Bolded and shaded light blue cells are statistically significant
[2]Abbreviations for age categories is as indicated: YA = Young Adult, MA = Middle Adult, OA = Old Adult
*Italicized ratios indicate the odds are greater in the 'rural' rather than urban sites

4.6.4 Multiple Fractures Between Settlements

4.6.4.1 Small Settlements

When small sites were compared, age and sex categories were collapsed, as age and sex were not significant within each site. Differences between Godmanchester and Vagnari were not significant; however, individuals at Godmanchester were 1.89 times more likely to have multiple fractures than those at Vagnari (Table 4.36).

Table 4.36 Results of Crude Prevalence Comparisons of Multiple Fractures Between Small Settlements.

	Chi Square X^2	**Degrees of Freedom (df)**	**Fisher's Exact (PFET)**	**P – Value**	**Odds Ratio**
	-	1	1	-	*1.89**

*Italicized ratio represents Vagnari as the baseline.

4.6.4.2 Large Settlements

When multiple fractures were only compared between the large towns, divided by age and sex categories, differences in the crude prevalence of old adult females across the three sites were significant (Table 4.37), while all other age categories were not. Barcelona had the greatest prevalence of multiple fractures in old adult females (30%) while Winchester had 5.6%, and Lisieux Michelet, at 2%, had the least (Figure 4.3).

Table 4.37 Results of Crude Prevalence Comparisons of Multiple Fractures Between Large Settlements.[1]

	Females				Males			
	Chi – SquareX^2	**Degrees of Freedom (df)**	**Fisher's Exact PFET**	**P-Value**	**Chi – Square X^2**	**Degrees of Freedom (df)**	**Fisher's Exact PFET**	**P-Value**
Young Adult	-	Df = 1	.255	-	-	Df = 2	.0823	-
Middle Adult	-	Df = 2	.12	-	-	Df = 1	.296	-
Old Adult	**-**	**Df = 2**	**.0161**	**-**	-	Df = 2	.564	-

[1]Shaded and bolded cells indicate statistical significance.

4.6.4.3 Large and Small Settlements

When samples were collapsed to compare large civitas and small settlements, very few tests could be run when divided between age and sex categories due to the rarity of multiple fractures at both rural sites. Multiple fractures were only present at Vagnari in a female young adult, and at Godmanchester in a male middle adult. Differences between the large towns and small sites in these two instances were not statistically significant (Table 4.38).

Table 4.38 Results of Crude Prevalence Comparisons of Multiple Fractures Between Large and Small Settlements.

	Females				Males			
	Chi – SquareX^2	**Degrees of Freedom (df)**	**Fisher's Exact PFET**	**P-Value**	**Chi – Square X^2**	**Degrees of Freedom (df)**	**Fisher's Exact PFET**	**P-Value**
Young Adult	-	Df = 1	.31	-	-	-	-	-
Middle Adult	-	-	-	-	-	Df = 1	1	-
Old Adult	-	-	-	-	-	-	-	-

4.7 Individuals with Healing Fractures

Fractures were also assessed for healing to determine possible differences in timing at each settlement. When considering fractures, of the 139 individuals with fractures across all sites, eleven individuals have fractures with ongoing healing at varying stages (Table 4.39). Fractures with healing were recorded to examine differences between settlements. Of the individuals with healing fractures, 81.8% are male, with two females and one undetermined individual. Six out of the eleven are middle adults, two are young adults, and three old adults.

Three individuals each come from Lisieux Michelet, Winchester, and Barcelona. The three individuals from Lisieux Michelet have no previous observable fractures, while two of the three individuals from Winchester had previous fractures, and all three from Barcelona had previous fractures. AY21-861 (Winchester) has previous rib fractures that were well healed, and LH 283 (Winchester) possesses well healed fibula and rib fractures. The individuals from Barcelona and Godmanchester likewise possess earlier fractures. VMD 37, VMD 29, and VMD 28 (Barcelona, Vila de Madrid) and PGO 37 (Godmanchester) all possess well healed rib fractures. Of the individuals with healing fractures, 72.7% have previous fractures.

Table 4.39 Individuals with Fractures with Ongoing Healing following Lovell (2008).

Skeleton	Age	Sex	Burial Type	Element	State of Healing	Estimated Age of Fracture	Previous Fracture
MIC 64	MA	UD	Pit	Right Rib	Consolidation	Several weeks to months	no

				Right Rib	Consolidation	Several weeks to months	no
MIC 177	YA	M	Pit	Right Clavicle	Consolidation	Several weeks to months	no
MIC 427	OA	M	Coffin	Right Rib	Remodelling	Several years	no
				Left Tibia	Remodelling	Several years	no
				Left Fibula	Remodelling	Several years	no
AY21-861	MA	M	Pit	Unsided Rib	Callus Formation	2-3 weeks to 8-9 weeks	yes
				Unsided Rib	Callus Formation	2-3 weeks to 8-9 weeks	yes
				Unsided Rib	Callus Formation	2-3 weeks to 8-9 weeks	yes
				Unsided Rib	Callus Formation	2-3 weeks to 8-9 weeks	yes
LANK 226	YA	M	Coffin	Femur	Callus Formation	2-3 weeks to 8-9 weeks	no
LANK 249	OA	F	Coffin	Unsided Rib	Callus Formation	2-3 weeks to 8-9 weeks	no
				Unsided Rib	Callus Formation	2-3 Weeks to 8-9 weeks	no
LANK 283	MA	M	Pit	Unsided Rib	Consolidation	Several weeks to months	yes
VMD ENT 29	OA	M	Pit	Unsided Rib	Consolidation	Several weeks to months	yes
				Unsided Rib	Consolidation	Several weeks to months	yes
				Unsided Rib	Consolidation	Several weeks to months	yes
VMD ENT 38	YA	M	Tile	Left Rib	Consolidation	Several weeks to months	yes
				Left Rib	Consolidation	Several weeks to months	yes

				Left Rib	Consolidation	Several weeks to months	yes
				Left Rib	Consolidation	Several weeks to months	yes
VMD ENT 37	MA	F	Coffin	Unsided Rib	Callus Formation	2-3 weeks to 8-9 weeks	yes
				Unsided rib	Callus Formation	2-3 weeks to 8-9 weeks	yes
				Unsided Rib	Callus formation	2-3 weeks to 8-9 weeks	yes
PGO 37	MA	M	Pit	Right Rib	Callus formation	2-3 week to 8-9 weeks	yes
				Right Rib	Callus formation	2-3 weeks to 8-9 weeks	yes
				Right Rib	Callus formation	2-3 weeks to 8-9 weeks	yes
				Right Rib	Callus formation	2-3 weeks to 8-9 weeks	yes
				Unsided	Callus formation	2-3 weeks to 8-9 weeks	yes

4.8 Fracture Patterns

Fracture pattern such as location were recorded to consider how fractures differed both *between* and *within* settlements beyond prevalence.

4.8.1 Fracture Element

4.8.1.1 Fracture Elements Between Settlements

At almost all sites, the most commonly fractured elements were ribs. The CPR for ribs at Lisieux Michelet is 5.7%; at Barcelona, 17%; Godmanchester, 7.5%; and Winchester, 6%. At Vagnari, rib fractures are as prevalent as tibia and fibula fractures (3%). Further, Vagnari (6.4%), Winchester (4.5%), and Godmanchester (5%) have a greater prevalence of lower limb fractures than upper limb fractures, although differences between the lower limb fractures between sites are not significant, (X^2 = 6.41, p = .169). Comparatively, Barcelona (10.9%) and Lisieux Michelet (4.6%) have a greater crude prevalence of upper limb fractures, and differences in the CPR of upper limb fractures between sites is significant **(X^2 = 11.807, p = .008).**

When TPR is considered, overall prevalence changed for each of the fractured elements (Table 4.40). At Lisieux Michelet, radii become the most commonly fractured elements (1.4%), followed by ribs. At Barcelona, ribs remain the most fractured element (3.2%). At Winchester, Vagnari and Godmanchester, fibulae are the most commonly fractured elements (Table 4.40); however, the differences between other elements were not significant between sites. When sites were compared by element using true prevalence, only differences in rib fractures were statistically significant (Table 4.41).

Table 4.40 True Prevalence of Elements with Fractures at Each Settlement.[1]

	Lisieux Michelet	Winchester	Barcelona	Vagnari	Godmanchester
Ribs	31/4623 (.7%)	63/3221 (2%)	45/1388 (3.2%)	3/303 (1%)	12/632 (1.9%)
Clavicle	7/531 (1.3%)	6/469 (1.3%)	2/135 (1.5%)	1/76 (1.3%)	0/60
Humerus	0/701 (0%)	2/734 (.3%)	1/143 (.7%)	1/111 (1%)	0/66
Radius	8/465 (1.4%)	6/613 (1%)	4/132 (3%)	0/107	0/66
Ulna	4/583 (.7%)	5/623 (1%)	3/134 (2.2%)	1/100 (1%)	0/67
Femur	1/671 (.2%)	2/904 (.2%)	0/139 (0%)	0/110	0/67
Tibia	4/501 (.8%)	14/883 (1.6%)	1/128 (.8%)	2/114 (1.8%)	0/66
Fibula	5/557 (.9%)	16/671 (2.4%)	1/115 (.9%)	2/90 (2.2%)	2/66 (3%)

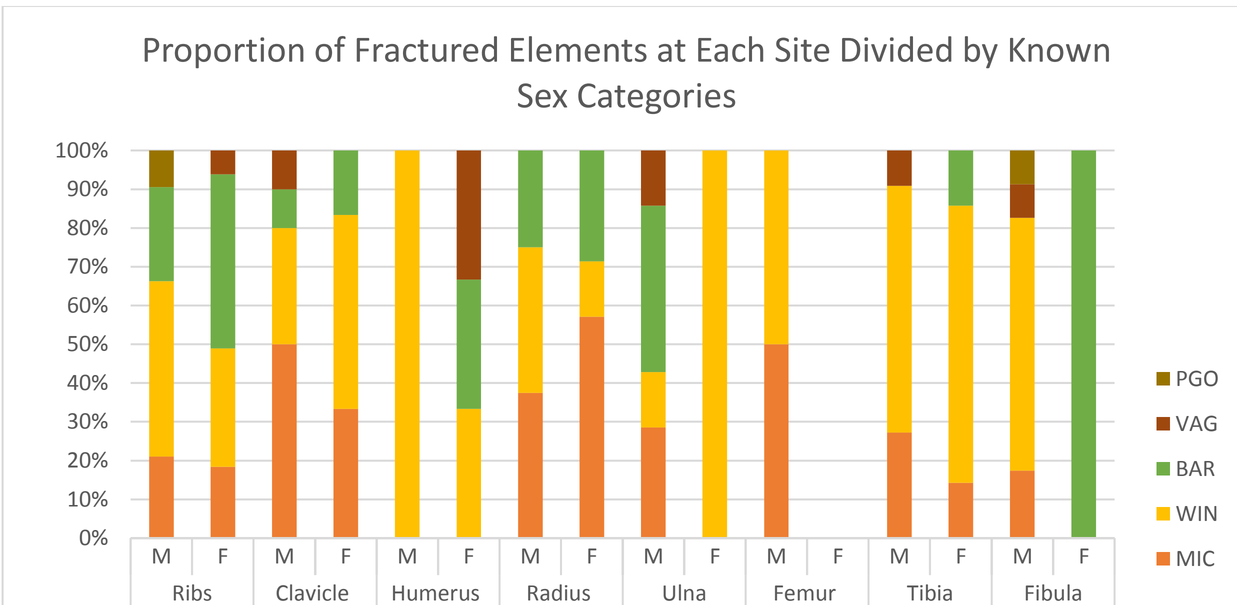
[1]Percentages below indicate the prevalence
[2]Site Abbreviations are as follows: MIC = Lisieux Michelet, WIN = Winchester, BAR = Barcelona, VAG = Vagnari. PGO = Godmanchester.

Table 4.41 Results of True Prevalence Comparison of Elements with Fractures Between Settlements.[1]

	Chi – Square (X^2)	Degrees of Freedom (df)	p-value
Ribs	**55.237**	**df = 4**	**.000**
Clavicle	.0321	df = 3	.998
Humerus	1.289	df = 2	.524
Radius	3.255	df = 2	.196
Ulna	3.06	df = 3	.382
Femur	.105	df = 1	.745
Tibia	2.007	df = 3	.570
Fibula	5.23	df = 4	.264

4.8.1.2 Fracture Element and Sex

Rib fractures occur at Lisieux Michelet, Winchester, and Godmanchester more frequently in males, at 71%, 68.3%, and 75%, respectively. Differences in the TPR of rib fractures between males and females at Winchester and Lisieux Michelet are statistically significant, while at Barcelona, Vagnari and Godmanchester they are not (Table 4.42) At Barcelona, the differences are minimal (51.1% of the rib fractures occur in males), and at Vagnari the three identified rib fractures are all in females (Figure 4.4). At all other sites and with respect to all other elements, differences between the sexes are not notable enough to be statistically significant.



	Ribs M	Ribs F	Clavicle M	Clavicle F	Humerus M	Humerus F	Radius M	Radius F	Ulna M	Ulna F	Femur M	Femur F	Tibia M	Tibia F	Fibula M	Fibula F
PGO	9	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
VAG	0	3	1	0	0	1	0	0	1	0	0	0	1	0	2	0
BAR	23	22	1	1	0	1	2	2	3	0	0	0	0	1	0	1
WIN	43	15	3	3	1	1	3	1	1	1	1	0	7	5	15	0
MIC	20	9	5	2	0	0	3	4	2	0	1	0	3	1	4	0

Figure 4.4 Elements with Fractures at Each Settlement Divided by Males and Females. Raw data (number of elements with fractures) is provided in the table below. Sex category abbreviations are as follows: F = Female and M = Male.

Table 4.42 Results of True Prevalence Comparison of Elements with Fractures Between Males and Females at Each Settlement.[1]

	Lisieux Michelet		**Winchester**		**Barcelona**		**Vagnari**		**Godmanchester**	
	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value
Ribs	**4.88**	**.028**	**9.483**	**.002**	1.41	.234	-	-	-	-
Clavicle	-	.252	-	1		1	-	-	-	-
Humerus	-	-	-	1	-	-	-	-	-	-
Radius	-	1	-	.623	-	1	-	-	-	-
Ulna	-	-	-	1	-	-	-	-	-	-
Femur	-	-	-	-	-	-	-	-	-	-
Tibia	-	.311	-	.565	-	-	-	-	-	-
Fibula	-	-	-	-	-	-	-	-	-	-

[1]Statistically significant results are bolded and shaded blue.

4.8.1.3 Fracture Element and Age

Fractures of elements also differed between age groups. At Lisieux Michelet (50%), Winchester (47.6%), and Godmanchester (91.6%), rib fractures occurred most often in middle adults (Figures 4.5-4.6). Differences between the TPR of rib fractures in age categories at Lisieux Michelet, Godmanchester, and Winchester are all significant (Table 4.43). At Barcelona, rib fractures occur marginally more in old adults (37.8%) than young adults (35.5%), but the differences are not significant (Figure 4.5-4.6 and Table 4.43). At Winchester, differences between the occurrence of fibular fractures are also significant, with middle adults having the most, and young adults the least (Table 4.43 and Figure 4.5-4.6).

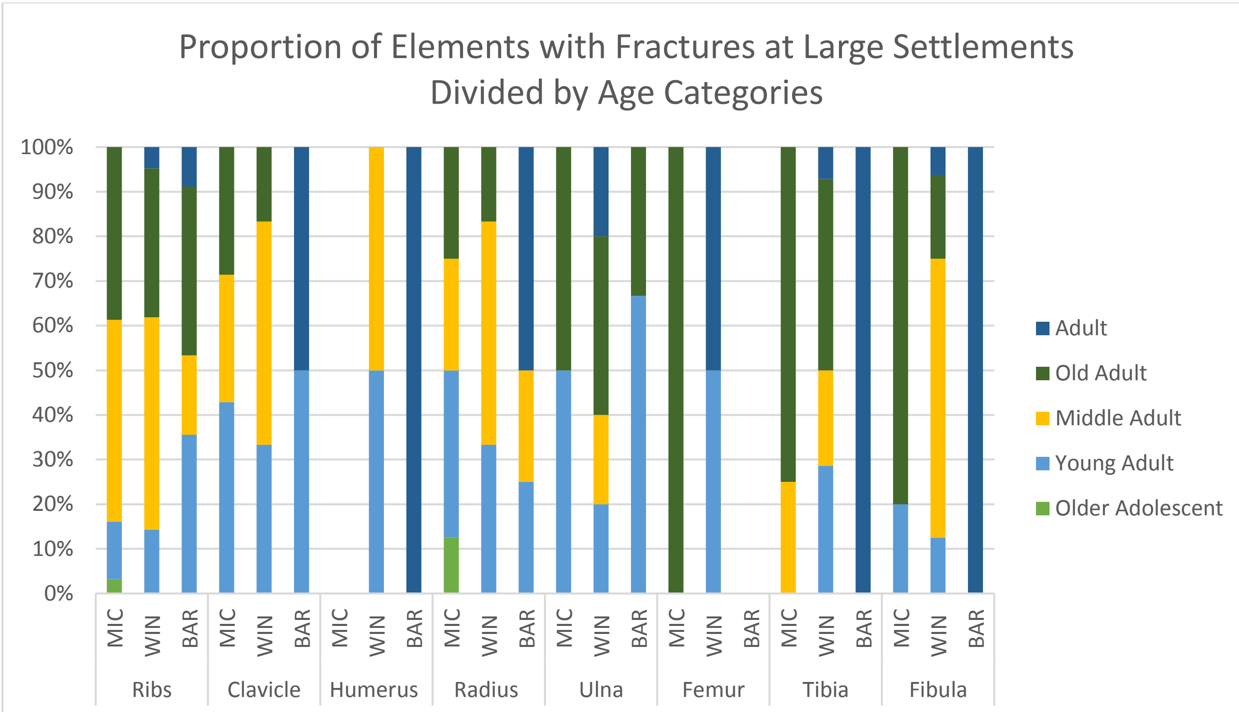


Figure 4.5 Proportion of Elements with Fractures at Large Settlements Divided by Age Categories. Site Abbreviations are as follows: MIC = Lisieux Michelet, BAR = Barcelona, WIN = Winchester.

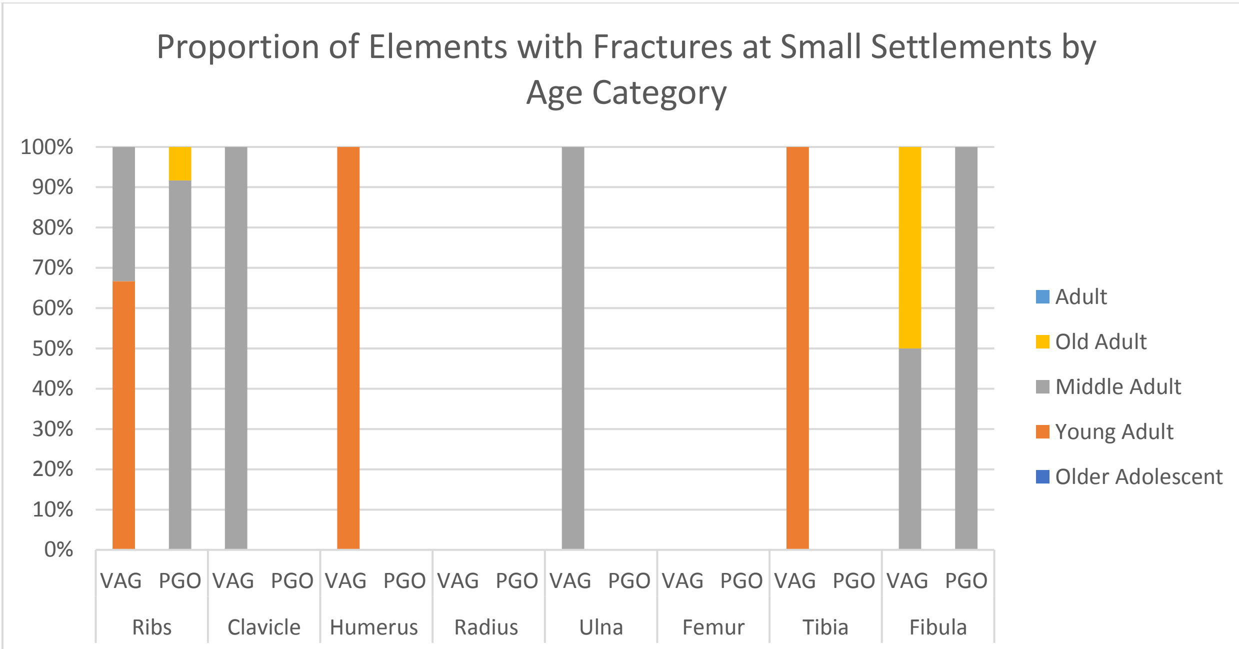


Figure 4.6 Proportion of Elements with Fractures at Small Settlements Divided by Age Categories. Site Abbreviations are as follows: VAG = Vagnari; PGO = Godmanchester.

Table 4.43 Results of True Prevalence Comparison of Elements with Fractures Between Age Categories at Each Settlement.[1]

	LM		**WIN**		**BAR**		**VAG**		**GOD**	
	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value	Chi – Square (X^2)	p-value
Ribs	**16.516**	**.0008**	**21.678**	**.000078**	3.464	.325	.0325	.856	**4.513**	**.033**
Clavicle	.5205	.770	1.01	.600	.226	.634	-	-	-	-
Humerus	-	-	.2063	.649	-	-	-	-	-	-
Radius	.290	.961	1.189	.551	2.12	.344	-	-	-	-
Ulna	.189	.663	3.24	.3557	.0462	.892	-	-	-	-
Femur	-	-	.901	.342	-	-	-	-	-	-
Tibia	.554	.456	5.533	.1366	-	-	-	-	-	-
Fibula	3.21	.072	**12.42**	**.00692**	-	-	.226	.634	-	--

[1]Statistically significant results are bolded and shaded blue.
[2]Site Abbreviations are as follows: MIC = Lisieux Michelet, WIN = Winchester, BAR = Barcelona, VAG = Vagnari. PGO = Godmanchester.

4.8.2 Fracture Location

While type analysis was not conducted, fracture location was considered in relation to possible fracture mechanisms (Figure 4.7 and Figure 4.8). At Lisieux Michelet, Winchester, and Barcelona, all but two of the radial fractures occur in the distal 1/3 of the shaft, or the distal epiphyses (Figure 4.7). At Lisieux Michelet, the second most common long bone fracture is midshaft clavicular fractures, which accounts for 25% of all long bone fractures (Figure 4.7). At all sites fibular fractures occurred significantly more in the distal 1/3, (Figure 4.7 and Figure 4.8).

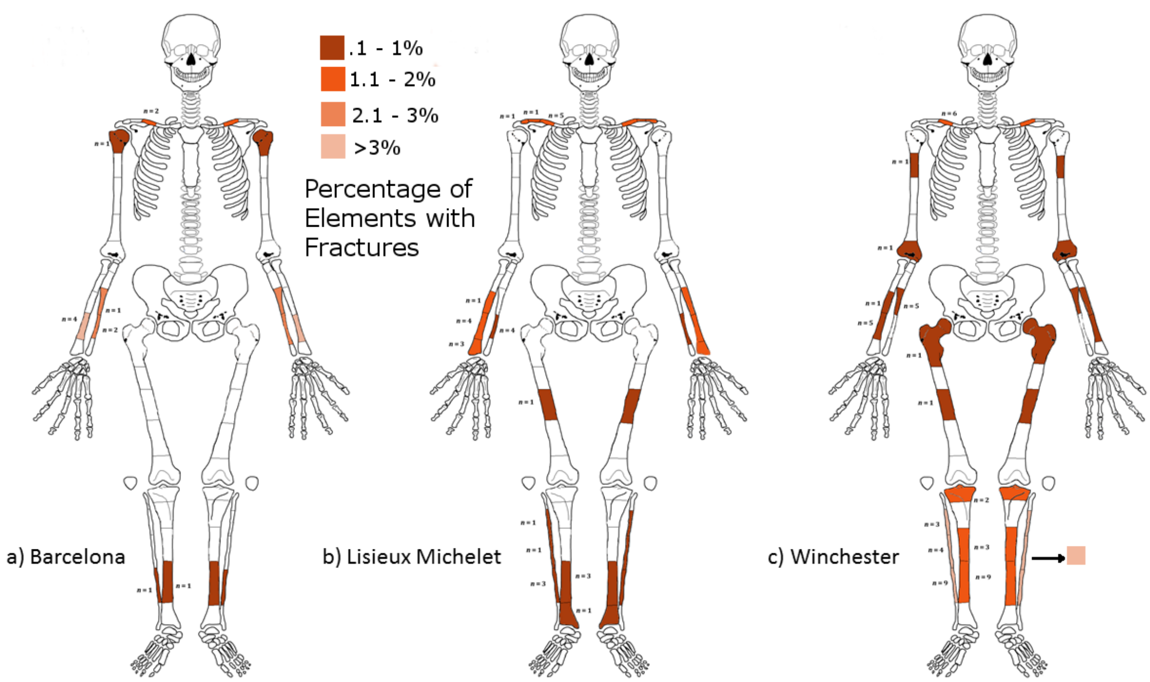


Figure 4.7 True Prevalence of Fractures by Element at Large Settlements.

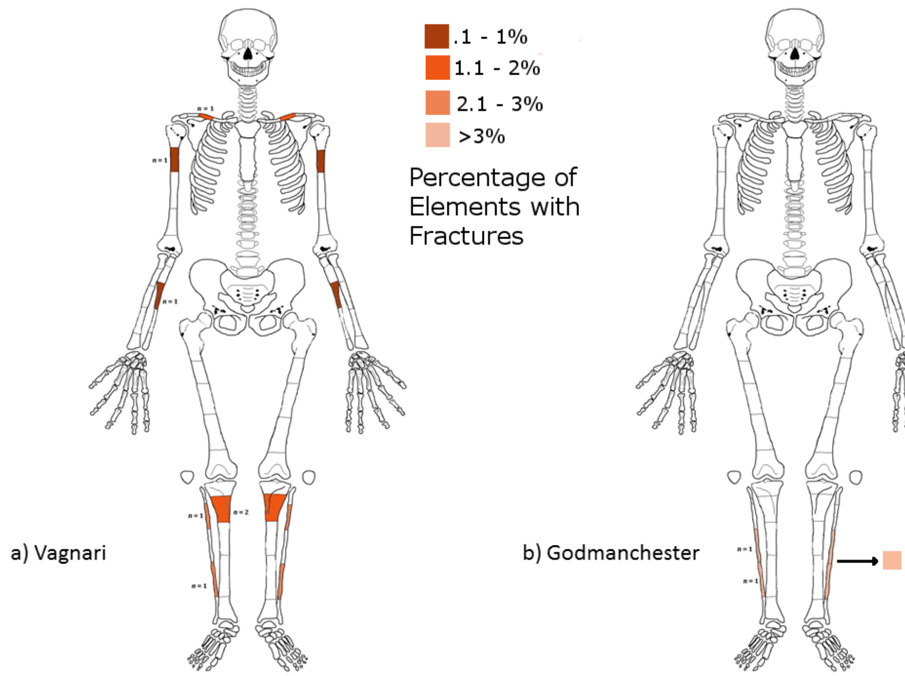


Figure 4.8 True Prevalence of Fractures by Element at Small Settlements

4.9 Summary

In this chapter, the results of fracture analysis for 1121 individuals was examined. Barcelona had the greatest crude prevalence of fractures (24%), while Lisieux Michelet (10.4%) had the least. Males at all sites had the greatest crude prevalence of fractures, and the differences between sex categories were significant at both Lisieux Michelet and Winchester. Old adults had the greatest crude prevalence of fractures at Winchester, Barcelona, and Lisieux Michelet, while at Vagnari and Godmanchester, middle adults had the greatest prevalence. Age differences in fracture prevalence were significant at Lisieux Michelet and Winchester. Differences between individuals in different burials were only significant at Winchester. When cross cutting variables are analysed, differences are compared to overall prevalence. At Barcelona, for example, while males are most commonly fractured across the whole of Barcelona, females had more fractures in tile burials.

Barcelona was the site with the greatest amount of multiple fractures (14.1%), which represented over 50% of the individuals with fractures. At Barcelona and Vagnari, females had more multiple injuries than male, while at the other three sites males had more fractures than females. At three of the five sites (Godmanchester, Winchester, and Lisieux Michelet) middle adults had the greatest prevalence of multiple fractures, while the only individual at Vagnari with multiple fractures was a young adult. The crude prevalence was considered between sites, examining small settlements and large towns. Notably, only the crude prevalence of fractures in young adult females between large towns was statistically significant. When examining multiple fractures between sites, only female old adults had significant differences between the three urban sites.

When elements are considered, the CPR and TPR of rib fractures between sites was significant, as well as the CPR of radial fractures. When the TPR of fractures by element was examined in relation to sex within each site, rib and ulnar fractures were statistically significant at Lisieux Michelet and Winchester. When examined in relation to age, differences in the true prevalence of rib fractures were significant at Godmanchester, Winchester, and Lisieux Michelet, as well as fibulae fractures at Winchester.

CHAPTER 5 DISCUSSION

5.1 Introduction

The goal of the current study, as proposed in the introduction, is to examine how multiple facets of identity, including age, sex, and burial type relate to fracture prevalence both *within* and *between* five settlements in the Roman Empire, guided by the theory of embodiment. In the following sections, the results of the thesis are situated in relation to the research aims using paleopathological, historical, and clinical literature. The following sections are divided into key questions in relation to the research aims:

1. *How do burial type, age, and sex relate to the prevalence of long bone and rib fractures sustained within a settlement?*
2. *How does long bone and rib fracture prevalence differ between age and sex groups within types of burials at each settlement?*
3. *How does the prevalence of fractures differ between settlements?*

5.2 Fracture Prevalence Between Age, Sex, and Burial Types Within a Settlement

5.2.1 Sex Differences

When considering the differences in crude prevalence of fractures between males and females, the results of the current study found that differences in crude prevalence were only statistically significant at two of the three large settlements (Lisieux Michelet and Winchester), but odds ratios and fracture patterns suggest that there were gender differences at the two smaller settlements as well, even when not significant. The results at Winchester, Godmanchester, Vagnari, and Lisieux Michelet were largely in keeping with the expectations set by textual Roman sources and other studies of fractures (*e.g.* Gardner 1986; Bonsall 2013; Gilmour *et al.* 2015; Gilmour *et al.* 2019) which suggests that expectations that there were differences between the lifeways of men and women in the Roman period, while the results at Barcelona suggest that lifeways of men and women were similarly at risk of fracture.

The results from Lisieux Michelet and Winchester suggest that while females in the urban setting sustained fractures, there were significant differences between men and women. At Winchester, males are only slightly more likely to have sustained a fracture, while at Lisieux Michelet, males are three times more likely to have sustained a fracture than their female counterparts (see Table 4.15). The differences in fracture prevalence between sexes suggest that males worked in difficult and labourious industries, particularly at Lisieux Michelet. The statistical significance of different fracture prevalence amongst males and females at both Lisieux Michelet and Winchester support much of the textual records of women's labour in the Roman period. Textual and epigraphic evidence of women's labour from the period is bifurcated by the individual's class status, as elite women and lower-class women engaged in different types of labour (Gardner 1986, 233-234; Dixon 2004, 64). Elite women (particularly after the 1st c. CE) were engaged in business, working as purveyors or merchants, as women's names have been found stamped on amphora (Dixon 2004, 62). As they were of higher status, these women could engage in whatever business motivated them (Dixon 2004, 62).

Comparatively, most evidence for work among middle class women suggests they were likely involved in retail professions, or were engaged in craft production, especially in major urban centres (Dixon 2004, 65). Finally, in the lower echelon of society, textual sources suggest that freed and slave women were required to engage in agricultural and craft-based labour, as it benefitted their owners to educate slaves in lucrative occupations, and to use bodies for harvesting, planting, and tending to animals (Scheidel 1996). Slave women in the city held crafting and labourious positions, likely separate from the lifeways of their upper peers (Gardner 1986, 237).

At Lisieux Michelet, two key occupations could be related to the differences between men and women: military service and crafting. *Noviomagus Lexiovorum,* the city associated with the necropolis of Lisieux Michelet, was conquered in the 1st c. CE, and was originally the capital of the *Lexovii* people (Paillard 2006). In the 3rd c. CE, a *castrum* (fortress) was erected as a defense against persistent attack from Anglo-Saxons, and the period following was likely of extreme turmoil and stress, a fact supported by evidence of cranial trauma in children (Paillard 2006; Timmins *et al.* 2017). Military personnel at Lisieux Michelet would have been a persistent force to help stabilize the city, and artifacts associated with soldiers have been recovered from the city itself, including triangle broaches, pins and bone combs (Paillard 2006) While soldiers were one of the primary migratory forces in the Roman Empire, Carrie (1993, 109-110) notes that they often stayed where they were stationed in the Western Empire rather than returning home. One explanation for the high rates of fractures in males compared to females at Lisieux Michelet could be associated with a military presence, as well as military training, either in soldiers who had migrated and died at Lisieux Michelet, or invading armies and ongoing skirmishes.

Another possible cause of differences between males and females could be related to crafts. Lisieux Michelet had evidence of smelting, as fifteen furnace bases were excavated with slag found around them (Paillard 2006, 23). Metalworking was commonly viewed as a skilled industry and a multistage process that involved high heat, heavy elements, and dangerous, intensive labour (McCarthy 2013, 97-98). In modern communities, metalworkers have a high rate of injury, which commonly include trauma to the arm, hand, and the trunk area, as individuals fall against objects while carrying forged metal (Nakata *et al.* 2006). Clavicular fractures accounted for 27% of long bone fractures sustained by males at Lisieux Michelet (Figure 4.4). The primary mechanism of injury for clavicle fractures is a direct blow to the shoulder through a fall, such as a fall when one's hands are occupied or falling onto one's shoulder when riding a bicycle, as well as contact sports, such as rugby or soccer (McKee 2015). Males at Lisieux Michelet also possessed distal radial and ulnar fractures and a significant number of rib fractures, all of which have been associated with falls (Figure 4.4). While the textual sources suggest that lower class women could have engaged in a variety of trades but were exempt from guilds (Gardner 1986, 237), the relative scarcity of similar injuries in females (females had a total of two clavicular fractures, nine rib fractures, no ulnar fractures and four radial fractures) suggest that women may have been excluded from such forms of labour (Figure 4.4). Differences in the fracture prevalence and pattern between males and females at Lisieux Michelet suggest that men had more difficult or laborious lifeways, with possible causes related to industries and lifeways such as metalworking from which women may have been largely exempt.

At Winchester, the difference in fracture prevalence between males and females is also suggestive of gendered labour and lifeways. Lower limb fractures (such as fractures to the tibia and the fibula) were the most prevalent long bone fractures and were found predominantly in males (Figure 4.4). According to clinical literature, injuries to the tibia and fibula have several causes. Tibial shaft fractures are found commonly in soccer players, while distal tibia/fibula fractures are caused by a rotated ankle when the foot is planted in a fixed position (Bolton and O'Toole 2015). Fractures to just the distal fibula (classified as a Type A unimalleolar fracture) are the most common type of ankle fracture in modern communities and are caused by twisting the ankle along with falls (Court Brown *et al.* 1998). Judd and Roberts (1999) found that the most common injuries in Medieval Britain were to the upper limb and the fibula, with the authors suggesting that the causes may have been agricultural in origin, as walking over uneven ground could result in the ankle torsion necessary for a fibular fracture. The differences between males and females in terms of lower limb fractures in the present study suggest that while males likely engaged in farming activities, such as the movement of animals or traversing uneven ground, women may not have.

Similar to the two urban sites, at Vagnari the odds of males having fractures was higher than females (Odds Ratio - 1.59; Table 4.15), and the fractures identified suggest differences in lifeways. At Vagnari, the *vicus* was likely made up of a work force of lower-class individuals who practiced agricultural and pastoral activity, such as keeping sheep and pigs (Carroll 2013). While the difference in fracture crude prevalence between males and females at the site are not significant, males have a greater proportion of fractures, in particular fractures associated with farming lifeways, such as distal tibial and fibular fractures (Table 4.15). The land around Vagnari was considered rocky terrain, which would have been difficult to navigate if individuals were keeping sheep, which require grazing and constant field rotation (MacKinnon 2011; Small 2014). In males, the prevalence of lower limb fractures suggests that males may have engaged in labour associated with falling and dealing with complex terrain. Females at Vagnari had no evidence of the lower limb fractures expected with pastoralism and the movement of animals; instead, the two types of fractures found in females are an upper humeral fracture, which occurs when an individual falls onto the shoulder (Gorczyca 2013), and rib fractures, which can have a variety of causes (Cundy and Williams 2018). Gilmour's (2017) study on fractures and biomechanics at Vagnari further supports that different lifeways existed for men and women at the site, and demonstrated that fractures sustained by males were more indicative of high energy trauma, while females sustained more unknown fractures. The results suggested that males were engaged in more at-risk lifeways, while females were more likely to sustain fractures due to everyday accidents, such as falls (Gilmour 2017). In keeping with these results, the current study found that while differences between the sexes were not statistically significant, differences in activities, such as agriculture and pastoralism, may be evident in individuals' fractures.

Sex based differences were also apparent at Godmanchester, where fractures were only evident in males and ambiguous individuals (Table 4.13). While not statistically examined, the absence of fractures in females suggests that gendered lifeways likely occurred. Similar to Vagnari, agriculture was the primary economic industry at Godmanchester (Green 1975, 190), and the majority of individuals would have engaged in food production. Males at Godmanchester had both fibula fractures and rib fractures which have been previously associated with agricultural activities. One further explanation might be the size and economy of Godmanchester. As a small town, Godmanchester likely served as a place of trade and sales, as individuals would have come into the town to sell goods at the market, from the rural communities (McCarthy 2013, 120-121). While the exact gender of buyers and sellers from surrounding lands is unknown, a mosaic depicting wool shipments and sales near Trier, Roman Britain suggests that transporters were likely men (McCarthy 2013, Figure 5.10).

Compared to the other sites, fracture prevalence between males and females at Barcelona was not statistically significant, and the odds ratio between males and females is close to 1 (Table 4.15), suggesting that men and women had similarly difficult lifeways. For individuals at Barcelona, one factor could be the status of the individuals in the community, where women and men had to engage in the same types of labour. As mentioned previously, while upper and middle-class women were likely engaged in certain types of labour, this was not the case for freedwomen and slaves. For example, Columella in the 1st c. CE treatise *De Re Rustica* (On Agriculture) demonstrates that while women in higher status positions were often relegated to more domestic tasks, those of lower status were field workers and engaged in food production (Scheidel 1996). Columella argues that when raining, slave women should be moved out of the field and indoors to do other domestic tasks (as presented in Scheidel 1996). Columella's casual reference further highlights how widespread women may have been in such occupations, as writers during the Roman period did not differentiate between men and women of the lower classes unless needed (Dixon 2004, 64). Women and men of the lower classes were often just referred to as slaves, Romans or non-Romans, which suggests that women were present in the workforce even if not identified. At Barcelona, one of the sites associated with the settlement had epigraphic evidence associated with poorer and lower status individuals (Vila de Madrid), while researchers inferred lower status at Carrer Ample 1 based on stress indicators and an absence of fish in the diet (Rissech *et al.* 2016). At Carrer Ample 1, isotopic studies of diet conducted by Rissech et al. (2016) found that, contrary to the importance of fishing and *garum* production at Roman Barcelona, the individuals all appeared to consume few marine resources. Fish were considered a luxury item, and rarely did individuals of lower status have access to them, suggesting that individuals at Carrer Ample 1 may have been working class (Rissech *et al.* 2016). When considering the fractures of the individuals, both males and females have a high prevalence of upper limb fractures with an equal number of radial fractures (Table 4.13), and a high prevalence of rib fractures (Table 4.13), suggestive of similarly difficult lifeways.

5.2.2 Burial Type

In the current study, differences in fracture prevalence were also compared between burial types at each settlement. Rather than a measure of direct status, burial types were treated as a complex metric associated with time, social status, wealth, and the ability to mobilize resources, with the notion that they represent the relationship between the living and the deceased. When the differences in fracture prevalence between burial types are considered, the differences are only significant at Winchester between coffin and pit burials (Table 4.16). At Winchester, individuals in pit burials are twice as likely as those in coffin burials to have fractures (Table 4.17). Similarly, at Godmanchester individuals with fractures were only found in pit burials (Table 4.16). At both sites, the difference in fracture prevalence between pit and coffin burials suggests that the lifeways of those buried in pits may have been riskier than those in coffin burials. However, at all other sites, differences in fracture prevalence between different types of burial were not statistically significant, suggesting that individuals had similar prevalence of fractures regardless of burial type (Table 4.17). Most surprising was the absence of significance at Lisieux Michelet, which was similar to Winchester in terms of sample size and burial types represented.

Given the literature, the absence of statistically significant differences at most of the sites is not surprising, as funerary treatment and health in the Roman period have largely proved inconclusive at different settlements. Robb *et al.*'s (2001) study of social differentiation in Iron Age Pontecagnano, Italy, found that there were subtle differences in relation to health and burial, but only with specific indicators. Similarly, Redfern and DeWitte (2011) found that burial type at Roman Dorset was not related to differences in mortality. In the current study, the absence of differences might be related to the simplicity of burial type analysis. For example, at Vagnari, there is a wealth of grave goods, but there are certain associated finds, such as bronze, being associated with a higher number of grave goods (Brent and Prowse 2014), suggesting that differences in burial at Vagnari may be more nuanced than burial type divisions can outline.

The results from Winchester and Godmanchester, however, suggest that there was some form of social differentiation evident in these two cemeteries, as individuals in pit burials had a greater prevalence of fractures (Table 4.16; 4.17). In considering the composition of towns and cities in the Roman Period, this result is not surprising, as there was a greater diversity in the economic wealth and status of individuals that lived in them. In Roman cities, the elite lived in larger homes that also housed workers and slaves (McCarthy 2013, 126). Richer and wealthier individuals would have owned several businesses, and rented out the shops to crafters and workers. The primary economy would have been retail and sales, with a variety of individuals making a living either manufacturing or selling goods (Elis 2018, 6-9). Merchants and traders would have been part of the overall landscape of the city, alongside poorer workers from rural communities who aimed to sell wares. Public buildings and government officials who were all firmly upper-class citizens would have also been present (Goodman 2007, 8). For example, at Godmanchester, higher class individuals could be those associated with the public administrative buildings. The results are in keeping with the findings of Pitts and Griffin (2012) who used multidimensional scaling and a Gini co-efficient to examine differences in burial treatment and health at multiple settlements in Roman Britain. The authors found that where there was evidence of social differentiation, individuals in 'poorer burials' had 'poorer health' when considered in relation to their community (Pitts and Griffin 2012). The results of the current study found that the simplest and least monumental form of burial had the highest prevalence of fractures. Comparatively, the stepped graves and lead coffins both show the lowest prevalence of fractures in the Winchester sample, suggesting that there were some forms of social differentiation not only between pit and coffin burials, but between overall types of burial. Differences between all types of burials at Winchester suggest that there were differences in lifeways based on the way an individual was interred.

5.3 Fracture Prevalence Between Age and Sex Groups Within Types of Burial

As burial type in the current study is treated as a complex metric associated with any number of facets of social identity, fracture prevalence between age and sex was also compared *within* types of burials. The results found that at Winchester and Lisieux Michelet, differences in fracture prevalence within coffin burials were statistically significant, while at other sites, the prevalence of fractures increases or decreases. At Lisieux Michelet, the differences in fracture prevalence between males and females were still significant in coffin burials, while it was not in pit burials (Table 4.19). The results suggest that while females in coffin burials at Lisieux Michelet had different lifeways than males, this was not true for females in pit burials. Likewise, at Winchester, differences in prevalence in age categories were still significant in coffin burials, but not in pit burials, suggesting that in pit burials one's age was not associated with whether one had a fracture (Table 4.21). Overall, the differences within burials highlight intra-community differences that are as important as intercommunity differences, in keeping with the findings of Robb *et al*. (2001), Pitts and Griffin (2012), and Agarwal (2012). As the theory of embodiment highlights social inequalities as they are experienced and represented in one's biology, the cross cuts of burial demonstrate how fracture prevalence within cemeteries is indicative of different, possibly unequal lifeways.

When applied, embodiment theory has the capacity to provide insight into complex systems of inequality, Robb *et al.* (2001) argued for the conjoined examination of "biological" and "social" status, or the notion that one's body, or embodied health, is an indicator of one's status in society, in conjunction with grave goods in Pontecagnano, Italy. In examining grave goods and various health indicators, Robb *et al.* (2001) found that one group had distinct differences, the male "no grave goods, greater ill health indicators" group. The authors suggest that this may be related to a harder lifeway, reflected in the combined indicators of grave goods and health. Similar studies include Agarwal's (2012) study of the intersection of age and gender in osteoporosis, and Pitts and Griffins' (2012) study of Roman intra-and-inter cemetery health. Agarwal (2012) found that osteoporosis is related to gendered practices, and not static across the life course, while Pitts and Griffin (2012) found that where there was inequality in cemeteries, there were overall indicators of poorer health. Rather than a straightforward analysis of burial treatment as richer or poorer, the authors found that when there was greater disparity within a cemetery in terms of burial wealth and funerary architecture, there was more likely to be a greater disparity of overall health.

When the nuance of burial type is considered, the sex-based differences at Lisieux Michelet highlight a more complex picture than the one provided by initial sex-based analysis. In the initial analysis where sex was examined in isolation, differences in fracture prevalence were distinct between males and females, suggestive of differences in lifeways, such as military service. When differences *within* burial types are considered, the statement should be modified. In coffin burials, males were just over four times more likely to have fractures than females (Table 4.19). However, in pit burials, the odds of males and females having fractures are near equal, with females having slightly more fractures (Table 4.19). For males and females in coffin burials, there may have been distinct lifeways that lead to differences in fracture prevalence, such as women undertaking fewer physically demanding tasks compared to males. For individuals in pit burials, this is not a true statement, and the fracture prevalence is notably lower for males relative to the rest of the sample and more equal for males and females. Males in coffin burials have nearly twice the fracture prevalence of males in pit burials, while females in pit burials have nearly twice the fractures of those in coffin burials, suggesting that there may be similar lifeways for males and females in pit burials (Table 4.19).

The results of the current study are, however, in keeping with the findings of Pitts and Griffin's (2012) study, which found that cemeteries containing individuals with the poorest health were not those with the least burial wealth, but rather those who showed differences in inequality *within* their cemetery. Furthermore, Pitts and Griffin (2012), found that cemeteries that demonstrated inequalities within burial communities (such as similar burial structure) were more likely to show greater issues associated with health. At Lisieux Michelet, if individuals in pit burials were considered those of 'lower class', as they were not able to mobilize resources, we would expect them to show the most significant number of fractures. Rather, in this case, the ‘wealthier’ burials of coffins show the highest prevalence of fractures. At Lisieux Michelet, coffin burials could, for example, contain the soldiers suggested above, or craftspeople who would have represented a lower/middle class individual. While craftsmen were looked down upon in Roman textual sources by the upper elites, educated labour such as blacksmithing was highly desirable, and required skill (Elis 2018, 96). Individuals who were craftsmen could have lived about their shops (or *tabernae*) and employed other workers, including apprentices (Elis 2018, 98). The males with the most significant numbers of fractures could reflect a working-class population within coffin burials (a widespread form of burial at Lisieux Michelet). In this case, at Lisieux Michelet, further analysis of grave goods, and funerary treatment alongside health might yield a more detailed analysis.

At Winchester, the differences between age categories were likewise more nuanced than the initial isolated analysis of age suggested. Further investigation into differences within coffin, pit, and possible coffin burials suggest that age structures differ depending on burial community. In coffin burials, the prevalence of fractures increased from young to old adult linearly, and differences between age categories were statistically significant, while in pit burials, fracture prevalence peaks in middle adult individuals, and is not statistically significant (Table 4.20; Table 4.21). When considering age and fractures, two things must be acknowledged: that fractures are cumulative across the lifetime (Glencross 2011), and that the longer an individual is alive, the more likely they are to have sustained a fracture (Glencross and Sawchuck 2003).

A higher prevalence of fractures in old adults suggests that individuals gained fractures throughout their lives, while a higher prevalence of fractures in middle adults suggests that individuals with fractures are dying earlier. Fracture peaks in individuals that died as middle adults have also been noted at other settlements in the Roman Empire. Gilmour *et al.* (2015) found that middle adults had the highest prevalence of fractures at *Aquincum*, a major urban centre in Roman *Panonnia* on the eastern frontier. Similarly, Gilmour's (2017) study of fractures in Romano-Britain and Italy found that at Ancaster, fractures peaked in middle adults, but only in males, suggesting that those who sustained fractures were dying earlier, and likely related to their rural lifeways. Gilmour (2017) and Jennings (2016) also found that fracture prevalence peaks in young adults at rural sites, suggesting that young people may have been engaged in more at-risk lifeways and died earlier. In considering age differences in modern farming and agricultural studies, men experience a slow and steady increase of injuries until old adulthood, and then a slow reduction towards old age as they become experienced workers (McCurdy and Carroll 2000; Rasmussen *et al.* 2000). Injuries sustained by young people in modern communities are typically due to inexperience and a lack of training, often associated with a temporary or limited form of labour, such as migrant workers (McCurdy and Carroll 2000). Migrant workers make up a high proportion of injuries, as they come to do low skill labour repetitively, often with minimal training, no health and safety standards, and low wages paid by the piece. In the Roman period, harvest season saw a comparable movement of labour as slaves and freedmen were borrowed and bought from other elite families (Varro 116-27 BCE as presented in Gardner and Wiedemann 1991, 71). The results at Winchester mirror what was found at Vagnari and Godmanchester, where middle adults had the highest prevalence of fractures, although the age structures differed across burial types. In this case, the fracture peak in middle adults suggests that individuals in pit burials may have been associated with a higher injury community or workforce. At Winchester, the difference in age structures between the two types of burials suggest that within the cemetery, the lifeways of these individuals were not experienced universally, but based on one's created social status, as represented in burial treatment.

Similar to Lisieux Michelet, at Barcelona sex differences within burials occur when an in-depth cross cutting analysis is considered, even though they are not statistically significant. Females in tile burials at Barcelona have more fractures than males, even though the overall sample shows relatively similar fracture prevalence between the sexes. This is counter to pit burials where males have a greater prevalence and risk of fractures than females (Odds Ratio - 2.11, Table 4.23). The similarities between males and females in tile burials and the greater prevalence of fractures for males in pit burials suggests that gendered lifeways existed for one burial community (pits) and not for the other (tiles). One explanation for this variation may involve considering the socio-cultural context of all burials and the time period that the burials are from. Jennings (2016) found that females at Gambier-Parry Lodge (a 4th c. CE settlement) had a higher number of multiple injuries and a greater true prevalence of fractures. The author suggests that Gambier-Parry Lodge was also associated with a small hillfort and suggests that as males were soldiers, females would have had to pick up the brunt of the labour associated with the rural life, such as farming. Likewise, Peck's (2009) study of pre- and post-Roman conquest York found that there was an uptick in fractures in the post conquest period overall, and a small uptick in fracture prevalence for females, while it stayed the same for males. In considering the individual sites within Barcelona, most females with fractures (5/6 or 83.3%) in tile burials occurred in the Market of Santa Caterina, a 4-6th c. CE cemetery. Comparatively, only three females had fractures from other sites: Carrer Ample 1 a 4th c. CE site, and Vila de Madrid, a 1st – 3rd c. CE site, with only one from Carrer Ample 1 in a tile burial. During the decline of the Roman Empire, conflict could have ensued as Barcelona was invaded by Barbarians and later again, retaken by imperials in the 5th century CE (Kulikowski 2004, 168-169), and women would have likely been required to pick up the tasks that new recruits left behind, such as crafting or working in production centres, as men would have been employed in the army. For example, women could have picked up most of the fishing and dock work associated with the *garum* production facility, as men were absent.

During such a period of turmoil and protracted fighting, violence may have also factored into the prevalence of fractures. Towns, alongside rural spaces, were the focus of post Roman period skirmishes in Spain, as various leaders vied for control of resources (Kulikowski 2004, 168-169). All the females at Santa Caterina have evidence of multiple healed rib fractures, with one individual also having a distal radial fracture. Along with other causes, rib fractures have been associated with violence (Sirmali *et al.* 2003; Cundy and Williams 2018), however, none of the individuals showed further evidence of violence such as fractures to the distal 1/3 of the ulna. As rib fractures have such a complex mechanism of injury, for females at Barcelona, the causes of rib fractures could reflect a variety of lifeways.

When considering males in pit burials, whose odds ratios are notably higher than females, burial types are associated comparatively with Vila de Madrid and Carrer Ample 1. Males with fractures from Santa Caterina account for 30.8% (4/13) of the total males with fractures, with the most coming from Vila de Madrid (38.5% or 5/13). As Vila de Madrid is from the height of the Roman Empire, and a stage of relative peace under the *Pax Romana* (Peck 2009, 53), women could have been exempt from more strenuous forms of labour. As both sexes have fractures during the time period of Santa Caterina, a crisis in which women were more likely to work could be the reason for the similarities in fractures, but that during the previous centuries, gendered lifeways may have been present.

When considering the smaller settlements, the cross cutting of burials did not yield any new perspectives but did change the overall crude prevalence. At Vagnari, fractures stayed predominantly male, and associated with middle adults, and at Godmanchester, middle adults still retained the highest prevalence of fractures (Tables 4.24 and 4.26). In considering both smaller settlements and the confluence of identities, the absence of new information may also be due to sample size, where there is not enough comparative data to highlight changes in fracture prevalence. Overall, the results suggest that when examined through the theoretical lens of embodiment and an understanding of urban settings in the Roman period, the differences at Lisieux Michelet, Barcelona, and Winchester are not surprising. Urban settings in the Roman period were diverse places where there may have been a greater diversity of social standing and lifeways, and where cities straddled multiple time periods (Eckardt *et al.* 2009; McCarthy 2013, 130-131). In considering status at Lisieux Michelet and Winchester, a significant factor in the urban setting was that elite individuals were present, and there were greater differences in the status of individuals (McCarthy 2013, 130-131). Robb *et al.* (2001) argues that there are two types of status that can be gleaned from individuals, one's 'social status' or their grave goods and funerary treatment, alongside their 'biological status' or their health as evidenced in the skeleton. Urban spaces were home to many individuals during war time and conflict, and at Barcelona, the confluence of time period, burial, and sex suggests that during a period of conflict, lifeways for women changed. In considering the intersection of multiple forms of identity, the results suggest that rather than a simple sex/age divide, these are complicated by one's position within the community as demonstrated by burial treatment.

5.4 Prevalence of Fractures Between Settlements

As fracture prevalence within settlements yielded differences, fracture prevalence was also assessed between settlements. When comparing major towns (Winchester, Lisieux Michelet, and Barcelona) and small settlements (Vagnari and Godmanchester), differences were not statistically significant (Table 4.35), suggesting that regardless of settlement size individuals had complex lifeways with potential risks for fractures. When odds ratios are considered, the risks in large towns and small settlements showed that there were differences in fracture prevalence in relation to one's age and sex, suggesting that life was heterogeneous and had different risks based on age and gender (Table 4.35).

For individuals in the Roman period, a number of lifeways likely involved a risk of fracture. McCarthy (2013) suggests that most individuals would have been relegated to food production, whether in the city or the village. When looking at the city, farms would have existed outside the city walls, and while many individuals would have lived on the farm, individuals would have also lived in the city and migrated to such farms for seasonal labour (Marzano 2013, 86-87). For example, Varro (116-27 c. BCE) argued that when buying or borrowing slaves and freedmen to help with agricultural labour, one should always choose those over the age of 22, as they were older and could handle the work associated with agriculture and farming (Gardner and Wiedemann 1991, 71). In clinical literature, agricultural and farm work are high risk for injury and fracture, as individuals interact with large animals and major machines (Cogbill and Busch 1985). Large animals such as oxen and donkeys were work animals that would have been found in and around cities to help run machinery such as mills and to carry supplies (McCarthy 2013, 112-113, 121). A study of livestock and animal husbandry by Criddle (2001) found that the lower limbs are primarily affected, as individuals are routinely stepped on and kicked when moving cattle. Other activities that would have been high risk for injury include extraction industries such as mining, construction, metalworking, and fishing (McCarthy 2013). In construction, which would have been found in greater quantity in the city, injuries are primarily sustained using hand tools, along with falling on or having materials fall on the individual (Welch *et al.* 2015).

One area of commonality between the settlements lies in the prevalence of rib fractures at all sites (Table 4.40). Rib fractures in the modern world occur for a variety of reasons. Typically, multiple bilateral fractures occur due to direct blows to the chest from interpersonal violence, while one sided rib fractures can occur due to falls, sustained stress, coughing, illness, and general bone weakness (Cundy and Williams 2018). In the elderly, rib fractures are commonly associated with decreased bone density, and are routinely associated with long term vitamin D deficiency (Cundy and Williams 2018). Unlike other fractures, rib fractures were found at all the sites, and had the highest crude prevalence of any element. Rib fractures were also the only elements that were significant when compared between sites, suggesting that differences in the number of rib fractures between settlements differed from the expected values. Barcelona had the highest true prevalence of rib fractures (3.2% of elements) while Lisieux Michelet (0.7%) and Winchester (2%) were significantly lower. In modern epidemiological data of agriculture and farming, trunk injuries make up a significant proportion of sustained injuries, as individuals are kicked by livestock (Richardson and May-Lambert 1997; Criddle 2001; Lindsay *et al.* 2004). Faunal evidence for meat consumption suggests that even in the urban setting, large animals would have been found in the city, whether they were migrated into the city for butchery, or kept in smaller individual plots for wool and milk (McCarthy 2013). However, when compared to Roberts and Cox's (2003, Table 3.28) all the settlements had a lower true prevalence of rib fractures than those reported, suggesting that while common, rib fractures were not as commonly reported as at other Roman sites.

The most similar to Roberts and Cox's data on rib fractures was Barcelona. At Barcelona, rib fractures had the highest prevalence followed by radial and ulnar fractures

(Table 4.40). When compared to other sites, fibula fractures had the highest true prevalence at Winchester, Godmanchester, and Vagnari, while at Lisieux Michelet, it was radial fractures followed by clavicular fractures. The prevalence of upper limb fractures compared to the other sites suggests that individuals may have engaged in different types of labour, but that these activities were not overtly riskier than the other sites. At Barcelona, rib fractures and upper limb injuries such as radial fractures were common, suggesting that individuals had greater underfoot accidents and falls onto outstretched hands, while fractures to the tibia and fibula are notably absent (Sogaard *et al*. 2007). At Barcelona, two major production activities would have been grape and *garum* processing, as well as industrial washing and dying and the export of such goods (Beltran *et al*. 2006). Fishing and dock work in clinical literature have exceptionally high rates of trauma, particularly to the chest, as individuals manage uneven footing, difficult weather, the movement of goods, and movement from ship to land (Norrish and Cryer 1992; Jensen 1996; 2000; Matheson *et al.* 2001). Injuries to the hand, chest and limbs are common as individuals fall on hard surfaces or are pulled by ropes (Jensen 2000). In the Roman world, evidence for fishing comes from archaeological and textual sources, where both land fishing and net fishing from boats is depicted (Bekker-Nielson 2010).

One other potential avenue for the high rate of rib fractures in Barcelona is in the washing and laundering of textiles. Found in *Placa del Rei* alongside the wine and *garum* production centres, Barcelona had a washing and dying textile production centre (Beltran 2002, 50-51). Archaeological evidence of urine, ash, lime, as well as structural evidence for sinks suggest that fabrics were not only washed but died and set (Beltran 2002, 51). In the Roman period, textile production outside of the home was conducted by both men and women, although certain textiles such as wool, were predominantly the realm of women. The floors of the production centre, according to Beltran (2002, 51), allowed for the overflow of water from the sink, which would have created a slippery surface for individuals to work on, and increased fracture risk. However, Jennings' (2016) study of the Roman rural site of Granada in Spain found that when compared to Roman Britain, there was a similarly high number of upper limb fractures, while both Roman Baldock and Gambier Parry Lodge had predominantly lower limb fractures, which suggests that there may be distinct differences in the agricultural practices that have not been explored in relation to Roman Spain as yet.

When compared to other analyses of 'urban' and 'rural', the results of the current study were counter to many of the studies done on medieval sites, as the overall crude prevalence between large and small settlements was not significant. Studies of medieval urban and rural fracture prevalence have typically found that individuals in the rural setting had a greater prevalence of fractures, as individuals in cities had significantly greater craft specialization. The medieval period (post-1000 CE), was also a period of prosperity that saw a massive rejuvenation in many of the cities. Judd and Roberts (1999) along with Agnew *et al.* (2015) both found that there were notable differences in the urban and rural sites under study. Agnew *et al*. (2015) found that there was a significant difference between the urban and rural settings, particularly in relation to vertebral fractures. The results of the study found that rural individuals had a greater prevalence of vertebral fractures associated with hard labour and more difficult lifeways (Agnew *et al.*

2015). In comparison, the results of the current study find that the fracture prevalence at large settlements and small settlements were not statistically different, and that in the Roman period, even the major cities had fractures indicative of more difficult lifeways.

While differences in overall fracture prevalence between the settlements were not significant, differences were evident in risk of fractures when considering age and sex, and odds ratios suggest that there were differences between major and minor settlements (Table 4.35). In the current study, all females and middle adult males had greater odds of fractures in smaller settlements, while young and old adult males had greater odds of fractures in large urban settlements, in keeping with the results of sex-based analysis above. When individual settlements are compared, there are significant differences in urban settings, where females have a low prevalence of fractures.

One potential difference in relation to young and old males is the movement of individuals to sell wares and other mercantile items from the supporting communities. For example, Godmanchester is classified as a small town with both public buildings and evidence of craft production, but it had a significant focus on farming, and acted as a bridge between the major cities and the rural countryside (Green 1975; Green and Malim 2017). Pitts (2016) argues that small towns in Roman Britain held a uniquely complex position, and served an intermediate purpose (Pitts 2016, 708-711), with evidence of markets, stalls, and administrative centres, where individuals would come in from the rural communities to sell ware. Transportation in the Roman period occurred along roads using horses, donkeys, and oxen-pulled carts, and along waterways in boats, ships, and canals (Greene 1986, 38-39). Transportation and the movement of goods was a major feature and capability of the Roman period, as individuals could collectively travel from one corner to the next (McCarthy 2013, 120-121). Evidence for the migration of goods and wares has been particularly focused on the evidence for butchering in major cities, as it was easiest to move livestock to an urban centre so that meat could be sold fresh (McCarthy 2013, 82-83). Studies of long-term Roman migration have found that individuals moved all over the empire, and that travel was a feature of cities and small towns (Eckardt *et al.* 2009), but fewer studies have considered the relationship between settlements and more local movement. In Collier and Primeau's (2019) comparison of rural and urban settlements and fractures in medieval Denmark, the authors found that there was no statistical significance to the differences in fracture prevalence between the two urban and rural settlements, due in part to the relative closeness of the rural site to the urban one, making the transportation of goods and the rural-urban relationship rather different than with an isolated rural site. Individuals at both settlements had fractures, and counter to other studies of the period, fractures occurred more frequently in some instances in the urban setting (Collier and Primeau 2019). In this case, the differences for young and old males may lie in the transportation and movement of goods associated with trades and wares to sell.

If trade was the only reason for the odds ratios, however, the results might be found across all ages equally (Table 4.35). As middle adult males had higher odds of fracture in rural settings, one key point might lie in career advancement. In young adult males advanced training in skills and crafts might also explain the differences in odds ratios. Morel (1993, 226-238) argues that for many individuals, young men particularly, the process by which individuals learned their craft was under the tutelage of another expert, and these were predominantly recorded in cities, where we have the greatest diversity of crafts (Morel 1993, 226-238). In the medieval period, Collier and Primeau (2019) found that young men had a higher rate of fractures in the city than their rural counter parts. The authors argue that for young men, trade specialization would have been crucial, with an apprenticeship being vital for young males to make a living, potentially resulting in a higher rate of fractures (Collier and Primeau 2019). Young males could have sustained fractures in more labourious industries such as smelting, which we have evidence of at Lisieux Michelet. Further, Gardner (1986, 239) states that while women were likely engaged in crafts, they are relatively absent in the more formal guilds. As a result, women in the urban setting could have been excluded from more rigorous crafts as prominent crafters.

In the Roman period, urban settlements have been considered along a number of lines, such as population size, settlement size, the presence of public buildings, baths, circuses, and *oppidum*. Wacher (1995) argues that many of the distinctions we draw between urban and rural living in the Roman period are not concrete and should be considered on a spectrum. In the current thesis, the differences between communities are based on lifeways related to one’s gender, age, and in the case of settlements, external confounding factors. Rather than a cut-and-dry metric of Roman small settlement and city, the differences in fractures are more akin to differences at the individual and community level in relation to who someone was and what they did. The differences in the current study, such as true prevalence of fractures, suggests that rather than a simple urban and rural distinction, a key factor is the primary economy and structure of the communities they lived in. For example, at Lisieux Michelet, a higher prevalence of fractures in males could be caused by a variety of lifeways, but one such cause could be crafts such as metalworking, while at Barcelona, lifeways of production and the fall of the empire likely had an impact on individuals' lives. Winchester, Godmanchester, and Vagnari showed the greatest similarity, with a common indicator of lower limb fractures suggestive of agriculture. The absence of statistically significant differences in crude prevalence between settlements could be related to the overall complexity and variability of lifeways at each of the settlements, and the primary economies of the settlements themselves.

5.5 Limitations

There were two major limitations to this study that must be addressed. First, this study relied on data collected by others, with my own assessment as an additional consideration. As the primary investigative tools in this study are photographs and records, the nature of the data is unfortunately limited, and I was unable to perform certain assessments, such as angulation, rotation, and fracture type assessment. To combat this limitation, the questions answered were aimed at examining only fracture prevalence, rather than fracture type, and considering the research from a large sample approach. Second, the sample size of the smaller Roman sites makes comparison between minor towns and major towns difficult. In this case, odds ratios were employed where possible (*e.g.* 2x2 chi-square), and data was lumped when not significant, as when comparing the smaller sites (Section 4.7.1).

5.6 Summary

In this thesis, the theory of embodiment was used to guide the consideration of fracture prevalence *within* and *between* five settlements in the Western Roman Empire. In response to the three questions that are posed at the beginning of this chapter, the findings are thus:

1. Sex based differences were evident at almost all the sites. Statistically significant differences in crude prevalence between sex categories at Lisieux Michelet and Winchester may be reflective of differences in lifeways, where women engaged in less at-risk labour or day-to-day activities than their male counterparts. At Vagnari and Godmanchester, while not statistically testable or significant, the differences between males and females suggest that there were some differences in lifeways. In the case of Barcelona, the lack of sex and age differences suggest that lifeways for these individuals may have been similar. This agrees with textual sources that speak of field labour for lower status groups.
2. Differences between burial types were not significant in almost all cases, but this was in keeping with the results of other studies that have examined trauma and burial types.
3. Fracture prevalence changes when examined *within* burials types and tells a different story than when identities (such as age, sex, and burial type) are considered as separate. The statistical significance of age at Winchester for individuals in coffin burials and the differences between males and females at Lisieux Michelet suggest that the differences *within* coffin burial types are as

important as those across the whole sample. The lack of differences within other types of burials at each of the settlements suggests that differences in lifeways were not universal across the sample but limited to specific groups. At Barcelona, for example, time period was a key indicator in the fracture prevalence of females, as fracture prevalence was much lower during the height of the Roman Empire, compared to during the fall. Lifeways in the larger settlement setting were nuanced and related to one's social position or time period, rather than overall differences.

4. Differences in fracture prevalence between large and small settlements were not significant, suggesting that rather than there being major differences in lifeways between small settlement and major city, individuals likely engaged in similarly difficult lifeways. Odds ratios demonstrate that risk of fracture was not the same for all individuals; for men in urban settings, the risk increases. This may be due to migration and militarization, as men in the Roman world moved into the urban setting for trade, military service, or seasonal labour.

CHAPTER 6 CONCLUSION

This thesis sought to examine whether fracture prevalence differed based on one's age, funerary treatment, or gender, both *within* and *between* five settlements of varying sizes in the Roman Empire. Embodiment theory argues that rather than a unidirectional flow of culture impacting biology, there is a more complex circle (Krieger 2005; Gravlee 2009). The results of the current study suggest that the body reflects how an individual moves through the world through fractures, and is changed by any number of factors, such as gender, one's age, one's geographic and temporal location, and one's lifeway. Overall, there were significant differences within settlements in relation to social identity, but an absence of difference between settlements.

When examining individual variables of sex, age, and burial treatment, odds ratios suggest that lifeways were gendered at almost all the sites, in keeping with textual sources. In considering the cyclical 'always already' approach of Heidegger, the results of the current study are in keeping with much of the textual evidence of gendered lifeways in the Roman period *(e.g* Gardner 1986), corroborating the gendered notions put forth about differences in activity. In this case, the bodies at Winchester, Godmanchester, and Lisieux Michelet corroborate what we know about gendered activities in the Roman period. The fractures sustained reflect bodies that were raised in and moved through a world defined by gendered behaviour and lifeways. We expect males to have more fractures, as men in the Roman period are documented to have more 'at-risk' lifeways.

When considering the confluence of identities within burial types, however, differences in lifeways are evident between gender, age, and time period at the three larger settlements. At Barcelona, a significant number of females with fractures from the 'dark period' of the fall of the Roman Empire is in keeping with Krieger's (2005) notion of "cannot or will not say." In this case, female bodies reflect a period for which we cannot provide direct context, but one that speaks to difficult and perhaps dangerous lifeways. The bodies of the females at Barcelona speak to a different lived experience than those of their earlier counterparts, one with a much higher rate of fractures.

In the analysis between settlements, the results suggest that there is an overall similarity in 'risk' associated with fractures at all sites, but a diversity of lifeways is evident in fracture patterns. Rather than a simple, cut-and-dry metric of large and small settlements, as we see in many of the medieval studies, differences in fracture patterns suggest that activities, economy, and time period were as important as who the individuals were in the settlements. In considering the body as shaping and shaped by how individuals move through the world, the complexity and absence of differences at settlements suggest that we cannot assume homogenous notions of lived realities in the Roman period. In considering life as 'embodied' at Lisieux Michelet, Winchester, and Barcelona, city living as reflected in the body speaks to a complex push and pull of lifeways that are distinct and different based on the confluence of environmental and social factors, such as economy.

In examining fractures from an 'embodiment' perspective, the results of the current study have highlighted how complex the world was for Romans and non-Romans. As fractures are long lasting demarcations of an insult to the body, whether through accident or intention, the results reflect lifeways that differed, and ways of moving through the world that were not necessarily similar or equal, dependent on who one was and where one lived. The bodies of the individuals analyzed in the current study demonstrate how the differences and particularities of lifeways are reflected on the skeleton.

The results have highlighted several areas for further research that should be explored. In examining social identity and the confluence of identity in relation to prevalence of fractures, two areas that require further exploration include *time*, and *migration.* Migration and mobility in the Roman world have been seen to affect the prevalence of disease in communities, as people migrated to and from urban centres across the empire (Redfern *et al.* 2018). While isotopic studies of Roman Britain (including Winchester) have been conducted (*e.g.* Eckardt *et al.* 2009), Roman Barcelona, which was settled much earlier than Britain, would benefit from similar isotopic analyses. The temporal transition was not examined as a variable in this study as several of the settlements did not occupy more than one time period, but as Gilchrist argues, the time period one lives in is vitally important (2012, 3), and life in the Roman period differed between the rise and the fall of the empire especially in regards to gender, age, and perhaps social standing. Lastly, studies of fractures when comparing urban and rural settlements have focused on medieval differences, where studies of urban and rural are significantly shaped by medieval growth and prosperity The absence of comparative analysis in the Roman period means that we are unable to determine how drastically different, or not, urban and rural living was embodied on the individual.

REFERENCES CITED

Adkins L, Adkins R. 1994. Handbook to Life in Ancient Rome. Oxford: Oxford University Press.

Agarwal SC. 2012. The past of sex, gender, and health: Bioarchaeology of the aging skeleton. Am Anthropol 114:322–335.

Agarwal SC. 2017. Understanding sex and gender related patterns of bone loss and health in the past. In: Agarwal SC, Wesp J, editors. Exploring Sex and Gender in Bioarchaeology. University of New Mexico Press. p 165–188.

Agarwal SC, Wesp JK eds. 2017. Exploring Sex and Gender in Bioarchaeology. Albuquerque: University of New Mexico Press.

Agnew AM, Betsinger TK, Justus HM. 2015. Post-cranial traumatic injury patterns in two medieval Polish populations: The effects of lifestyle differences. PLoS One 10:1–18.

Agresti A, Franklin C. 2013. Statistics: The Art and Science of Learning from Data, 3rd edition. New York: Pearson Education.

Andreau J. 1993. The freedmen. In: Giardina A, editor. The Romans. Chicago: University of Chicago Press. p 175–198.

Athwal G. 2015. Distal humeral fractures. In: Court-Brown C, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 1230–1286.

Avery LC. 2016. Analysis of Dental Health in Relation to Sex and Social Status. Unpublished MA Thesis. Hamilton: McMaster University

Barchiesi A, Schiedel W eds. 2010. The Oxford Handbook of Roman Studies. Oxford: Oxford University Press.

Barei D. 2015. Pilon fractures. In: Court-Brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2474–2541.

Bekker-Nielsen T. 2010. Fishing in the Roman world. In: Bekker-Nielsen T, Casasola D, editors. Ancient Nets and Fishing Gear: Proceedings of the International Workshop on Nets and Fishing Gear in Classic Antiquity, Cadiz November 15-17, 2007. Cadiz: Aarhus University Press. p 187–204.

Beltran J. 2002. From Barcino to Barcinona (1st to 7th Centuries): The Archaeological Remains of Placa del Rei in Barcelona. Barcelona: Museu d'Historia de la Ciutat/Ajuntament de Barcelona.

Beltran J, Comas I Sola M, Gurri I Costa E, Tresserras J. 2006. Noves aportacions sobre la produccio de vi a la laietania Romana: Instal-Lacions vinicoles I analisis de residus. Quarhis Quad d'Arqueologia i Història la Xiutat Barcelona 2:92–107.

Beltrán JHB. 2007. La via sepulchralis de la Plaza Vila de Madrid: Un ejemplo del ritual Funerario Durante El Alto Imperio en La Necropolis Occidental de Barcino. Quarhis 2(33):12-63

Boldsen JL, Milner GR, Konigsberg LW, Wood JW. 2002. Transition analysis: A new method for estimating age from skeletons. In: Hoppa RD, Vaupel JW, editors, Paleodemography: Age Distributions from Skeletal Samples. Cambridge: Cambridge University Press. p 73-106

Bonsall L. 2013. Variations in the Health Status of Urban Populations in Roman Britain: a Comparison of Skeletal Samples from Major and Minor Towns. Unpublished Dissertation. Edinburgh: University of Edinburgh.

Boulton C, O'Toole R. 2015. Tibia and fibula shaft fractures. In: Court-Brown C, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2416–2473.

Brent L, Prowse TL. 2014. Grave goods, burial practices and patterns of distribution in the Vagnari cemetery. In: AM Small, editor. Beyond Vagnari: New Themes in the Study of Roman South Italy. Bari: Edipuglia. p 99-110.

Brickley M, Mays S, Ives R. 2005. Skeletal manifestations of vitamin D deficiency osteomalacia in documented historical collections. Int J Osteoarchaeol 15:389–403.

Brickley MB. 2006. Rib fractures in the archaeological record: A useful source of sociocultural information? Int J Osteoarchaeol 16:61–75.

Brickley M, Mays S, Ives R. 2010. Evaluation and interpretation of residual rickets deformities in adults. Int J Osteoarchaeol 20:54–66.

Brickley MB, Mays S, George M, Prowse TL. 2018. Analysis of patterning in the occurrence of skeletal lesions used as indicators of vitamin D deficiency in subadult and adult skeletal remains. Int J Paleopathol 23:43–53.

Brooks S, Suchey J. 1990. Skeletal age determination based on the os pubis: A comparison of the Acsadi-Nemeskeri and Suchey-Brooks methods. Human Evolution 5:227-238.

Brothwell DR. 1963. Dental Anthropology. Pergamon Press, Oxford.

Buikstra JE, Ubelaker DH. 1994. Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at the Field Museum of Natural History. La Fayette: Arkansas Archeological Survey.

Burnham B, Wacher J. 1990. The Small Towns of Roman Britain. California: University of California Press.

Cappella A, Amadasi A, Castoldi E, Mazzarelli D, Gaudio D, Cattaneo C. 2014. The difficult task of assessing perimortem and postmortem fractures on the skeleton: A blind test on 210 fractures of known origin. J Forensic Sci 59(6): 1598–1601.

Cardoso HFV. 2008a. Epiphyseal union at the innominate and lower limb in a modern Portuguese skeletal sample, and age estimation in adolescent and young adult male and female skeletons. Am J Phys Anthropol 135: 161-170.

Cardoso HFV. 2008b. Age estimation of adolescent and young adult male and female skeletons. II. Epiphyseal union at the upper limb and scapular girdle in a modern Portuguese skeletal sample. Am J Phys Anthropol 137: 97-105.

Carrie JM. 1993. The soldier. In: Giardina A, editor. The Romans. Chicago: University of Chicago Press. p 100-137.

Carroll M. 2011. 'The Mourning was Very Good:' Liberation and liberality in Roman funerary commemoration. In: Hope V, Huskinson J, editors. Memory and Mourning: Studies in Roman Death. Oxford: Oxbow Books. p 126–149.

Carroll M. 2013. Investigating Agricultural Activities at the Roman Imperial Estate at Vagnari (Puglia), 2013. Available at: www.romansociety.org/fileadmin/documents/pdf/M_Carroll_2013.pdf

Chapman R. 2013. Death, burial, and social representation. In: Nilsson Stutz L, Tarlow S, editors. The Oxford Handbook of the Archaeology of Death and Burial. Oxford: Oxford University Press. p 47-57.
Clarke G. 1979. Pre-Roman and Roman Winchester: The Roman cemetery at Lankhills (Vol. 3). New York: Clarendon Press.
Cogbill T, Busch HM. 1985. The spectrum of agricultural trauma. Clin Commun 3:205–210.
Cohen J. 1988. Statistical Power Analysis for the Behavioral Sciences. New Jersey: Routledge.
Collier L, Primeau C. 2019. A tale of two cities: A comparison of urban and rural trauma in Medieval Denmark. Int J Paleopathol 24:175–184.
Collinge C, Wiss D. 2015. Distal femur fractures. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2229–2269.
Court-Brown CM, McBirnie J,Wilson G. 1998. Adult ankle fractures — an increasing problem?. Acta Ortho Scandi 69(1): 43-47.
Court-Brown CM, Wood A, Aitken S. 2008. The epidemiology of acute sports-related fractures in adults. Injury, Int J Care Injured 39: 1365-1732.
Criddle LM. 2001. Livestock trauma in central Texas: Cowboys, ranchers, and dudes. J Emer Nurs 27(2):132-140
Cucina A, Tiesler V. 2003. Dental caries and antemortem tooth loss in the Northern Peten area, Mexico: A biocultural perspective on social status differences among the Classic Maya. Am J Phys Anthropol 122:1–10.
Cundy P, Williams N. 2018. Rib fractures. BMJ Best Practice. Available from: https://bestpractice-bmj-com.libaccess.lib.mcmaster.ca/topics/en-us/1009
Daegling DJ, Warren MW, Hotzman JL, Self CJ. 2008. Structural analysis of human rib fracture and implications for forensic interpretation. J Forensic Sci 53:1301–1307.
Dixon S. 2004. Exemplary housewife or luxurious slut? In: McHardy F, Marshall E, editors. Womens Influence on Classical Civilization. New York: Routledge. p 56–74.
Djuric M, Roberts C, Rakocevic Z, Djonic D, Aleksandar L. 2006. Fractures in late Medieval skeletal populations from Serbia. Am J Phys Anthropol 130:167–178.
Dyson R. 2003. The Roman Countryside. London: Gerald Duckworth & co.
Eckardt H, Chenery C, Booth P, Evans JA, Lamb A, Müldner G. 2009. Oxygen and strontium isotope evidence for mobility in Roman Winchester. J Archaeol Sci 36:2816–2825.
Eckardt H, Müldner G, Lewis M. 2014. People on the move in Roman Britain. World Archaeol 46:534–550.
Egol K, Koval K, Zuckerman J eds. 2015. Handbook of Fractures. Philadelphia: Lippencott Williams and Wilkins.
Ekengren F. 2013. Contextualizing grave goods. In: Tarlow S, Nilsson Stutz L, editors. The Oxford Handbook of the Archaeology of Death and Burial. Oxford: Oxford University Press. p 173–194.
Elis S. 2018. The Roman Retail Revolution. Oxford: Oxford University Press.

Esmonde Cleary S. 2012. The ‘endings’ of Roman Britain. In Hinton D, Crawford S, Hamerow H, editors. The Oxford Handbook of Anglo-Saxon Archaeology. Oxford: Oxford University Press. p 13-29.
Esmonde Cleary S. 2016. Britain at the end of the empire. In: Millett M, Revell L, Moore A, editors. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press. p 134–149.
Fowler C. 2013. Identities in transformation. In Tarlow S, Nilsson Stutz L, editors. The Oxford Handbook of the Archaeology of Death and Burial. Oxford: Oxford University Press. p 512-526
Galloway A, Zephro L, Wedel V. 2014. Classification of fractures. In: Wedel V, Galloway A, editors. Broken Bones: Anthropological Analysis of Blunt Force Trauma. Springfield: Charles C Thomas. p 59–71.
Gardner J. 1986. Women in Roman Law and Society. Indianapolis: Indiana University Press.
Gardner J, Wiedemann T. 1991. The Roman Household. London: Routledge.
Garnavos C. 2015. Humeral shaft fractures. In: Court-Brown C, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green’s Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 1287–1340.
Geller PL. 2008. Conceiving sex: Fomenting a feminist bioarchaeology. J Soc Archaeol 8:113–138.
Gilchrist R. 2012. Medieval Life: Archaeology and the Life Course. Suffolk: Boydell and Brewer.
Gilmour RJ, Gowland R, Roberts CA, Bernert Z, Klara Kiss K, Lassanyi G. 2015. Gendered differences in accidental trauma to upper and lower limb bones at Aquincum, Roman Hungary. Int J Paleopathol 11:75–91.
Gilmour RJ. 2017. Resilient Romans: Cross-Sectional Evidence for Long-Term Functional Consequences of Extremity Trauma. Unpublished Dissertation. Hamilton: McMaster University, Department of Anthropology.
Gilmour RJ, Brickley MB, Jurriaans E, Prowse TL. 2019. Maintaining mobility after fracture: A biomechanical analysis of fracture consequences at the Roman Sites of Ancaster (UK) and Vagnari (Italy). Int J Paleopathol 24:119–129.
Gingrich P. 1992. Introductory Statistics for the Social Sciences. Regina: University of Regina.
Glencross, B. 2003. An Approach to the Paleoepidemiology of Bone Fractures. Unpublished Dissertation. Toronto: University of Toronto.
Glencross B, Sawchuk L. 2003. The person-years construct: Ageing and the prevalence of health-related phenomena from skeletal samples. Int J Osteoarchaeol 13:369–374.
Glencross B. 2011. Skeletal injury across the life course: Towards understanding social agency. In: Agarwal SC, Glencross B, editors. Social Bioarchaeology. Oxford: Wiley-Blackwell. p 390–409.
Goodman A, Leatherman T eds. 1998. Building a New Biocultural Synthesis: Political-Economic Perspectives on Human Biology. Ann Arbor: University of Michigan Press.

Goodman P. 2007. The Roman City and its Periphery: From Rome to Gaul. New York: Routledge.
Gorczyca J. 2013. Proximal humeral fractures: Open fixation and reduction. In: Wiss D, editor. Fractures. Philadelphia: Lippencott Williams and Wilkins. p 47–64.
Gowland R. 2006. Ageing the past: Examining age identity from funerary evidence. In: Gowland R, Knusel C, editors. Social Archaeology of Funerary Remains. Oxford: Oxbow Books. p 143–154.
Gowland R. 2017. Embodied identities in Roman Britain: A bioarchaeological approach. Britannia 48:175–194.
Grauer AL. 2012. Introduction: The scope of paleopathology. In: Grauer A, editor. A Companion to Paleopathology. Chichester: Wiley-Blackwell. p 1–14.
Grauer AL, Miller AG. 2017. Flesh on the bones: A historical and bioarchaeological exploration of violence, trauma, sex, and gender in medieval England. Fragments 6:38–79.
Gravlee CC. 2009. How race becomes biology: Embodiment of social inequality. Am J Phys Anthropol 139:47–57.
Green HJM. 1975. Godmanchester. In: Rodwell W, Rowley T, editors. The 'Small Towns' of Roman Britain. Oxford: British Archaeological Reports. p 183 – 211.
Green HJM, Malim T. 2017. Durovigutum: Roman Godmanchester. Oxford: Archaeopress.
Greene K. 1986. The Archaeology of Roman Economy. London: B.T. Batsford
Griffin R, Pitts M, Smith R, Brook A. 2011. Inequality at Late Roman Baldock, UK. J Anthropol Res 67:533–556.
Gustafson G, Koch G. 1974. Age estimation up to 16 years of age based on dental development. Odontologisk Revy 25(September): 297–306.
Harlow M, Laurence R. 2002. Growing Up and Growing Old in Ancient Rome. London: Routledge.
Hollimon S. 2011. Sex and Gender in Bioarchaeological Research: Theory, Method, and Interpretation. In: Agarwal SC, Glencross B, editors. Social Bioarchaeology. Oxford: Wiley Blackwell. p 149 – 182.
Hollimon S. 2017. Bioarchaeological approaches to nonbinary genders: Case studies from Native North America. In: Agarwal SC, Wesp JK, editors. Exploring Sex and Gender in Bioarchaeology. Albuquerque: University of New Mexico Press. p 51–70.
Hope V. 2007. Death in Ancient Rome: A Sourcebook. New York: Routledge.
Hunt P. 2018. Ancient Greek and Roman Slavery. New York: John Wiley and Sons, Ltd.
Jennings E. 2017. Analysis of Trauma Patterns and Post-Traumatic Time Interval in a Late Romano-British and Spanish Context. Unpublished Masters Thesis. Hamilton: McMaster University.
Jennings E, Buckberry J, Brickley M. 2018. Radiographically recognizable? An investigation into the appearance of osteomalacic pseudofractures. Int J Paleopathol:1–6.
Jensen OC. 1996. Work related injuries in Danish fishermen. Occup Med 46:414–420.

Jensen OC. 2000. Non-fatal occupational fall and slip injuries among commercial fishermen analyzed by use of the NOMESCO injury registration system. Am J Ind Med 37:637–644.
Jones A. 2003. Summary and introduction. In: Jones A, editor. Settlement, Burial and Industry in Roman Godmanchester. Birmingham: Archaeopress. p 2–8
Jordana XC, Malgosa AM. 2007. Enterraments d'epoca Romana a la Placa de la Vila de Madrid: Resultats de la recerca antropològica. Quarhis 2(3): 64-81.
Judd MA, Roberts CA. 1999. Fracture trauma in a medieval British farming village. Am J Phys Anthropol 109:229–243.
Judd M. 2002a. Comparison of long bone trauma recording methods. J Archaeol Sci 29:1255–1265.
Judd M. 2002b. Ancient injury recidivism: An example from the Kerma period of ancient Nubia. Int J Osteoarchaeol 12:89–106.
Judd MA. 2008. The parry problem. J Archaeol Sci 35:1658–1666.
Judd M, Redfern RC. 2012. Trauma. In: Grauer AL, editor. A Companion to Paleopathology. Oxford: Wiley-Blackwell. p 359–379.
Jurmain R. 1999. Stories from the Skeleton. Oxford: Taylor & Francis.
Kaey S. 1988. Roman Spain. California: University of California Press.
Kaey S, Terrenato N eds. 2001. Italy and the West: Comparative Issues in Romanization. Oxford: Oxbow Books.
Karl JW, Olson PR, Rosenwasser MP. 2015. The epidemiology of upper extremity fractures in the United States, 2009. J Orthop Trauma 29:242–244.
Katz D, Suchey J. 1986. Age determination of the male os pubis. Am J Phys Anthrop 69:427-435.
Keating J. 2015. Femoral neck fractures. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2032–2074.
Keegan S. 2002. Inhumation Rites in Late Roman Britain. Oxford: British Archaeological Reports 333.
Kjellstrom A. 2014. Interpreting violence: A bioarchaeological perspective of violence from Medieval central Sweden. In: Smith M, Knusel C, editors. The Routledge Handbook of the Bioarchaeology of Human Conflict. New York: Routledge. p 237–250.
Klaus HD. 2014. Frontiers in the bioarchaeology of stress and disease: Cross-disciplinary perspectives from pathophysiology, human biology, and epidemiology. Am J Phys Anthropol 155:294–308.
Knusel C. 2014. Introduction. In: Knusel C, Smith MJ, editors. The Routledge Handbook of the Bioarchaeology of Human Conflict. London: Routledge. p 3–24.
Kolendo J. 1993. The peasant. In: Giardina A, editor. The Romans. Chicago: Chicago University Press. p 199-213.
Krieg J. 2013. Humeral shaft fractures: Intermedullary nailing. In: Wiss D, editor.
Fracture. Philadelphia: Lippencott Williams and Wilkins. p 125–138.
Krieger N. 2005. Embodiment: A conceptual glossary for epidemiology. J Epidemiol Community Health 59:350–355.

Kulikowski M. 2004. Late Roman Spain and It's Cities. Baltimore: Johns Hopkins Press.

Large W. 2008. Heidegger's Being and Time. Edinburgh: Edinburgh University Press.

Larsen P, Elsoe R, Hansen SH, Graven-Nielsen T, Laessoe U, Rasmussen S. 2015. Incidence and epidemiology of tibial shaft fractures. Injury 46:746–750.

Laurence R, Esmonde Cleary S, Sears G. 2011. The City in the Roman West. Cambridge: Cambridge University Press.

Linderholm A, Jonson CH, Svensk O, Lidén K. 2008. Diet and status in Birka: Stable isotopes and grave goods compared. Antiquity 82:446–461.

Lindsay S, Selvaraj S, Macdonald JW, Godden DJ. 2004. Injuries to Scottish farmers while tagging and clipping cattle: a cross-sectional survey. Occup Med (Chic Ill) 54:86–91.

Love JC, Symes SA. 2004. Understanding rib fracture patterns: incomplete and buckle fractures. J Forensic Sci 49:1153–8.

Lovejoy CO, Heiple KG. 1981. The analysis of fractures in skeletal populations with an example from the Libben site, Ottowa County, Ohio. Am J Phys Anthropol 55:529–541.

Lovell NC 1997. Trauma Analysis in Paleopathology. Yearbook Phys Anthropol 40:139–170.

Lovell NC. 2008. Analysis and interpretation of skeletal trauma. In: Katzenberg A, Saunders SR, editors. Biological Anthropology of the Human Skeleton. 2nd Edition. New Jersey: John Wiley and Sons, Ltd. p 341–386.

MacKinnon M. 2011. The faunal remains. In: Small A, editor. Vagnari: The Village, the Industries, the Imperial Property. Bari: Edipuglia. p 305-328.

Marsh J, Karam M. 2015. Tibial plateau fractures. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2304–2369.

Martin DL, Harrod RP. 2015. Bioarchaeological contributions to the study of violence. Am J Phys Anthropol 156:116–145.

Marzano A. 2013. Agricultural production in the hinterland of Rome: Wine and olive oil. In: Bowman A, Wilson A, editors. The Roman Agricultural Economy: Organisation, Investment, and Production. Oxford: Oxford University Press. p 85-106.

Mas JA, Arroyo JH, Veraguer FPi. 2005. Santa Caterina de Barcelona: Assiag d'ocupacio i evolucio Quarhis 1:11–43.

Matheson C, Morrison S, Murphy E, Lawrie T, Ritchie L, Bond C. 2001. The health of fishermen in the catching sector of the fishing industry: a gap analysis. Occup Med 51:305–311.

Matos V. 2009. Broken ribs: Paleopathological analysis of costal fractures in the human identified skeletal collection from the Museu Bocage, Lisbon, Portugal (late 19th to middle 20th centuries). Am J Phys Anthropol 140:25–38.

McCarthy M. 2013. The Romano-British Peasant. Oxford: Oxbow Books.

McCurdy SA, Carroll DJ. 2000. Agricultural injury. Am J Ind Med 38:463–480.

McKee M. 2015. Clavicle fractures. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 1428–1474.

McQueen M. 2015. Fractures to the distal radius and ulna. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 1057–1121.
Meskell L. 2007. Archaeology of identities. In: Insoll T, editor. The Archaeology of Identities: A Reader. New York: Routledge. p 23–43.
Millet M. 2016. 'By small things revealed:' Rural settlement and society. In: Millet M, Revell L, Moore A, editors. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press. p 699-720.
Millet M, Revell L, Moore A eds. 2016. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press.
Milner GR, Boldsen JL. 2012. Transition analysis: A validation study with known-age modern American skeletons. Am J Phys Anthrop 148: 98-110.
Milner GR, Boldsen JL. 2017. Life not death: Epidemiology from skeletons. Int J Paleopathol 17:26–39.
Milnor K. 2011. Women in Roman society. In: Peachin M, editor. The Oxford Handbook of Social Relations in the Roman World. Oxford: Oxford University Press. p 609–622.
Morel JP. 1993. The craftsman. In: Giardina A, editor. The Romans. Chicago: Chicago University Press. p 214-244.
Morris I. 1992. Death-Ritual and Social Structure in Classical Antiquity. Cambridge: Cambridge University Press.
Nadal R. 2015. Les necropolis de les Drassanes Reials de Barcelona (Segles I-VIII). Quarhis 2(11): 16-64.
Nakata A, Ikeda T, Takahashi MT, Haratani TH, Hojou MH, Swanson NGS, Fujioka YF, Araki SA. 2006. The prevalence and correlates of occupational injuries in small-scale manufacturing enterprises. J Occup Health 48:366–376.
Nork S. 2015. Femoral shaft fractures. In: Court-Brown M, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2151–2228.
Norrish AE, Cryer PC. 1990. Work related injury in New Zealand commercial fishermen. Br J Ind Med 47:726–732.
Ottaway P, Qualmann K, Rees H, Scobie G. 2012. The Roman Cemeteries and Suburbs of Winchester: Excavations 1971-86. Winchester: Winchester Museums.
Palet JM, Julià R, Riera S, Orengo H a, Picornell Gelabert L, Llergo Y. 2012. The role of the Montjuïc promontory (Barcelona) in landscape change: human impact during roman times. Var environnementales, Mutat Soc nature, intensités, échelles temporalités des Chang XXXII: 323–334.
Paillard, D. 2006. The Michelet Site. Unpublished site report.
Parkin T, Pomeroy AJ. 2007. Roman Social History: A Sourcebook. London: Routledge.
Pearce J, Millett M, Struck M. eds. 2000. Burial, Society and Context in the Roman world. Oxford: Oxbow Books Limited.
Pearce J. 2016. Status and burial. In: Millet M, Revell L, Moore A, editors. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press. p 341–362.

Peck JJ. 2009. The Biological Impact of Culture Contact: A Bioarchaeological Study of Roman Colonialism in Britain. Unpublished Dissertation. Ohio: Ohio State University.

Petts D. 2016. Christianity in Roman Britain. In: Millett M, Revell L, Moore A, editors. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press. p 660–680.

Philpott R. 1991. Burial Practices in Roman Britain: A Survey of Grave Treatment and Furnishing AD 43-410. Oxford: British Archaeological Reports 219.

Pitts M, Griffin R. 2012. Exploring health and social well-being in late Roman Britain: An intercemetery Approach. Am J Archaeol 116:253–276.

Pitts M. 2016. Rural transformations in the urbanized landscape. In: Millett M, Revell L, Moore A, editors. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press. p 720–740.

Pujol-Bayona A, Rissech C, Prida D, Turbón D. 2011. Estudio bioantropológico del conjunto funerario de época tardorromana Carrer Ample 1 de Barcelona. Rev. Esp. Antrop. Fís. 32: 1–19.

Rasmussen K, Carstensen O, Lauritsen JM. 2000. Incidence of unintentional injuries in farming based on one year of weekly registration in Danish farms. Am J Ind Med 38:82–89.

Redfern R. 2010. A regional examination of surgery and fracture treatment in Iron Age and Roman Britain. Int J Osteoarchaeol 20:443–471.

Redfern RC, Dewitte SN. 2011. Status and health in Roman Dorset: The effect of status on risk of mortality in post-conquest populations. Am J Phys Anthropol 146:197–208.

Redfern RC, Dewitte SN, Pearce J, Hamlin C, Dinwiddy KE. 2015. Urban-rural differences in Roman Dorset, England: A bioarchaeological perspective on Roman settlements. Am J Phys Anthropol 157:107–120.

Redfern RC. 2016. Injury and Trauma in Bioarchaeology: Interpreting Violence in Past Lives. Cambridge: Cambridge University Press.

Redfern RC. 2018. Blind to chains? The potential of bioarchaeology for identifying the enslaved of Roman Britain. Britannia 49:251–282.

Redfern RC, DeWitte SN, Montgomery J, Gowland RL. 2018. A novel investigation into migrant and local health-statuses in the past: A case study from Roman Britain. Bioarchaeology Int 2.20-43.

Richardson J. 1996. The Romans in Spain. Oxford: Blackwell Publishers.

Richardson S, May-Lambert S. 2008. Agricultural injuries and illnesses in Texas. J Agromedicine 4:257–268.

Rissech C, Pujol A, Christie N, Lloveras L, Richards MP, Fuller BT. 2016. Isotopic reconstruction of human diet at the Roman site (1st-4th c. AD) of Carrer Ample 1, Barcelona, Spain. J Archaeo Sci: Rep 9: 366–374.

Robb J, Bigazzi R, Lazzarini L, Scarsini C, Sonego F. 2001. Social "status" and biological "status": A comparison of grave goods and skeletal indicators from Pontecagnano. Am J Phys Anthro 115:213–222.

Robbins Schug G, Gray K, Mushrif-Tripathy V, Sankhyan AR. 2012. A peaceful realm? Trauma and social differentiation at Harappa. Int J Paleopathol 2:136–147.
Roberts CA, Cox M. 2003. Health and disease in Britain: from Prehistory to the Present Day. Gloucestershire: Sutton Publishing.
Russell T. 2015. Intertrochanteric fractures of the hip. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2075–2130.
Sassoon A, Langford J, Haidukewych G. 2015. Subtrochanteric femur fractures. In: Court-Brown C, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2131–2150.
Sauer N. 1998. The timing of injuries and manner of death: Distinguishing among antemortem, perimortem, and post-mortem trauma. In: Reichs KJ editor. Forensic Osteology: Advances in the Identification of Human Remains, 2nd Edition. Springfield: Charles C. Thomas. p 321-332.
Scheidel W. 1996. The most silent women of Greece and Rome: Rural labour and women's life in the ancient world (II). Greece Rome 43:1–10.
Schumacher L. 2011. Slaves in Roman society. In: Peachin M, editor. The Oxford Handbook of Social Relations in the Roman World. Oxford: Oxford University Press. p 589–608.
Sharma OP, Oswanski M, Jolly S, Lauer S, Dressel R, Stombaugh H. 2008. Perils of rib fractures. Am Surg 74:310–314.
Shepherd JP, Shapland M, Pearce NX, Scully C. 1990. Pattern, severity and aetiology of injuries in victims of assault. J R Soc Med 83:75–78.
Sirmali M, Turut H, Topcu S, Gulham E, Yazici U, Kaya S, Tastepe I. 2003. A comprehensive analysis of traumatic rib fractures: Morbidity, mortality, and management. Euro J Cardio-thora Surg 24:133-138.
Šlaus M, Novak M, Bedić Ž, Strinović D. 2012. Bone fractures as indicators of intentional violence in the eastern adriatic from the antique to the late medieval period (2nd-16th century AD). Am J Phys Anthropol 149:26–38.
Small A, Small C, Abdy R, Stefano A, Guiliani R, Henig M, Johnson K, Kenrick P, Prowse, T. 2007. Excavation in the Roman cemetery at Vagnari, in the territory of Gravina in Puglia, 2002. Papers Bri Sch Rome 75: 123–229.
Small AM. 2011. Vagnari: The Village, the Industries, the Imperial Property. Bari: Edipuglia
Sofaer J. 2006. The Body as Material Culture. New York: Cambridge University Press.
Sofaer J, Sorensen M. 2013. Death and gender. In: Tarlow S, Nilsson Stutz L, editors. The Oxford Handbook of the Archaeology of Death and Burial. Oxford: Oxford University Press. p 527–542.
Sogaard A, Gustad T, Bjertness E, Tell G, Schei B, Emaus N, Meyer H. 2007. Urban-rural differences in distal forearm fractures: Cohort Norway. Osteoporos Int 18:1063–1072.
Streubel P, Pesantez R. 2015. Diaphyseal fractures of the radius and ulna. In: Court-brown CM, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and

Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 1120–1179.
Szumilas M. 2010. Explaining odds ratios. J Can Acad Child Adolesc Psychiatry 19:227–229.
Timmins S, Sereville-Niel C, Brickley M. 2017. Childhood cranial trauma from a late Roman and Merovingian context from Michelet, Lisieux, France. Int J Osteoarchaeol 27:715–722.
Toynbee J. 1971. Death and Burial in the Roman World. New York: Cornell University Press.
Ubelaker DH, Adams BJ. 1995. Differentiation of perimortem and post-mortem trauma using taphonomic indicators. J For Sci 40: 509-512.
Ubelaker DH, Montapero K. 2014. Trauma interpretation in the context of biological anthropology. In: Knüsel CJ, Smith MJ, editors. The Routledge Handbook of the Bioarchaeology of Human Conflict. New York: Routledge. p 25–38.
van Staa T, Dennison E, Leufkens H, Cooper C. 2001. Epidemiology of fractures in england and wales. Bone 29:517–522.
Verlinden P, Lewis ME. 2015. Childhood trauma: Methods for the identification of physeal fractures in nonadult skeletal remains. Am J Phys Anthrop 157(3): 411–420.
Viruell-fuentes EA, Miranda PY, Abdulrahim S. 2012. More than culture: Structural racism, intersectionality theory, and immigrant health. Soc Sci Med 75:2099–2106.
Wacher J. 1995. The Towns of Roman Britain. London: Routledge
Waldron T. 1994. Counting the Dead: The Epidemiology of Skeletal Populations. Chichester: John Wiley and Sons, Ltd.
Wedel VL, Galloway A (eds). 2014. Broken bones: anthropological analysis of blunt force trauma. Illinois: Charles C Thomas.
Weekes J. 2016. Cemeteries and funerary practice. In: Millett M, Revell L, Moore A, editors. The Oxford Handbook of Roman Britain. Oxford: Oxford University Press. p 425–447.
Welch LS, Hunting KL, Murawski JA. 2005. Occupational injuries among construction workers treated in a major metropolitan emergency department in the United States. Scand J Work Environ Heal 31:11–21.
Wesp JK. 2017. Embodying sex/gender systems in bioarchaeological research. In: Exploring Sex and Gender in Bioarchaeology. Albuquerque: University of New Mexico Press. p 99–128.
Wheatley BP. 2008. Perimortem or postmortem bone fractures? An experimental study of fracture patterns in deer femora. J Foren Sci 53(1): 69–72.
White T, Bugler K. 2015. Ankle Fractures. In: Court-Brown C, Heckman J, McQueen M, Ricci W, Tournetta P, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippencott Williams and Wilkins. p 2542–2593.
Whittaker C. 1993. The poor. In: Giardina A, editor. The Romans. Chicago: University of Chicago Press. p 272–299.
Wladis, A, Bonström L, Nilsson B. 1999. Unarmed violence-related injuries requiring Hospitalization in Sweden from 1987 to 1994. J Trauma: Inj Infect Crit Care 47: 733-737.

Wiss D. 2013. Clavicle fractures: Open reduction and internal fixation. In: Wiss D, editor. Fractures. Philadelphia: Lippencott Williams and Wilkins. p 2–16.
Zephro L, Galloway A. 2014. The biomechanics of fracture production. In: Broken Bones: Anthropological Analysis of Blunt Force Trauma. p 33–46.

APPENDICES

Appendix A – Age and Sex Forms, Adult Pathology Forms and Burial Treatment Forms

Appendix Figure 1 Sex and Age Form Used in the SSHRC study. Developed by Dr. Megan Brickley and Dr. Tracy Prowse.

Sex/Age Estimation Date: ______________ Site ______________

Observer: ______________ Sk # ______________

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: ______________________ Site -______________________

Observer: ______________________ Sk # ______________________

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Appendix Figure 2 Adult Pathology Form Used in the SSHRC Study. Developed by Dr. Megan Brickley and Dr. Tracy Prowse.

Date: ______________________ Site ______________________

Observer: ______________________ Sk # ______________________

Adult Pathology

Ribs

	Left	Right	Unsided
Number of ribs (count using proximal ends)	-	-	
Presence of abnormal curvature*	-	-	
Number of ribs with single fracture	-	-	-
Number of ribs with multiple fractures	-	-	-
Total number of fractures	-	-	-
Notes (e.g., indicate any flaring of ribs):			

* can only be assessed on complete ribs; if present - describe curvature in notes section

Ribs – record state of fracture(s) for each rib with one or more fractures

		Fracture 1			Fracture 2			Fracture 3		
Rib*	Side	New Bone	Fracture Union	Location	New Bone	Fracture Union	Location	New Bone	Fracture Union	Location
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-
Notes:										

Photo

*indicate approximate location in rib cage (1st, 2nd, upper, middle, lower, 12th) and the location on the rib itself (e.g., head, angle, shaft).

Sternum

	Presence (%)	Abnormal Curvature
Manubrium	-	-
Sternal body	-	-
Notes:		

Photo

- = not present; <25%; 25-50%; 50-75%; >75%

Observer:________________________ Sk #________________________

Scapulae

	Left	**Right**
Presence (%)	-	-
Can curvature of body be assessed? (y/n)	-	-
Was curvature present? (y/n)	-	-
Spinous process present	-	-
Fracture (present/absent)	-	-
State of fracture (woven/lamellar/spiculated)	-	-
Coracoid process present	-	-
Fracture (present/absent/pseudofracture)	-	-
State of fracture (woven/lamellar/spiculated)	-	-
Lateral border present (%)	-	-
Fracture (present/absent/pseudofracture)	-	-
State of fracture (woven/lamellar/spiculated)	-	-
Fracture at alternate location*	-	-
Bone formation at alternate location*	-	-

Notes:

Photo ☐

*indicate specific location in notes box

Vertebrae

	Body	**Arches**
Presence		
Cervical vertebrae (7)	-	-
Thoracic vertebrae (12)	-	-
Lumbar vertebrae (5)	-	-

Pathology	**Collapse/buckling of vertebral body**	**Fractures of laminae**
Cervical vertebrae	-	-
Thoracic vertebrae	-	-
Lumbar vertebrae	-	-

	Present/Absent
Kyphosis (posterior thoracic curvature)	-
Lordosis (anterior lumbar curvature)	-
Scoliosis (lateral curvature)	-

Notes:

Photo ☐

Observer:______________________ Sk #__________________________

Innominates

	Presence	Folding	Fracture	Other*
LEFT				
Innominate (% present)	-	-	-	-
Iliac crest	-	-	-	-
Ascending pubic ramus	-	-	-	-
Pubis	-	-	-	-

	Presence	Folding	Fracture	Other*
RIGHT				
Innominate (% present)	-	-	-	-
Iliac crest	-	-	-	-
Ascending pubic ramus	-	-	-	-
Pubis	-	-	-	-

Photo ☐

Notes**:

*If yes, describe pathology in notes section

**'Other' features to consider include: cortical thinning; decreasing antero-posterior length of the ilium, among other features.

Sacrum (keeping in mind the normal variation in curvature between the male and female sacrum)

Presence (%)	Can curvature of body be assessed? (y/n)	Abnormal Curvature
-	-	-

Notes:

Photo ☐

Long Bones - Presence

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	-	-	-	-	-	-	-	-	-	-
Humerus	-	-	-	-	-	-	-	-	-	-
Radius	-	-	-	-	-	-	-	-	-	-
Ulna	-	-	-	-	-	-	-	-	-	-
Femur	-	-	-	-	-	-	-	-	-	-
Tibia	-	-	-	-	-	-	-	-	-	-
Fibula	-	-	-	-	-	-	-	-	-	-

* segment preservation : - = not present; <25%; 25-50%; 50-75%; >75%

Long Bones – Pathology

	Fracture	State of Fracture		Location	Bending Deformity	Other Feature*
LEFT Side		New Bone	Fracture Union			
Clavicle	-	-	-	-	-	-
Humerus	-	-	-	-	-	-
Radius	-	-	-	-	-	-
Ulna	-	-	-	-	-	-
Femur	-	-	-	-	-	-
Tibia	-	-	-	-	-	-
Fibula	-	-	-	-	-	-

Photo**

Notes:

	Fracture	State of Fracture		Location	Bending Deformity	Other Feature*
RIGHT Side		New Bone	Fracture Union			
Clavicle	-	-	-	-	-	-
Humerus	-	-	-	-	-	-
Radius	-	-	-	-	-	-
Ulna	-	-	-	-	-	-
Femur	-	-	-	-	-	-
Tibia	-	-	-	-	-	-
Fibula	-	-	-	-	-	-

Photo

Notes:

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.

Additional Notes:

X-rays required (y/n) (indicate in 'additional notes' which bones/elements to be radiographed)	-
X-rays completed (y/n)	-

Summary

Possible Vitamin D deficiency present? -

Possible previous Vitamin D deficiency? -

Appendix Figure 3 Artifact Recording Form Used in this Study. Form created for the SSHRC study by Dr. Tracy Prowse, Dr. Michele George, and Dr. Megan Brickley.

Date:_____________ Site: ______________________________

Observer:_____________ Burial/Feature # _________________________

Skeleton # _____________________________ (if different than burial number)

Vitamin D Project
Artifact Recording Form

Grave construction/type	-
Single/multiple burial?	-
Position of skeleton	-
Disturbance	

Date of burial	

If grave type is not listed in the drop-down menu, fill in manually
Position of skeleton – **extended** (on back), **prone** (face-down), **semi-flexed** (90-180 degrees between axis of legs and axis of trunk), **flexed** (<90 degrees), **tightly flexed** (angle approaches 0 degrees), other (describe). Indicate other unusual features of the burial in the Notes section (e.g., decapitation, animal bones present in the grave).
Disturbance – if the grave is disturbed, indicate what kind of disturbance (e.g., robbed in antiquity, modern disturbance (plow), animal activity, other type not listed).

Is an illustration or photo of the grave available? (Y/N)	-
If YES, indicate page numbers in published reports.	
Is an illustration or photo of the skeleton and/or grave goods available? (Y/N)	-
If YES, indicate page numbers in publications or reports.	
Grave goods associated with burial? (Y/N) If YES, fill out Table 1.	-

Notes:

Date:____________ Site: ______________________________
Observer:___________ Burial/Feature # ______________________
Skeleton # ___________________________ (if different than burial number)

Table 1 – Itemized List of Grave Goods

ID	Item	Preservation	Material	Description/Notes
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	
	-	-	-	

ID – list the identification number for the artifact, if any.
Item - choose from the drop-down menu; if the item is not listed, enter it manually.
Preservation – Indicate if the item is incomplete, complete, or indicate percentage (e.g., 50%). Select 'not indicated' if there is no information on preservation.
Material – choose from the drop-down menu; if the type of material is not listed, enter it manually.

Estimated total number of grave goods	

Appendix B – Individuals with Fractures

Site	Individual	Age Category	Sex	Burial Type	Number of Fractures	Element	Location	Healing
				LISIEUX MICHELET				
MIC	MIC 369	Old Adult	F	Coffin	3	Rib	Left Rib Angle	Healed
						Rib	Left Rib Angle	Healed
						Rib	Rib Shaft	Healed
MIC	MIC 449	Older Adolescent	F	Pit	1	Lower Left Rib	Angle	Healed
MIC	MIC 676	Middle Adult	F	Coffin	4	Left Radius	Distal Epiphysis	Healed
						Right Tibia	Distal 1/3	Healed
						Right Rib	Shaft	Healed
						Right Rib	Shaft	Healed
MIC	MIC 738	Old Adult	F	Coffin	1	Left Clavicle	Mid 1/3	Healed
MIC	MIC 812	Older Adolescent	F	Pit	1	Right Radius	Distal Epiphysis	Healed
MIC	MIC 11	Young Adult	M	Coffin	1	Right 11/12 Rib	Shaft	Healed
MIC	MIC 23A	Old Adult	AM	Coffin	1	Left Ulna	Distal 1/3	Healed
MIC	MIC 64	Middle Adult	UD	Pit	2	Right Middle Rib	Angle	Consolidation
						Right Lower Rib	Angle	Consolidation
MIC	MIC 125	Middle Adult	M	Coffin	1	Left Clavicle	Distal Epiphysis	Healed
MIC	MIC 151	Old Adult	M	Coffin	2	Right Ulna	Distal 1/3	Healed
						Right Fibula	Proximal 1/3	Healed
MIC	MIC 167	Old Adult	M	Sarcophagus	1	Right Femur	Mid 1/3	Healed
MIC	MIC 177	Young Adult	M	Pit	1	Right Clavicle	Mid 1/3	Consolidation
MIC	MIC 179	Middle Adult	F	Coffin	1	Left lower rib	Angle	Healed

MIC	MIC 188	Middle Adult	M	Coffin	1	Left Radius	Distal 1/3	Healed
MIC	MIC 286	Young Adult	M	Coffin	1	Right Radius	Distal 1/3	Healed
MIC	MIC 328	Old Adult	AM	Coffin	1	Right Fibula	Distal 1/3	Healed
MIC	MIC 333	Old Adult	M	Coffin	1	Unsided Upper Rib	Angle	Healed
MIC	MIC 337	Young Adult	M	Coffin	2	Left Fibula	Distal 1/3	Healed
						Right Radius	Distal 1/3	Healed
MIC	MIC 427	Old Adult	M	Coffin	3	Left Fibula	Distal 1/3	Remodelling
						Left Tibia	Distal 1/3	Remodelling
						Right Middle Rib	Shaft	Remodelling
MIC	MIC 471	Middle Adult	M	Coffin	1	Left Clavicle	Mid 1/3	Healed
MIC	MIC 491	Old Adult	M	Coffin	4	Right Fibula	Mid 1/3	Healed
						Unsided Lower Rib	Shaft	Healed
						Unsided Lower Rib	Shaft	Healed
						Unsided Lower Rib	Shaft	Healed
MIC	MIC 513	Old Adult	F	Tile	1	Left Clavicle	Mid 1/3	Healed
MIC	MIC 560	Old Adult	F	Pit	1	Left Radius	Distal 1/3	Healed
MIC	MIC 566	Young Adult	AM	Coffin	2	Left Radius	Distal Epiphysis	Healed
						Left Ulna	Distal 1/3	Healed
MIC	MIC 577	Young Adult	M	Coffin	1	Left Clavicle	Distal 1/3	Healed
MIC	MIC 592	Old Adult	M	Pit	1	Right Middle Rib	Shaft	Healed
MIC	MIC 597	Young Adult	M	Coffin	2	Left Ulna	Distal 1/3	Healed
MIC	MIC 647	Old Adult	M	Coffin	1	Left Tibia	Distal Epiphysis	Healed
MIC	MIC 654	Middle Adult	M	Coffin	3	Left Rib	Shaft	Healed

						Right Middle Rib	Shaft	Healed
						Right Middle Rib	Shaft	Healed
MIC	MIC 670	Young Adult	M	Coffin	1	Unsided Upper Rib	Shaft	Healed
MIC	MIC 714	Young Adult	M	Coffin	2	Unsided Rib	Shaft	Healed
MIC	MIC 723	Old Adult	F	Coffin	1	Unsided Rib	Shaft	Healed
MIC	MIC 767	Middle Adult	M	Coffin	1	Left Upper Rib	Shaft	Healed
MIC	MIC 808	Old Adult	M	Coffin	1	Left Tibia	Mid-Distal 1/3	Healed
MIC	MIC 842	Middle Adult	M	Coffin	5	Left Upper Rib	Shaft	Healed
						Left Upper Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
MIC	MIC 873	Old Adult	M	Coffin	1	Unsided Upper Rib	Shaft	Healed
MIC	MIC 919	Young Adult	M	Coffin	2	Left Clavicle	Mid 1/3	Healed
MIC	MIC 930	Young Adult	F	Coffin	1	Right Lower Rib	Shaft	Healed
MIC	MIC 549	Old Adult	F	Coffin	1	Left Radius	Mid 1/3	Healed
WINCHESTER								
WIN	AR 311	Old Adult	F	Pit	1	Unsided Rib	Shaft	Healed
WIN	AR 312	Middle Adult	AM	Pit	4	Left Radius	Distal 1/3	Healed
						Left Ulna	Distal 1/3	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed

WIN	AR 318	Old Adult	M	Coffin	4	Right Tibia	Distal 1/3	Healed
						Right Fibula	Proximal 1/3	Healed
						Right Middle Rib	Shaft	Healed
						Right Middle Rib	Shaft	Healed
WIN	HYS 012	Young Adult	F	Pit	1	Right Clavicle	Mid 1/3	Healed
WIN	HYS 015	Middle Adult	M	Pit	2	Right Tibia	Mid 1/3	Healed
						Right Fibula	Mid 1/3	Healed
WIN	HYS 020	Young Adult	M	Pit	2	Left Radius	Distal 1/3	Hea;ed
						Left Ulna	Distal 1/3	Healed
WIN	HYS 024	Middle Adult	M	Pit	1	Right Fibula	Distal 1/3	Healed
WIN	AY21-55	Old Adult	F	Coffin	1	Left Ulna	Distal 1/3	Healed
WIN	AY21-61	Middle Adult	F	Coffin	1	Right Humerus	Distal Epiphysis	Healed
WIN	AY21-84	Young Adult	F	Stepped Grave	1	Unsided Rib	Shaft	Healed
WIN	AY21-95	Adult Undetermined	UD	Pit	1	Unsided Rib	Shaft	Healed
WIN	AY21-212	Old Adult	F	Pit	1	Right Rib	Angle	Healed
WIN	AY21-232	Old Adult	AM	Pit	1	Right Ulna	Distal 1/3	Healed
WIN	AY21-281	Middle Adult	M	Coffin	1	Left Clavicle	Mid 1/3	Healed
WIN	AY21-429	Old Adult	F	Coffin	1	Right Tibia	Distal 1/3	Healed
WIN	AY21-459	Young Adult	UD	Coffin	2	Right Tibia	Mid 1/3	Healed
						Right Fibula	Mid 1/3	Healed
WIN	AY21-522	Young Adult	M	Coffin	2	Right Middle Rib	Shaft	Healed
						Right Middle Rib	Shaft	Healed
WIN	AY21-0623	Young Adult	F	Pit	2	Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed

WIN	AY21-0636	Old Adult	AM	Coffin	1	Right Tibia	Proximal Epiphysis	Healed
WIN	AY21-0683	Middle Adult	M	Pit	10	Left Radius	Distal 1/3	Healed
						Right Radius	Mid 1/3	Healed
						Left Middle Rib	Shaft	Healed
						Left Middle Rib	Shaft	Healed
						Left Middle Rib	Shaft	Healed
						Left Middle Rib	Shaft	Healed
						Left Middle Rib	Shaft	Healed
						Right Middle Rib	Shaft	Healed
						Right Middle Rib	Shaft	Healed
						Right Middle Rib	Shaft	Healed
WIN	AY21-806	Old Adult	F	Pit	1	Right Radius	Distal 1/3	Healed
WIN	AY21-852	Middle Adult	M	Coffin	1	Right Fibula	Distal 1/3	Healed
WIN	AY21-861	Middle Adult	M	Pit	9	Right Lower Rib	Shaft	Healed
						Right Lower Rib	Shaft	Healed
						Unsided Lower Rib	Shaft	Healed
						Unsided Mid-Lower Rib	Shaft	Healed
						Unsided Mid-Lower Rib	Shaft	Healed

						Unsided Mid-Lower Rib	Shaft	Callus Formation
						Unsided Mid-Lower Rib	Shaft	Callus Formation
						Unsided Mid-Lower Rib	Shaft	Callus Formation
						Unsided Mid-Lower Rib	Shaft	Callus Formation
WIN	AY21-862	Young Adult	M	Coffin	1	Left Tibia	Distal 1/3	Healed
WIN	AY21 – 897	Adult Undetermined	UD	Coffin	1	Right Ulna	Distal 1/3	Healed
WIN	AY21-914	Old Adult	F	Coffin	1	Right Lower Rib	Shaft	Healed
WIN	AY21 – 939	Old Adult	M	Coffin	1	Unsided Rib	Shaft	Healed
WIN	AY21 – 1103	Young Adult	F	Coffin	1	Left Rib	Shaft	Healed
WIN	AY21 – 1134	Middle Adult	F	Pit	3	Left Upper Middle Rib	Shaft	Healed
						Middle Rib	Shaft	Healed
						Middle Rib	Shaft	Healed
WIN	AY21-1209	Middle Adult	M	Coffin	3	Left Middle Lower Rib	Shaft	Healed
						Left Middle Lower Rib	Shaft	Healed
						Left Middle Lower Rib	Shaft	Healed
WIN	AY21-1232	Middle Adult	M	Pit	1	Right Fibula	Middle 1/3	Healed
WIN	AY21-1289	Young Adult	M	Coffin	1	Right Humerus	Proximal 1/3	Healed

WIN	AY21-1361	Old Adult	F	Coffin	2	Left Mid Upper Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
WIN	AY21-1393	Middle Adult	M	Coffin	1	Left Middle Rib	Shaft	Healed
WIN	AY21-1517	Middle Adult	M	Pit	1	Unsided Rib	Shaft	Healed
WIN	AY21-1640	Old Adult	M	Coffin	2	Left Fibula	Distal 1/3	Healed
WIN	AY21-1757	Adult Undetermined	UD	Coffin	1	Right Femur	Mid 1/3	Healed
WIN	LH 13	Old Adult	M	Coffin	1	Unsided Rib	Shaft	Healed
WIN	LH 37	Middle Adult	M	Coffin	1	Left Clavicle	Mid 1/3	Healed
WIN	LH 45	Old Adult	F	Coffin	2	Left Clavicle	Mid 1/3	Healed
						Left Tibia	Mid 1/3	Healed
WIN	LH 47	Middle Adult	M	Coffin	2	Right Tibia	Distal 1/3	Healed
						Right Fibula	Distal 1/3	Healed
WIN	LH 331	Middle Adult	M	Coffin	1	Left Clavicle	Mid 1/3	Healed
WIN	LH 319	Old Adult	M	Possible Coffin	2	Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
WIN	LH 291	Young Adult	M	Coffin	3	Right Tibia	Distal 1/3	Healed
						Right Fibula	Distal 1/3	Healed
						Left Middle Rib	Shaft	Healed
WIN	LH 283	Middle Adult	M	Pit	3	Right Fibula	Distal 1/3	Healed
						Left Rib	Angle	Healed
						Unsided Rib	Shaft	Consolidation
WIN	LH 277	Old Adult	M	Coffin	3	Unsided Middle Rib	Shaft	Healed
						Unsided Middle Rib	Shaft	Healed

						Unsided Middle Rib	Shaft	Healed
WIN	LH 261	Adult	M	Coffin	2	Right Tibia	Distal 1/3	Healed
						Right Fibula	Proximal 1/3	Healed
WIN	LH 249	Old Adult	F	Coffin	1	Left Tibia	Distal Epiphysis	Healed
WIN	LH 229	Old Adult	F	Coffin	2	Middle Rib	Shaft	Callus Formation
						Middle Rib	Shaft	Callus Formation
WIN	LH 226	Young Adult	M	Coffin	1	Right Femur	Proximal Epiphysis	Callus Formation
WIN	LH 212	Young Adult	UD	Coffin	1	Right Radius	Distal 1/3	Healed
WIN	LH 204	Young Adult	F	Coffin	1	Right Tibia	Distal 1/3	Healed
WIN	LH 171	Young Adult	F	Coffin	1	Left Clavicle	Mid 1/3	Healed
WIN	LH 166	Adult	M	Coffin	1	Unsided Rib	Shaft	Healed
WIN	LH 87	Young Adult	F	Coffin	1	Unsided Rib	Shaft	Healed
WIN	LH 78	Young Adult	M	Coffin	1	Unsided Rib	Shaft	Healed
WIN	LH 408	Middle Adult	M	Coffin	1	Right Fibula	Mid 1/3	Healed
WIN	LH 399	Old Adult	F	Coffin	1	Left Tibia	Distal 1/3	Healed
WIN	LH 349	Old Adult	M	Coffin	6	Right Fibula	Prox 1/3	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
WIN	LH 461	Adult	UD	Possible Coffin	1	Left Middle Rib	Shaft	Healed
WIN	LH 447	Middle Adult	M	Possible Coffin	1	Right Fibula	Distal 1/3	Healed
WIN	LH 411	Middle Adult	AM	Possible Coffin	1	Unsided Rib	Shaft	Healed
WIN	LH 410	Middle Adult	M	Coffin	3	Left Fibula	Distal 1/3	Healed

						Right Tibia	Distal 1/3	Healed
						Right Fibula	Distal 1/3	Healed
BARCELONA								
BAR	ENT 38*	Young Adult	M	Tile	7	Left Middle Rib	Shaft	Consolidation
						Left Middle Rib	Angle	Consolidation
						Left Middle Rib	Shaft	Consolidation
						Left Lower Rib	Angle	Consolidation
						Left Upper Rib	Angle	Healed
						Right Upper Rib	Shaft	Healed
						Unsided Lower Rib	Shaft	Healed
BAR	ENT 37	Middle Adult	F	Coffin	7	Left middle Rib	Angle	Healed
						Right Lower Rib	Angle	Healed
						Right Middle Rib	Angle	Healed
						Right Middle Rib	Angle	Healed
						Unsided Middle Rib	Shaft	Callus Formation
						Unsided Middle Rib	Shaft	Callus Formation
						Unsided Middle Rib	Shaft	Callus Formation
BAR	ENT 35	Young Adult	M	Pit	1	Left Ulna	Mid 1/3	Healed
BAR	ENT 34	Old Adult	M	Pit	1	Left Ulna	Distal 1/3	Healed

BAR	ENT 29*	Old Adult	M	Pit	6	Right Middle Rib	Shaft	Consolidation
						Unsided Lower Rib	Shaft	Consolidation
						Unsided Middle Rib	Shaft	Consolidation
						Unsided Middle Rib	Shaft	Healed
						Unsided Lower Rib	Shaft	Consolidation
						Unsided Rib	Shaft	Consolidation
BAR	ENT 20	Middle Adult	M	Pit	1	Unsided Middle Rib	Shaft	Healed
BAR	UF 715	Adult	M	Tile	1	Right Clavicle	Mid 1/3	Healed
BAR	SAC UF926 UE9142	Old Adult	F	Tile	2	Unsided Middle Rib	Shaft	Healed
						Same Rib	Shaft	Healed
BAR	SAC UF713 UE7333	Old Adult	M	Tile	3	Right Lower Rib	Shaft	Healed
						Left Lower Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
BAR	SAC UF 707	Young Adult	F	Pit	3	Unsided Middle Rib	Shaft	Healed
						Unsided Middle Rib	Shaft	Healed
						Unsided Middle Rib	Shaft	Healed
BAR	ENT 10 UE 1178	Young Adult	F	Tile	3	Right Radius	Distal 1/3	Healed
						Left middle Rib	Angle	Healed
						Right Middle Rib	Angle	Healed

BAR	ENT 12 UE 1154	Young Adult	F	Pit	1	Right Clavicle	Mid 1/3	Healed
BAR	ENT 13 UE 1162	Middle Adult	M	Pit	1	Left Radius	Distal 1/3	Healed
BAR	ENT 15 UE 1189	Young Adult	M	Pit	2	Left Ulna	Distal 1/3	Healed
						Left Rib	Shaft	Healed
BAR	SAC UF703	Adult	F	Tile	2	Unsided Upper Rib	Shaft	Healed
						Left Radius	Distal 1/3	Healed
BAR	UF 756	Young Adult	M	Tile	3	Right Upper Rib	Angle	Healed
						Right Middle Rib	Angle	Healed
						Right Middle Rib	Shaft	Healed
BAR	ENT 20 UE 1223	Old Adult	M	Tile	1	Right Lower Rib	Angle	Healed
BAR	UF 733	Old Adult	M	Pit	1	Unsided Middle Rib	Angle	Healed
BAR	UF 732	Adult	F	Tile	6	Left Humerus	Proximal Epiphysis	Healed
						Right Tibia	Distal 1/3	Healed
						Right Fibula	Distal 1/3	Healed
						Left Middle Rib	Angle	Healed
						Right Middle Rib	Angle	Healed
						Right Middle Rib	Angle	Healed
BAR	ENT 14	Adult	PM	Pit	1	Right Radius	Distal 1/3	Healed
BAR	UF 724	Old Adult	F	Tile	2	Unsided Middle Rib	Shaft	Healed
						Unsided Middle Rib	Shaft	Healed

BAR	UF 709	Old Adult	F	Tile	2	Right Middle Rib	Shaft	Healed
						Unsided Middle Rib	Shaft	Healed
				VAGNARI				
VAG	F68	Middle Adult	M	Cappuccina	1	Left Clavicle	Mid 1/3	Healed
VAG	F67	Middle Adult	M	Cappuccina	1	Left Fibula	Prox 1/3	Healed
VAG	F42A	Young Adult	UD	Cappuccina	1	Left Tibia	Proximal 1/3	Healed
VAG	F249	Young Adult	F	Cappuccina	2	Left Rib	Angle	Healed
						Right Rib	Angle	Healed
VAG	F231	Young Adult	M	Libation	1	Right Tiba	Proximal 1/3	Healed
VAG	F131	Middle Adult	M	Libation	1	Right Ulna	Distal 1/3	Healed
VAG	F216	Old Adult	M	Cappuccina	1	Right Fibula	Distal 1/3	Healed
VAG	F204	Young Adult	F	Cappuccina	1	Left Humerus	Proximal 1/3	Healed
VAG	F200	Middle Adult	F	Cappuccina	1	Unsided Rib	Shaft	Healed
				GODMANCHESTER				
PGO	PGO 54	Old Adult	UD	Pit	1	Unsided Rib	Shaft	Healed
PGO	PGO 37	Middle Adult	M	Pit	9	Right Rib	Angle	Healed
						Same Rib	Shaft	Healed
						Right Rib	Shaft	Callus Formation
						Right Rib	Shaft	Callus Formation
						Right Rib	Shaft	Callus Formation
						Unsided Rib	Shaft	Callus Formation
						Right Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed
PGO	PGO 34	Middle Adult	M	Pit	1	Left Fibula	Distal 1/3	Healed

PGO	PGO 30	Middle Adult	M	Pit	1	Right Fibula	Mid 1/3	Healed
PGO	PGO 24	Middle Adult	AM	Pit	2	Left Rib	Shaft	Healed
						Unsided Rib	Shaft	Healed

Appendix C - Pairwise Comparisons

Appendix Table 1: Pairwise Comparisons between Age Categories at Lisieux Michelet.[1]

Lisieux Michelet				
	Older Adolescent[2]	**Young Adult**	**Middle Adult**	**Old Adult**
Older Adolescent		OR = 1.1, CI .22-5.37 P_{FET} = 1	OR = 1.4, CI .28-7.16 P_{FET} = .733	OR = 2.4, CI .516-11.1 P_{FET} = .357
Young Adult			OR = 1.584, CI .623-4.02 X^2_{YATES} = .53 p=.4666	OR = 2.667, CI 1.20-5.90 X^2= 6.17 p=.0129
Middle Adult				OR = 1.68, CI .713-3.97 X^2= 1.43 p=.2317
Old Adult				

[1]Bolded cells as statistically significant.
[2]P-value after Bonferroni Correction (Equation 3.6) is 0.008.

Appendix Table 2: Pairwise Comparisons between Age Categories at Winchester.[1]

Winchester				
	Young Adult[2]	**Middle Adult**	**Old Adult**	**Adult Undetermined**
Young Adult		**OR = 3.23, CI 1.6-6.5 X^2= 11.3 p=.000615**	**OR = 3.69, CI 1.81-7.52 X^2= 13.06 p=.000302**	OR = 1, CI .379-2.661 X^2_{YATES} = 0.06 p=.806
Middle Adult			OR = 1.08, CI .544-2.15 X^2= 0.05 p=.82	OR = 3.25, CI 1.21-8.47 X^2= 6.3 p=.012
Old Adult				**OR = 3.514 CI 1.33-9.233 X^2= 7.1 p=0.0077**
Adult Undetermined				

[1]Bolded cells as statistically significant.
[2]P-value after Bonferroni Correction (Equation 3.6) is 0.008.

Appendix Table 3 Pairwise Comparisons between Burial Types at Winchester.[1]

Winchester				
	Coffin[2]	**Pit**	**Possible Coffin**	**Stepped Grave**
Coffin		**OR = 2.67, CI 1.42-5.01 X^2YATES = 8.7 *p*=.003182**	OR = 1.32, CI .442-3.98 *P*FET = .7575	OR = 2.01, CI .26-15.45 *P*FET = .708
Pit			OR = 2.013, CI .618-6.56 X^2YATES = .83 *p*= .3622	OR = 5.3684, CI .667-43.19 *P*FET = .107
Possible Coffin				OR = 2.66, CI .275-25.83 *P*FET = .637
Stepped Grave				

[1]Bolded cells are statistically significant.
[2]P-value following a Bonferroni Correction (Equation 3.6) is 0.008