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UNIVERSITY OF SOUTHAMPTON

Faculty of Humanities

Archaeology

Doctor of Philosophy

Islam in Iberia or Iberian Islam: Sociobioarchaeology and the Analysis of
Emerging Islamic Identity in Early Medieval Iberia.

By

Sarah Alice Inskip

Thesis for the degree of Doctor of Philosophy

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ABSTRACT

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Islam in Iberia or Iberian Islam: Sociobioarchaeology and the Analysis of
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This research aims to demonstrate how archaeology can contribute to the analysis of religion and religious change. By viewing religion as a social construct, that takes meaning within its own context, the analysis of material culture provides an opportunity to look at long term religious change. This is because while religion strongly influences material culture, it is also reproduced by it. In particular, the body is critical in recreating and negotiating ideology due to physical conformity to religious ideals, which actively constructs identity. As bone adapts to reflect the physical strain placed on it during life, the analysis of changes in activity-related skeletal modifications provides a mechanism for assessing whether religious identity, and therefore ideology, changed and adapted over time. When combined with other evidence from material culture and historic sources, this social-cultural approach explores the development of religion and its role as a structuring principle, but also how it is influenced by other social, political and historic factors.

This was demonstrated through the analysis of physical activity patterns from skeletal material from early Medieval Islamic Iberia (al-Andalus) AD 711- 1200, a region that underwent rapid social change with the emergence of Islam into a previously Christian state. Islam, as a historic religion, has well established religious traditions. A comparison of ideal behaviour and actual behaviour, as evidenced through activity-patterns, was carried out in order to analyse the impact of other social factors on identity in the region. In particular, this thesis focused on whether ideals surrounding gender division and prayer were adhered to in al-Andalus. Entheseal changes, osteoarthritis,

non-pathological articular modifications and bone morphology data from Islamic and pre-Islamic individuals from the Islamic cemetery at Écija, Sevilla, and the pre-Islamic basilica at Cortijo de Coracho, Córdoba were compared. A distinct change in activity patterns occurred with the emergence of Islam. A greater gendered division of labour was identified in the Islamic group, as well as possible evidence for the adoption of ritual prayer and reduced female mobility. The emergence of an Islamic identity was supported by clear trends in burial data and historic sources. Diachronic analysis of Islamic data implied that adherence to Islamic tradition appeared to strengthen over time. Overall, this research appeared to support historical documentation which suggests an orthodox Islamic identity in Iberia.

To understand the emergence of an orthodox Islamic Iberian identity, important social and political factors were considered. Firstly, proximity to Christianity meant the observance of Islamic tradition was important for creating a distinction between ‘us’ (Muslims) and ‘them’ Christians. This became more important later when religious tensions increased in Iberia, where the Christian north organised into a credible threat to the Islamic South, but also in the east, with the initiation of the crusades. Secondly, the arrival and staunch Caliphal support of Maliki law, which has strong emphasis on Qur’anic rituals. Thirdly, Écija, is close to Córdoba, the capital of al-Andalus, and traditions could have spread easily from Córdoba along well established trade routes. This research therefore demonstrated that Islamic identity, and therefore Islam in Iberia was a product of the interpretation of tradition in a particular context, thus demonstrating the unique nature of Iberian Islam.

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I, Sarah Inskip, declare that the thesis entitled 'Islam in Iberia or Iberian Islam: Sociobioarchaeology and the Analysis of Emerging Islamic Identity in Early Medieval Iberia'. and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
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- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission, **or** [delete as appropriate] parts of this work have been published as: [please list references]

Signed:

Date:.....

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Glossary of Arabic terms

al-Andalus – Region of Iberia under Islamic rule, which includes parts of modern day Spain and Portugal

amsar – Garrison towns originally set up for Muslims to remain autonomous, living off the taxes of the land. Kufa, Basra and Old Cairo (Fustat) were originally garrison towns

bid'a – Innovation. Religious ideas or practices that have no precedent in Islamic law

dar al-Islam – All regions of the world where Islamic law prevails

dhimmi – Protected people. Under Islamic law, people of the revealed faiths (Christianity and Judaism) living in Islamic regions, were permitted to remain in their faith if they paid a poll tax.

du'aa – Devotional, or reflective prayer which is differentiated from *salat* (ritual) prayer.

halal –allowable or permissible by law. Often used in relation to food.

haram –Actions that, according to the law, are prohibited or forbidden

hadith – Traditions based on the saying of the Prophet Mohammed

hajj – One of the five pillars of Islam requiring all able Muslims to undertake pilgrimage to Mecca once in their lifetime.

hijra – The migration of the Prophet Mohammed and the first Muslims from Mecca to Medina in AD 622. This marks the beginning of the Islamic calendar.

Ifriqiya –Medieval region of North Africa, including parts of modern western Libiya, Tunisia and eastern Algeria.

isnad – chain of authenticity for *hadith* traditions

ijma – the clarification of a point of law through consensus of learned men.

Ka'ba – a cube-shaped structure at the center of the Mosque in Mecca. Considered by some as the centre of the world, it is the direction (*qibla*) of prayer and burial.

makbara - Cemetery

makruh – Referring to behaviour - reprehensible

masjid – Mosque. Arabic meaning place of prostration

mihrab – A niche in the mosque wall that faces Mecca which is the focus of Islamic prayer

minbar – pulpit or raised chair from which the imam preaches.

Mudejár – Muslims that lived under Christians rule in Iberia.

muhaddithun – A person who studies the authenticity of *isnads*.

muwallad – A native Iberian Muslim client

Al-Muwatta – A collection of *hadiths* compiled by Imam Abu Abdallah Malik ibn Anas, the founder of the Malikist school of thought which focuses strongly on Islamic jurisprudence found in the Qur'an.

qadi – Muslim judge whose role is to judge on their relevant school of Islamic thought

qibla – The direction of prayer towards Mecca. Also the wall in a mosque which is orientated towards Mecca.

qiyas – Process of analogical reasoning used to create jurisprudence in Sunni law

Qur'an – The holy book of Islam

rakat – a complete cycle of prayer, different prayers have different numbers of *rakats*.

salat – Ritual Prayer. This is one of the five pillars of Islam. Prayer should be undertaken five times a day, preferably at a mosque, but any location is sufficient. Prayer follows a set of actions, which is repeated a number of times depending on the time and day (Fridays have different prayer sequences).

Saqiya – an animal-driven water wheel arriving in Iberia the 9th century

Shafi'ism – A Sunni school of Islamic thought based on the teachings of Al-Shafi

shahada – One of the pillars of Islam which requires the profession of faith including 'There is no God but Allah and Mohammed is his messenger'

shari'a - Islamic law including the Qur'an and the *sunnah*

shi'a – A branch of Islam which believes that Ali Ibn Abi Talib was the rightful successor to Muhammed. Sometimes known as 'supporters of Ali'

sunna – the example of exemplary living set by the Prophet Mohammed.

sunni – the largest branch of Islam which places emphasis on the *Sunnah*

sura – a chapter of the Qur'an

sawm – fasting

takbir – a term used to describe the greatness of god - 'Allahu Akbar', God is great.

ulama – Learned men sometimes seen as guardians of the faith. In Sunni Islam, there are three types; *qadis* or official judges of the state, *Muftis* whose opinions have

considerable authority, but are not binding, and *fiqih*, an unofficial expert in the Islamic faith.

umma – people of the worldwide Islamic community

zakat – one of the five pillars of Islam which requires Muslims to pay alms.

Chapter 1: Introduction

Religion is critical in structuring and shaping life. Even in increasingly secularised societies, religion still impacts on behaviour, if only through the remnants of old traditions and laws, as is the case in some Western societies. Religion has been recognised by scholars of anthropology, ethnography, theology and sometimes archaeology as a crucial building block in the construction of society (Durkheim 1965, Eller 2007, Insoll 2004c, Nesbit 1976, Renfrew 1994). Despite this, the sacred is not fully integrated into archaeological discourse, even though religious ideology greatly shapes material culture, the fabric of archaeology.

The incorporation of religion into archaeological discourse has been hampered by numerous problems. The most significant difficulty is an inability to define religion, a fault which arises from its metaphysical and individual nature. Such ‘indefinability’ has subsequently prevented the identification of religion in past societies, and has resulted in under-acknowledgement of religious influence in structuring the archaeological record. While archaeologists and anthropologists have attempted instead to explore what constitutes religion, this has also been dogged by problems, which has ultimately led to a preoccupation with classification. Religion became deconstructed by scholars into recognisable features, largely based on contemporary understandings of monotheistic world faiths. Such a typological approach fails to demonstrate the dynamic nature of religion, and imposes modern Western concepts of religion onto past populations. As a result, these methodologies do not demonstrate the varied role of religion in constructing different societies or highlight what religion even *is* for each society.

While it is not possible to directly access the actual beliefs of past peoples archaeologically, Renfrew (1994) and others (Boyer and Bergstrom 2008, Insoll 2004c) argue that observation of behaviour induced by beliefs provides a way forward for archaeology. According to Geertz (1968:2) religion is sustained in this world through symbols and social arrangements. These symbols can be both metaphysical and material, and make up part of religious identity. It is therefore possible to analyse changes to religious belief through

assessing changes to religious symbols and their associated identities. This can be achieved in archaeology, because as material conditions are produced, religious symbols are maintained and constructed (Diaz-Andreu 2005:6). In fact, one of the greatest symbols of religion, which has not yet been studied, is the body. As there is a link between the physical and social symbolic body, analysis of changing physical activity patterns makes it possible to look at changing religious ideology. Therefore, this thesis aims to analyse changing patterns of the body, particularly the human skeleton, to gain an understanding of the development of religion, religious identity and therefore religion's role in social construction and maintenance. This analysis addresses the primary debate of this research, which is to demonstrate how archaeology can be used to explore religion and its development in past societies.

As no structure currently exists to analyse religion in archaeology, chapter 2.1 explores how scholars of sociology, anthropology and archaeology have attempted to assess religion, its formation and development (see section 2.1.2 for a more detailed look at these approaches). This information identified that the supernatural element of religion remains lost to scholars, which has provoked researchers of anthropology and sociology to focus on the role of religion in societies (Renfrew 1994, Morris 2006). Consequently, anthropologists have acknowledged that religion is a social construct which takes meaning within its own context (Asad 1993, Eller 2007, Morris 2006). As such, this was the approach used in this thesis.

In order to demonstrate how taking a social approach to analyse the body enables archaeology to contribute to the study of religious development, a case study was required. Section 2 of chapter 2 outlines this case study. It was decided that Islam was ideal for this research for a number of reasons. As a historically documented faith, significant quantities of records exist on religious ideology. Often seen as a way of life rather than a religion, in Islam the distinction between the religious and secular is blurred. The social role of Islam in this sense has been argued to be one of a structuring principle (Insoll 1999) or a structuring tradition (Asad 1986, Marranci 2008), and can be viewed as an orthopraxy (Lindsay 2005:22). As part of this, Islam requires the undertaking of a number of behaviours to be

obedient before god and has a significant effect on daily life. As such, there is a link between belief, activities and the practice of rituals in Islam. Religious ideology will therefore be manifested in the material record, in this case the skeletal body. However, as the adherence and interpretation of tradition is also subject to other cultural factors, temporal variations in activity and material culture inform about the development of Islamic identity and its changing role in society. Accordingly, the main aim of this case study was to assess whether there was temporal deviation in behaviour from that expected based on religious sources outlined in section 2.2, and to identify whether these changes related to the geographic, historic and political situation. In essence by comparing ideal behaviour with that of reality, an assessment of variation in Islam and how this may have occurred was permitted. This highlighted change to Islam itself, therefore demonstrating that it is possible to explore the development of religion in the past through archaeology.

The region of focus is Islamic Iberia AD 711–1200. The impact of Islam on Iberia was profound, and is clearly evident today in local customs and culture (Menocal 2002). During the early Medieval period, the arrival and integration of Islam into a previously Christian state coincided with substantial social change (Imamuddin 1981). This period provides an excellent research focus as the social and political situations of the region are well documented. The emergence of an indigenous Muslim population in proximity to Christian Europe provides an ideal situation for change to Islam and Islamic identity. This is because while Islam may have created a social structure for those living in Iberia, it was maintained by those who conformed. As such, through agency, religious identity and ideology could be subject to change over time. The inclusion or exclusion of pre-existing traditions, with the arrival of new incoming practices has the ability to create new religious identities and regional Islam (Marranci 2008). Critical in shaping these new identities are historical and social influences (Morris 2006). Political interests also play a significant part through dictating acceptable deviations in behaviour and activities. The use of historic documentation is therefore a key aspect of this thesis. It highlights important factors that impact on the expression of Iberian religious identity, which could shed light on religion as a social constructor. This was the purpose of chapter 3, where in section 3.2 Visigothic Iberia, its governmental structure and historic background is outlined. In section 3.3 the

arrival of Islam in Iberia, historic evidence surrounding the conversion to Islam and how this impacted on the indigenous population is presented.

Chapter 4 outlines how human skeletal remains can be used to explore major social change. As a dynamic tissue, bone adapts during life to support stresses which are imposed on the body (Mays 2010). The skeleton therefore acts as a record of physical activity that can be analysed like other types of material culture to inform on social change (Sofaer 2006). By seeing skeletal remains as a product of society, and as a symbol for religion, diachronic analysis of bone changes provides a mechanism to explore religious development. Specifically, as physical activities are influenced by Islamic ideology, analysis of activity-related skeletal changes (ARSM) provides an ideal way to assess modifications to Islamic identity. While human skeletal remains have been used to investigate differences in subsistence strategies and identity, (e.g. Dlamini and Morris 2005, Lai and Lovell 1992, Larsen 1997, Lovell and Dublenko 1999, Munson Chapman 1997, Peterson 1998, Ruff 1994, Sofaer-Derevenski 2000, Stock and Pfeiffer 2001, Wilczak 1998), religious identity has not been studied in this manner. Where osteoarchaeology has been consulted, the focus is strongly on burial rites e.g. Gilchrist (1994) and interred grave goods, rather than the remains themselves, which are the people living and initiating change. This makes this research unique.

To satisfy the aim of identifying whether Islam became and remained important in the social organisation of Iberia, a diachronic comparative analysis of ARSM from pre-Islamic and Islamic sites was required to compare what existed before and during the Islamic period. Skeletal material from two sites was required for this research. Chapter 5 introduces the sites used in this research. Remains from the largest excavated Islamic cemetery in the world, Plaza de España, Écija, Sevilla, were used. The cemetery contains over 4500 individuals from seven phases of occupation dating from AD 711 until the 13th century. Comparative pre-Islamic individuals were obtained from excavations of Cortijo de Coracho, Lucena, Córdoba province, 80km south east of Écija. Coracho is one of the largest Visigothic cemeteries in the region, containing over 300 burials. Previous research

on Écija and Cortijo de Coracho was used to complement the results from this investigation.

There are many different facets of Islamic identity which could be analysed for temporal variation. It was important, however, that the aspects chosen for analysis could be accessed through human remains, but are also proscribed in literature to detect variation from the ideal. As strong ideas about gender are found in *shari'a* law, information regarding changes to gender roles and division were sought from bones when analysed according to sex. To further assess the impact of agency in the development of Islamic identity, examination of gender roles and division was undertaken by comparing the ARSM in pre-Islamic and Islamic individuals to observe continuity and change. To explore whether religion remains a key structuring principle with developing Islamic identity, a further diachronic assessment of gender division was undertaken by comparing early and late Islamic ARSM. While agency or the introduction of new technologies may create variation in gendered activities over time, if the role of religion remains a fundamental structuring principle and, in particular, key to structuring gender identity, a gendered division of labour should still exist, albeit in a different form in the later Islamic period.

Another potentially visible facet of Islamic life is that of prayer. Prayer is one of the five pillars of Islam, five obligatory requirements of being a Sunni Muslim. Ritual prayer should take place five times a day in a particular sequence and in a specific posture. As a result, it may be possible to detect the emergence of this repetitive activity in the load-bearing bones of the knees, ankles and feet. If changes occur over time in the prevalence of these modifications, it is likely to be tied strongly to changes in identity.

Previous research has demonstrated that the particular ARSMs that have been selected for this project are successful in revealing activity differences. They include enthesal changes, non-pathological articular modifications, osteoarthritis and bone geometry. The four activity-related skeletal modification types, which are outlined in chapter 6 and assessed in chapter 7, were chosen as each adds a different perspective to the same question. Enthesal changes were selected as they have been demonstrated to show differences in muscle use

and intensity (e.g. Godde and Wilson-Taylor 2011). Non-pathological articular modifications have been used to highlight differences in working postures (e.g. Molleson 1989). Patterns and prevalence of osteoarthritis have the ability to inform about repetitive loading on extra-spinal joints (e.g. Larsen 1997). Finally, bone geometry has been utilised to interpret sexual dimorphism as well as patterns of activity (e.g. Pomeroy and Zakrzewski 2009). Few osteoarchaeological studies have used multiple indicators of activity, despite clear evidence for the benefits of such an approach. This enhances the unique nature of this research.

Through analysing the skeletal material in this manner, chapter 8 provides a new perspective on a critically important part of Spain's history. Overlooked in favour of Roman and later Medieval studies, early Medieval Spain is under-studied. This research is the first significant analysis of Islamic identity through direct analysis of human skeletal remains. By viewing the body as a symbol for Islam, this research explores how the bones of Iberians can be used to detect changing patterns of activity which were significant for creating shifts in Islamic religious identity. Through this it will demonstrate that although Islam provides a strong life-structuring principle, the role of agency has the potential to create variation in religious identity. This variation is tied up to the socio-political historical context. In this sense, Iberian Islam, like all Islams, was unique.

Overall, this thesis demonstrates that to successfully integrate religion into the archaeological discourse, the varying role that religion takes in past societies has to be understood. This requires stepping back from trying to fit religion into a type. The nature of religion as a variable social construct means that it does not lend itself to this approach. In the case of Islam, this means understanding it as a life structuring principle or tradition. By taking a contextual approach to the examination of religious identity, this study shows that it is necessary to consider the wider political and historical circumstances, given that these can be key factors in the development and expression of identity and the construction of religion.

Chapter 2: The Archaeology of Religion and Islam

Firstly, in order to move forward, this chapter outlines the current inadequacies of religious study in archaeology, and the lack of archaeological theories of religion. The first section of this chapter discusses problems inherent in the analysis of religion, and turns to anthropology to understand how these difficulties have been managed and tackled. Following this, an assessment of archaeology's attempts to access religion is presented, thus evaluating the problems with current practices.

Secondly, as this project aims to use Islam as a case study to present a new approach to the study of religion, it was necessary to present the origins of Islam as well as its religious doctrine and previous research. This is outlined in the second section of this chapter as it was deemed critical for the construction of a new approach exploring religious identity development.

2.1 The study of religion

The study of religion is inherently complicated. As summarised earlier, scholars of anthropology, philosophy, history and archaeology have found tackling religion particularly problematic due to an inability to reach a definition (Rowan 2011). Religion is a multifaceted and individual phenomenon, taking on different forms in different groups. This has led to the emergence of multiple definitions. For example, Spiro (1987:19), a cultural anthropologist, defines religion as an 'institution consisting of culturally patterned interaction with culturally postulated superhuman beings' whereas Durkheim (1965), a sociologist, simply suggests 'a set of beliefs and practices by which society represents itself to itself'. Perhaps the most significant issue leading to this indefinability was identified by Otto (1950), and echoed by Geertz (1968), who suggested that the supernatural element of religion means it cannot be assessed. This element has been described by Sharpe (1986:164) as the 'numinous', a metaphysical and individual element in religion and belief. It is the numinous or the supernatural, which prevents the formation of a single satisfactory definition of religion. Regardless of the constant and arguably unending debate over what religion comprises, the impact of religion on society has been acknowledged by researchers

in most fields. Geertz (1968:1) recognised that characterization of religion need not be a problem, but discord lay in the identification of what was actually religious, be this behaviour or material culture.

Archaeologists have failed to produce their own framework for assessing religion (Edwards 2005, Insoll 2004a, Whitely and Hays-Gilpin 2008). This is despite the fact that many other disciplines have been able to address religion. In order for archaeology to move forward, perhaps some light can be shed by assessing anthropological approaches to religion.

2.1.1 Anthropological approaches to the study of religion, its origins and role

Anthropological study of religion is far more advanced in its mode of analysis than archaeology (Renfrew 1994, Insoll 2004a). Generally there are three broad frameworks which exist in the anthropological thought; historical/evolutionary, psychological and social (Eller 2007, Morris 2006). Within these frameworks many different approaches have been taken. Accordingly, common anthropological approaches are outlined below within the general framework from which they originate. It is worth noting that some approaches overlap.

2.1.1.1 Evolutionary framework of religion

Evolutionary scholars understand religion to be a consequence of human nature (Boyer and Bergstrom 2008). One of the earliest anthropological approaches was to observe religion as an evolving phenomenon. Tangled up with the industrial revolution and the advent of Darwinism, religion, like society, was viewed as moving from something primitive through to more evolved complex forms (Gellner 1999). Most famously, religion, or the development of religion, was broken down into three phases by Taylor (1903), who thought that religion initially existed as spirit religions (animism) which evolved into more complex polytheism and eventually culminating in monotheism. This installs a sense of hierarchy in religions, locating modern Western concepts of religion above all others. This creates a biased picture of 'primitive' religions as they became evaluated and measured against the 'pinnacle' monotheistic faiths (Bowie 2000). Inferiority is inferred to non-monotheistic religions as increasing complexity is associated with superiority. This was well

summarised by Malinowski (1948:7) who argued that there is a preconception that origins must equate to simple or savage, and later forms must be more complex. All religions do not evolve uniformly, as is clearly exhibited by the range of non-monotheistic faiths globally.

Recent resurgence of interest in evolutionary theories of religion has been summed up by Boyer and Bergstrom (2008:114) who suggest that religion is subject to natural selection. Religion in this respect can be traced like genes which can be mapped. Through this, cultural transmission (in this case religion), can be tracked like genes, while taking into account other social factors that may influence its spread and variation. This permits the variation in religion to be explored and understood.

Durkheim (1965), although technically social in his approach, suggested that religion can be accessed through examining previous and earlier forms. Durkheim (1965) inferred that initially the whole world was religious, but god has been withdrawn from different aspects of it due to the advancement of technology via the acquisition of knowledge. Science, in this respect, replaces religion. This demonstrated that Durkheim (1965) registered that religion can change. However this approach does not focus on the origins of religion, nor does it acknowledge the individual religious experience.

Other recent developments of the evolutionist approaches suggest that religion acts as a way to store knowledge of the past which is advantageous to society (Lachmann 1983, 2010). Renfrew (1994) posits that hymns could be seen as a method by which experiences of the past could be orally transmitted over generations.

2.1.1.2 Psychological framework of religion

Proponents of psychological approaches see religion as a psychological phenomenon (Eller 2007). While scholars working in a psychological framework agree that religion is created/experienced by the individual, its expression can be the result of different initiating factors. These factors are explored below.

Intellectualist approaches to religion

Intellectualist approaches have sought to explain the origins of religion as a means by which people explain and orientate their worlds, particularly the unexplainable (Horton 1967). Cunningham (1999:23) posits that in intellectualist approaches, religion is used as a way to explain why things happen in the past, the present and the future. Spencer (1885), in a combination of intellectual and evolutionary approaches, believed that societies evolved and that religion is a crucial part of societies, which would not exist without it. Spencer (1885) argued that religion evolved as knowledge of the world increased. Religion, in this sense, is argued to explain the gaps in what was not yet known. This is an idea that was posited by Frazer (1890), and later reiterated by Durkheim (1965), who argued that religion was progressively replaced by science as knowledge improved. As most of the modern world continues to practice religion, it is clear that this idea is deficient in our understanding of the purpose of religion which is still prominent in people's lives (Bowie 2000).

Later intellectualist approaches have explored the interaction between religion and other modes of understanding. Horton (1967) suggests that religion acts to organise the world and make everything a cohesive whole. He suggested that religion operated to place events in context with something that is broader than common sense alone. In the past it may have been used as a substitute or in addition to science (Morris 2006). For example, X event occurred which influenced Y, and this event was caused by something supernatural. Horton and Peel (1976) have subsequently argued that in terms of easing conversion, religion could be used to legitimise new behaviours to make them fit with pre-existing beliefs. New ideas are assimilated in terms of what converting groups already know.

Emotionalist theories of religion.

Cunningham (1999:23) outlines emotionalist theories as those that describe religion as a response to emotional stress. The importance of emotion in religion is underscored and viewed as its most important feature (Eller 2007). This is unlike intellectual approaches that describe religion as a response to unexplainable events. Morris (2006:3) suggests that

religions is a 'mechanism for which people are able alleviate fears and anxieties'. As such, rituals can be explained as having a therapeutic effect. Freud (1985) explained the presence of religion as an infantile manifestation of the father complex. The idea of religion occurring as a result of emotional stress was something that Malinowski (1948) shared with Freud. The emotion however can be love, awe, wonder and fascination as well as dread and fear. However, both Freud and Malinowski were more concerned with individual psyche rather than with group emotion. As such emotionalist approaches fall short when applied to the analysis of religion as a collective phenomenon.

Phenomenological theories of religion.

Edmund Husserl was the pioneering scholar in phenomenology of religion (Bowie 2000, Morris 2006). Phenomenological approaches explore religion through experiences neutrally/objectively; that is, to try and experience religion for what it is, rather than worry about whether beliefs were true (Bowie 2000:5). Laughlin (1999:484) describes phenomenology as the study of essential processes of consciousness by contemplation of experience, emotions, feelings and physiological reactions. In order to achieve this, examination requires assessment without prejudices by ignoring 'bracketing' common sense understandings. This is what Husserl (1931) termed 'epoché'. This will allow the phenomenon to be experienced for what it is, thereby permitting understanding of the nature or essence of religion or eidetic vision (Bowie 2000, Erricker 1999, Morris 2006).

Critics of the phenomenological approach oppose the fact that religion is treated as a separate aspect of life. Through this, the social role of religion and as a constructor of society is denied. Phenomenology stresses the personal experience of the individual (Renfrew 1994), something that was previously argued to be inaccessible (Hawkes 1954). A second criticism lies in the fact that it is incredibly difficult to be totally impartial and restrict the impact of personal cultural patterns (Insoll 2004a:39). Even more problematic, therefore, is trying to experience the religions of past populations where it is not possible to immerse oneself in the researched group.

Cognitive theories of religion.

Cognitive approaches to religion include elements from evolutionary psychology and socio-biology. Although religion is apparently against common sense, it is seen as being natural and a 'basic or pan-cultural human characteristic' (Morris 2006:4). Whitley (2008) implies that cognitive approaches to religion accept that emotion and altered states of consciousness are important factors in human behaviour and development. Importantly, cognitive approaches also recognise the importance of the numinous, as well as the definitional and analytical problems that this inherently creates, but do not dismiss them as unapproachable. The inability to assess the numinous, it is argued, is a product of 19th and 20th century thinking where religion and science were seen as at conflict (Midgley 2003). Emotion itself has a biological basis and is a pan human characteristic. In fact Whitley (2008) argues that humans may actively seek to feel emotion or achieve an altered state of consciousness. These emotions may be critical in forming and perpetuating religious behaviour and rituals in the present and past. Emotional responses may be culturally specific. It however still remains difficult to assess these emotions in extinct populations.

2.1.1.3 Sociological framework of religion

Proponents of sociological framework believe that the origins of religion are social, that it is formed of the collective (Eller 2007), but disagree over its social function. Morris (2006:7) states that this could be as a Marxist, legitimising oppression or as a maintainer of society or it could be as a uniting factor through the construction of morality (following Durkheim). Accordingly within the sociological framework many theories cross over. While the main focus is on religion as social phenomenon, it stresses that a requirement for understanding religious development is knowledge of the socio-historical context (Gellner 1999). This highlights the possibility and causes of religious identity variation.

Structural functionalist theories of religion.

Structural functionalism views society as an entity made up of many different interrelated parts, of which religion is just one (Johnson 2010). According to Eller (2007), religion's most important role is in the creation of society, not in the comfort of the individual, a

disparate idea to emotionalist views. Religion acts as the glue that holds society together and maintains its functionality (Gellner 1999). The way in which this is achieved however is not universally agreed.

Marx viewed religion as an ideology. Marxist theories have attempted to tackle the origins of religion through examination of the apparent control that religions can have on a society (Furseth and Repstad 2006:30). Furthermore, Furseth and Repstad (2006:30) indicate that Marxists view religion as a means by which elites controlled or oppressed the lower classes. This is achieved by the formation of 'ideologies' which act to recreate systems of dominance (Shanks and Tilley 1992). Religion in this sense could be seen as an illusion created to justify or hide the agendas of the ruling class. This theory may well work in modern Western ideas of religion and the larger world faiths, but this may not apply to 'tribal' or past religions. Marx was writing in a time with emerging capitalism, where strong class oppositions were developing, therefore this type of approach falls short in societies not organised in this manner. Marxist theories also fail to consider the varying roles that agency and ritual have in manipulating and changing religion, as well as the ideology, and therefore material culture produced as a result of it.

A slightly different structuralist functionalist approach was taken by Durkheim (1965) who saw religion as a way of creating social unity rather than one based on opposition like Marxist views. Society is tied together by morality and social solidarity. Religion is therefore necessary and critical in the creation of morality, which itself is required in societies (Durkheim 1965). However, this approach does not focus on the origins of religion. In addition, structural functionalists do not acknowledge the importance of individual religious experience.

Structural functionalist theories have tended to overlook religion as a critical factor in the development of society suggesting that religion might have a constraint on society, but not as something that might control it. Structural functionalist approaches have been criticised generally by Johnson (2010:82) for insufficiently explaining change. Bowie (2000:16) suggests that the development of religion was overlooked and that it just made up part of

the large 'organic whole' that is society. This leaves religion separate from other aspects of identity, analysed as an independent entity without consideration of the interaction that can take place with other aspects of society.

Morris (2006:4) further suggests that one of the major criticisms of structural functionalist theories is that they are ahistorical. Again, they assume that populations in the past function and react as we do today. More importantly, and in relation to this study, they deny the importance of human agency in religious identity development.

Symbolic theories of religion

Clifford Geertz, an American anthropologist, was a critically important scholar who sought to explain religion as a representation of social values. Geertz (1968) explained this by seeing religion as a set of symbols which fit in with culture, which was described as a larger set of symbols. As such, symbols are not just material, but represent a social process and social thought. They are a tangible expression of ideas/notions. Accordingly, and as Bowie (2000:22) indicates, the study of religion from a symbolic perspective assesses what religion represents rather than what it seeks to explain. As symbols can be dualistic, in that they can take on religious and secular meanings, and even vary between individuals, context is absolutely critical in the interpretation of symbols (Rowan 2011). The analysis of symbols also permits the analysis of religious change.

2.1.2 Archaeological approaches to religion

The inability to define religion, and subsequent failure to recognise the importance of religion in people's lives has resulted in the sacred being considered separately from other aspects of life, if at all in archaeology. One reason for this may stem from Hawkes' (1954) ladder of inference and the concept of the numinous. Religion has been seen as too difficult to tackle, or too problematic to place within frameworks used for assessing other aspects of identity. For example, gender identities may be considered independently from religious ones, despite the fact that religious ideology often dictates gender ideals (Coakley 2000, Insoll 2004a:152). Processual studies really ignored the influence of religion (Rowan

2011), possibly due to the failure of structural functionalism to acknowledge the constructive nature of religion in other aspects of society. Incomplete and fragmentary approaches have resulted from what Edwards (2005:111) suggests is the reluctance of archaeologists to produce archaeological theories of the development of religion. This has resulted in narratives of the past being largely areligious.

This is not to say that religion has not been approached at all within the archaeological record. Historians, anthropologists and sociologists have all used material culture from past populations as evidence to back up their own theories of religion. Early evolutionary perspectives in anthropology influenced archaeological interpretation of the past through the equating of primitive religions with animism or polytheism and civilised societies with monotheistic religions (Insoll 2004a). Rowan (2011:3) argues that such an approach has led to the formation of archaeological typologies. Not only did this result in the analysis of the sacred being reduced to practices and materials that are overtly religious (i.e. burial practices, religious buildings, shrines), it denies complexity to past populations.

Archaeologists have, however, borrowed from anthropology to try to create more nuanced interpretations (Edwards 2005), but the nature of archaeology means that many anthropological approaches are simply not suitable for investigation of past religions. For instance, psychological approaches focus on the individual element of religion, something that is not observable archaeologically. Hawkes (1954) warned against this, as was reiterated by Renfrew (1994). It is simply not possible to access the minds of past peoples to directly analyse feelings or emotions. The use of phenomenology is also problematic, although possibly has more application than other psychological approaches (Rowan 2011). It may be possible, in the case of research that involves extant religions, to immerse oneself in a society and to experience their religion. Phenomenology has also been used for the interpretation of major religious structures or landscapes (e.g Thomas 1994), but difficulties arise when extrapolating findings to the past, when it is not clear that the human condition has remained constant overtime. It is clear that religions, their ideologies and practices vary over time, perhaps decreasing the value of phenomenological analysis.

Insoll (2004a) argues, and is further developed by Boyer and Bergstrom (2008:113), instead of focussing on what people believed (which we cannot access) archaeologists should focus on what they did as a result, which we can see archaeologically. This shift may be related to the general post-processual movement, which sought to ask more rhetorical questions (Rowan 2011) and to address more cognitive factors (Johnson 2010). As such, we should turn to the social theories of religion in anthropology outlined in section 2.1.1.

Archaeologists have settled for examining the communal aspects of religion and its role in society. Religion generally has been assessed through the study of rituals, sacred places and symbols.

Symbolic approaches have been particularly popular recently in archaeology, because as Diaz-Andreu (2005:23) argues, material culture can serve as a symbol. Examining how symbols have been used in three main traditions of archaeology (processual, structuralist and post modern), Robb (1998a) demonstrated that any attempt to understand past cultures requires a consideration of symbols. Hodder (1982:185-186) emphasises that material culture is active, and is produced with symbolic meanings in mind, as part of a wider social strategy. Through agency, material culture can create change in these strategies through the adaptation of symbols. Hodder also stresses that material symbols play an important part in negotiating relationships between groups, but fails to mention how they may be involved in religion. As a social phenomenon which is constructed and maintained, religion contains many physical and metaphorical symbols that are an integral part of its expression. Due to this, symbols probably represent one of the best means to approach religion in the past (Renfrew 1994). By taking a symbolic approach to analyse material culture, archaeologists have found a way of assessing the development of religion. Changes in the symbolic meaning of material culture can therefore be used to demonstrate changing religious identities and religion (Robb 1998a). Rather than being a framework for the interpretation of religion in the archaeological record, the notion of symbolism provides archaeologists with a mechanism in order to view material culture and then place it within a framework (e.g. cognitive, as discussed below). Robb (1998a) demonstrated this with a study that explored how archaeologists have used symbols to explore various changing cultural phenomena (including gender, transitions in lifeways, power and evolutionary studies).

Archaeologists from a cognitive persuasion have, in particular, moved towards studying religion through the analysis of rituals and symbols. Renfrew and Bahn (2001:408) and Renfrew (1994) suggest that the religions or ‘cults’ of past populations can be recognised in the archaeological record as there are a number of features that differentiate cult from secular activities. This includes ‘focussing of attention, boundary zones between this world and the next, presence of a deity and participation and offering’ (Renfrew 1994:51). However, this approach actually almost reverts to early ideas of religion as a discreet entity and is fundamentally typological in nature (Insoll 2004a, Rowan 2011). Furthermore, as Insoll (2004a:97), argues this approach places the focus solely on religious places or overtly religious materials. Aldenderfer (2011) indeed cautions that archaeologists should not over-emphasise ritual as the sole means of exploring belief. Morris (2006:1) warns us that ‘Religion is a social institution, a socio-cultural system: as it is thus ill understood when viewed simply as an ideology, or as a system of beliefs, still less as merely a symbolic system’.

A definition problem that has blighted archaeologists in the analysis of religion through symbols and rituals is the distinction between religious and secular, otherwise known as the sacred and profane debate initiated by Durkheim’s research (Durkheim 1965). Renfrew (1994) suggests it can be difficult to analyse the meaning of material culture as it was intended when it can hold both secular and religious meanings, and, indeed both at different times. More problematically, Brück (1999) indicates that in many societies, no distinction between religious and secular exists, and this dichotomy probably results from modern Western experience. Therefore, failure to elucidate the entire role that religious ideals have on the structure and practices of daily life can result. More crucially, by analysing only those symbols and rituals that are overtly religious, one may miss the importance of religion in social organisation and how other areas of identity can be influenced and structured by religious ideology. An example of this could be economy in Islam where laws pertaining to trade, food taboos and alms giving are critical elements in *shari’a* law. Admittedly, this is less problematic for historically documented faiths where a good idea of the purpose of material culture can be obtained. Therefore, due to the innate variability of

rituals and symbols, when interpreting material culture analysis of context is key to interpreting artefacts as religious (Renfrew 1994).

Structured deposits are an additional way in which archaeology has sought to assess the actions of past peoples (Joyce 2011). Items buried may not initially appear as religious or ritual in nature, but the repetitive deposition of the same objects may be, for example, the deposition of apparently secular grave-goods in Anglo-Saxon burials. The repetitive deposition of the same objects in a similar fashion suggests ritualisation. The assumption that rituals are always religious cannot be made (Joyce 2011). Structural deposit analysis unfortunately is only applicable to deliberately buried material, and this may only make up a small part of religious processes.

In reaction to disjointed methods of study, Insoll (2004a:23) has advocated a more integrated approach to the study of religion, one that moves away from seeing the sacred as an independent feature of life, to one that takes into consideration how all aspects of life can be influenced by religion. Insoll (2004a:23) suggests that religion could act as an umbrella under which all other aspects of identity could be subsumed, arguably placing religion in a position more accurately reflecting its role in life and structuring societies. While it is clear that Insoll's (2004a) suggestion of an all-encompassing method provides a beneficial standpoint, it still has to be remembered that religion is highly variable and so is its importance in life. Subsuming all aspects of identity under religion assumes homogeneity amongst faiths. The assumption that religion is the central structuring principle in all societies is dangerous (Rowan 2011). A large quantity of Insoll's (1999, 2004a, 2004b, 2004c) work focuses on Islam where the division between the secular and religious is blurred, making this model appropriate (but even in Islam this may fail to be case).

It is clear from the above themes that there is no single method which provides the best means to study the origins, development and role of religion archaeologically. There are a wide range in ways in which religion can be interpreted. All of the theories and approaches above have validity, but equally they all have faults. Interestingly, and taking definitional

problems into account, the variation in approaches may be related to the fact that religion is variable, and what it is to one society, it might not be to another. What is clear is that the more religion is studied, the more complicated and variable it appears. While this may appear discouraging, it is not. This, in itself, informs about religion. What does emerge from the research discussed above is the fact that context is key when interpreting material culture.

2.1.3 Contemporary approaches to the archaeology of religion: context, identities and agency

The variable nature of religion means that a single method for the analysis of all religions and even sub-groups of religions should probably be abandoned. This is something that can be learned from consideration of various different approaches outlined above in section 2.1.1. The acknowledgement of the adaptability of religion is demonstrated by evolutionary, social and symbolic approaches. Archaeologists are well placed to explore such religious change over time. Archaeological deposits can span hundreds of years and this provides scholars with a means by which to explore the changing role of religion in the construction of societies via analyses of changes to material culture (Rowan 2011).

As the expression of religious ideology, archaeologists might find some way to proceed forward through the analysis of religious identities. Religions themselves are formed by people conforming to religious ideals (Marranci 2008) and living a religious identity. Changes to religious identity will therefore reflect changes to religion. In fact, Insoll (2004a:10) suggests that since material culture is the expression of thoughts and beliefs, the strong link between religion and religious identity can be exploited to explore religion. The analysis of phenomena in this manner is not new to archaeology, and is used in the analysis of age, gender and ethnicity (e.g. Hakenbeck 2011, Sofaer-Deverenski 2000). A key factor in interpretation of changing religious identities is the recognition of the role of agency and the changing of communal (in this case religious) behaviour. As religion may have a key structuring role in all other aspects of life, changes in religious identity have the potential to create changes in overall social organisation and can be expressed in material culture.

Factors shown to instigate agency, and therefore change religious identity, are highlighted in anthropology. Morris (2006:315) indicates that not only is the development of religious identity strongly dependent on how the religion originally formed, but also the contemporaneous social-historical context. As such, the strength of the relationship between religion and other aspects of society is variable. Analysis may benefit from placing religion on an equal footing with these other aspects but with the simultaneous realisation that all can be influenced, albeit not always equally, by each other. This is in effect a contextual analysis of religion that moves beyond structural functionalism. As religious ideology and identity are tied up with the socio-historical context, analysis of material culture requires consideration of other social processes influencing agency occurring at the same time, including internal and external influences e.g. war, disease, geography, previous religious background and conversion. In relation to this, an apparent absence of religion in the material record should not be ignored. If religion appears not to influence material culture, and therefore other aspects of society, it means that religion was not an influencing factor in society, or it cannot be observed through the chosen material culture.

A process that has been identified as playing a major role in creating religious identity variation is syncretism. Van der Veer (1994) describes the process of syncretism in a religious context as ‘a process of religious amalgamation, of blending of heterogeneous beliefs and practices’. This results in fusion of old and new religious practices and traditions, which effectively creates new traditions and identities. Important in this process is the acceptance or prohibition of certain behaviours and practices by the group (agency) and, in particular controlling institutions or people (e.g. church or ruling classes). This is particularly important in places undergoing conversion where new behaviours have to be introduced and reconciled with old systems (Horton and Peel 1976). Syncretistic religions are clearly evident across the globe, not just between faith groups, but by denomination where previous traditions still remain part of the new identity. For example, being Christian in England is different from being Christian in the southern States of the USA today, and being a Christian in Jerusalem 1800 years ago. A number of syncretistic analyses have emerged in archaeology (Carvajal Lopez 2009, forthcoming, Edwards 1999, Insoll 2004b, Oestigaard 2009) but significant research does exist in anthropology. Therefore, by viewing

religion as a social phenomenon, which has a symbiotic relationship with other parts of society, through analysing the changing use and form of material culture, archaeologists are well placed to observe agency, syncretism, and therefore changing religious identities and ideologies. This would permit an analysis of the changing role of religion in creating society. This is the approach taken in this research.

2.2 Islam and Archaeology

Research in section 2.1 demonstrates the variable nature of religion in societies. It is therefore critical that the theoretical approach used to understand Islam is outlined. Islam is a strong life-structuring principle as indicated by the commonality in customs and rituals seen across the *dar al-Islam* (Islamic world). Yet, while Islam can and does impact on other aspects of life and identity, the degree varies by region. In this sense, it might be wise to follow ideas produced by Asad (1986) who states that Islam is a tradition applied in different cultural contexts. Eickelmen (1982:1-2) indicates that the challenge is to describe and analyse how the universal principles of Islam have been realised in various social and historical contexts. In this sense, Islam can be viewed as a social structural tradition, Islamic identity is the expression of this tradition within a specific social and historic context. Therefore, the key to the interpretation of Islamic identity in archaeology is an understanding of the interaction between Islam with the pre-existing and contemporaneous culture. Islamic identity variation specifically is bound up with the acceptance and prohibition of pre-existing customs, as well as the appearance of new Islamic customs and rituals. Importantly as material culture is usually integral to customs or rituals (e.g. as prayer beads or mosques) or as symbols for religious ideologies (e.g. structure of buildings and gender ideology), variation in material culture reflects changes in custom or ritual. This permits the archaeological analysis of changing religious identity, the role of Islam as a structuring tradition and formation of Islams.

2.2.1 Early History of Islam

Before assessing how and whether Islam interacted with indigenous cultures to create new identities in Iberia, it is critical that the history and principles of Islam are presented so that

comparisons can be made. Accordingly this section will provide a background to Islam, its foundation, structure, law and rituals.

Islam, the newest of the major world faiths, has its origins in Mecca and Medina, situated in modern-day Saudi Arabia. Islam is seen as a way of life that governs everything a person does with little distinction from the secular. With 1.3-1.6 billion Muslims worldwide (Stencel *et al.* 2009), Islam is now the second largest religion after Christianity. The word 'Islam' itself means 'self-surrender' (Ruthven 2000:1). It describes 'the willing and active recognition and submission to the command of the One, Allah' (Waines 1995:3). A follower of Islam, or a person who undertakes self-surrender is known as a Muslim. Each Muslim has in common this self-submission to god and belief in the revelations from Allah. As a result, early Islamic policies attempted to transcend Islam above ethnic and cultural boundaries in order to create a worldwide community known as the *umma*. While this was achieved with some success, some areas were blighted with internal disputes for many years (Kennedy 1996, Lapidus 2002) (see chapter 3 for issues in Iberia). The majority of Muslims fall into two denominations, Sunni or Shi'a who differ in opinion about the correct successors to the prophet Muhammad (Berkley 2003, Waines 1995). Insoll (2007:319) suggests that archaeologically these differences are minimal as both hold the Qur'an, the holy book of Islam, and the Pillars of Islam central to the faith.

Allah's revelations were communicated to the prophet Muhammad early in the 7th century through the angel Gabriel, and it was these messages that formed the Qur'an. Muhammad's task was to restore the true faith of Islam from which the other monotheistic religions had strayed and which then neglected (Lapidus 2002:25, Waines 1995:14).

Lapidus (2002:22) indicates that by AD 615, Muhammad had become leader of a budding Islamic community. In AD 622, persecution in Mecca prompted Muhammad and his fledgling community to seek refuge elsewhere (Bulliet 1994:5). Medina offered safety to Muhammad and his followers. The migration from Mecca to Medina is a critically important part of Islam as it marks the transition from paganism to the Muslim world (Insoll 1999:17). As such, it represents the first year of the Islamic calendar (AD 622) and

is known as the *hijra* (Lapidus 2002:23). Eight years passed before Mecca came under the control of Islam. Just two years later (AD 632) Muhammad passed away and was buried in Medina, by which time Islam was already found in all parts of the Arabian Peninsula (Bulliet 1994:5). The newly founded faith was successively controlled by the four ‘rightly guided’ Caliphs.

A growing Arab and Muslim army spread out of Mecca and Medina taking with it early ideas of Islam. Over the next 100 years, the army moved across Arabia, Asia and the Mediterranean at a phenomenal rate (Goody 2007:19). By AD 750 Muslims had reached Spain in the west and Iran in the east (Lindsay 2005, Kennedy 2007, Morris 2006). The driving force behind the conquests is thought to have included a lust for booty and a religious passion to subdue and connect the world under Islam (Lapidus 2002:3).

2.2.2 Islamic Law (*Shari‘a law*)

Islamic law or *shari‘a* law is not, as such, a body of legislation, but is more a code of behaviour that developed during the first three centuries of Islam (Lindsay 2005:21). *Shari‘a* law touches on every aspect of life ranging from trade and marriage to food. Islamic law can be derived from four places; the Qur’an, the *Sunna* (*hadiths*), *ijma* and *qiyas* (Berkley 2003, Ruthven 2000:74). Islamic law is concerned with upholding society with the salvation of humanity as a key aspect of its function. In particular, human behaviour/contact is divided into five categories; regulatory/obligatory, proscribed and prohibited, recommended, discouraged, and permitted but socially indifferent (Ruthven 2000:85). On judgement day, a person’s actions will be judged according to these categories (Waines 1995:89).

The four roots of Islamic law will be briefly considered in order of precedence. Critically important are the ‘five pillars of Islam’, or five mandatory requirements of Islam which form part of Islamic identity. In the following section, each pillar will be discussed. A brief dialogue of the importance of law on the development of Islamic society will then be presented.

The Qur'an

The Qur'an is the holy book of Islam. Lapidus (2002:24) describes the Qur'an as setting the norms for Islam. Containing 114 *suras* (chapters), the Qur'an is seen as the basis of the Islamic faith (Insoll 1999:18, Marranci 2008). Recorded as it was received, the Qur'an's content follows an obscure sequence. This obscure order is used as a demonstration of the authenticity of the Qur'an as the unedited word of Allah. The Qur'an, however, was not compiled in its standard written form until Caliph Uthman, the third successor to Muhammad, some twenty years after Muhammad's death (Lawrence 2006). Accordingly, there may be some mutability in Qur'anic text in this period. For example, amendments to an early Qur'an can clearly be seen in the David collection in Copenhagen (Alison Gascoigne *pers. comm.*). The scripture in the Qur'an is open to interpretation and debatable, but as the word of god, is unchangeable or undeniable (Morris 2006:83). The central theme of the Qur'an is the warning of judgement day and that individuals will be dealt with according to their behaviour on earth (Abu Hamdiyyah 2000:46). One of the key themes within Islam is the family which is seen as the most important social unit. Laws are found in the Qur'an to protect this. While in its totality the Qur'an contains little information on specific laws (with as little as 10% concerned with such matters (Ruthven 2000:74)), crucial information about family law, criminal law, witness law and food prohibitions (Waines 1995:74) can be found.

The Sunna and hadiths

The *Sunna* is based on the life of Muhammad. The *Sunnah* is law made up of *hadiths* which contain the recorded examples, customs, legal decisions and teachings of Muhammad's life (Hussain 2003). *Hadiths* were originally passed down through a process of oral transmission in the first centuries after Muhammad's death, which led to disagreement of their authenticity (Ruthven 2000). Bulliet (1994:13) highlights that the *hadith* needs to be recited with a chain of authenticity to be considered legal, e.g. A said to B that C had told them that the Prophet said/did X. This chain is known as the *isnad* (Berkley 2003, Brown 2009, Hussain 2003). The recitation initially had to be verbal and confirmed by a

muhaddithun, (a person who studies the authenticity of *isnads*). *Hadiths* can be measured in levels of authenticity (strong and weak) and not all make it into the *Sunnah* (Buliet 1994, Hussain 2003). Problems include the length of time after the Prophet's death since they were collated, but also breaks and inconsistencies in the *isnad*. There are six *hadiths* that are particularly important as they are considered authentic by nearly all Muslims (Sunni and Shi'a). There are, inevitably, some *hadiths* that contradict each other, which can lead to interpretative problems (Ruthven 2000:74). In relation to this, there is the possibility that *hadith* traditions were falsified, or created to meet an agenda, for example, to make pre-existing behaviour acceptable under Islam or to help ease the transition of one culture into Islam and to aid conversion (Buliet 1994, Horton and Peel 1976). Marranci (2008:20) points out that *hadiths* might also be created in order to ease Qur'anic rules. This creates regional variation in behaviour as it is possible to interpret *hadiths* in multiple ways. Education is an important part of being a Muslim and Lindsay (2005:196) emphasizes that in a *hadith* Muhammad said to his followers that they should seek religious knowledge 'even to China; that is, to the ends of the earth'. *Hadiths* are taught to children and in particular boys (Lindsay 2005:194); however once a boy started earning a living and supporting his family, learning *hadiths* was no longer a priority (Buliet 1994:14). Regardless, some people travelled to different parts of the Islamic world in order to hear *hadiths* from other scholars and regions. Despite this, Buliet (1994:84) suggests that such people were likely to have been few and far between. Furthermore, gravitation may have tended towards larger, important Islamic centres (e.g. Mecca or Damascus). It is unlikely, as Buliet (1994:85) highlights, that scholars from Spain would travel to Iran or other peripheral regions of the Islamic empire, although this is contradicted by Marin (1992), who argues that people did make the journey. Regardless, selective transmission of *hadith* could occur firstly as a result of restricted outside contact, but also as law would only be consulted when a new or unusual problem occurs, and these problems are likely to be related to localised issues which would vary throughout the *dar al-Islam*.

Ijma and Qiyas

Ijma means consensus, and is a root of jurisprudence (Waines 1998:82). Muhammad recognised that full consensus on all matters was unlikely. Accordingly law can be created

through consensus of the local Muslim community, and in particular, of a group of Muslim scholars (*ulama*) (Berkley 2003, Ruthven 2000). There are many conditions to *ijma* which means it is not always binding. Again, this is likely to have a level of regionalisation within the Islamic world and depend on the priorities of the scholars and local political values. While important in the early days of Islam, Hussain (2003) suggests that it has become difficult, if not impossible to create a law through *ijma* due to the vast differences of opinions that now exist in the Islamic world.

Qiyas is carried out using a process of logic and analogy (Ruthven 2000, Miller 2008, Waines 1995). A new problem can be resolved by finding similarity with an existing problem, and using the teachings in the *hadiths* and the Qur'an. Hussain (2003:38) presents an example of where *qiyas* were used to find a punishment for the consumption of alcohol. Analogy was used with people who make false accusations due to the fact that while drunk, people rave and make false accusations.

2.2.2.1 The Five Pillars of Islam

Part of the obligatory component of Islam (and arguably the most common feature of Islamic identity globally) is the requirement of all Muslims to adhere to the five pillars (al-Shahri *et al.* 2007, El Guindi 2008). These pillars are fundamental to *shari'a* law (Marranci 2008). Despite acting as a strong connector between Islamic societies, adherence to these pillars is variable as is discussed below.

The first pillar is the profession that 'there is no god but God and Muhammad is the prophet of God'. This is known as the *Shahadah*. Worshipping anyone or anything else is considered a great sin.

Ritual prayers (*salat*) are the second pillar of Islam (Abu-Hamdiyyah 2000:57, Lapidus 2002, Marranci 2008). Henkel (2005) argues that it is the most visible and important of the five pillars. The requirement for ritual prayer was revealed to Muhammad by Allah in heaven after the death of his first wife Khadija (Ruthven 2000:32), and is therefore a practice as old as the faith. Abu-Hamdiyyah (2000:57) suggests prayers are an attempt to

communicate with god, to seek guidance, forgiveness, protection and assistance. Prayer patterns vary very little between faith denominations, which may be a result of its presence in the Qur'an, the universal text of Islam. Friday prayer is seen as the most important, being the day of rest for Muslims which distinguishes them from Christians and Jews (Waines 1996:90). Citing various authors, Insoll (1999:26) suggests that prayer is not just a spiritual action, it also teaches equality and brotherhood through communal prayer. Prayer strengthens the community (Henkel 2005), which may be particularly important in the early years of Islam, where Muslims were the minority in the conquered populations (Kennedy 1996).

Followers are required to pray or undertake *salat* five times a day; at dawn, midday, mid-afternoon, sunset and nightfall (Waines 1995:89). Prayer is highly ritualised and follows a strict set of actions (Henkel 2005). Before prayer, a Muslim must physically cleanse through a ritual washing of the body. First the arms and hands, followed by the mouth and nostrils, and finally, the ankles to feet. Water symbolises purity and the act of washing represents external purification of the soul. Internal purification then takes place during prayer itself.

Although it is preferable to pray with others at a mosque, any clean location is acceptable. Each prayer is made up of *rakats*, which consists of a set of actions and recited Qur'anic verses. The number of *rakats* performed depends on the day and time, with Friday prayer being different to the other days of the week. Prayer should be offered in the direction of the *qibla*, orientated to Mecca. However, in early Islam, prayer direction is thought to have been originally towards Jerusalem (Johns 2003), demonstrating malleability in early Islam.

The actions of the prayer can be divided into several steps. First the individual should stand facing Mecca, and while reciting the *takbir* ('God is Great' ('*Allahu Akbar*')), he or she raises the hands to the ears (palm forward) as if to hear. While standing, the hands fall by the side and the individual bends from the waist; the hands should be placed on the knees and the back kept parallel to the floor. The individual rises keeping their arms at their side. The individual then kneels on the floor with the toes flexed behind them, places their hands

on their knees and slowly lowers their head, and in particular, their nose to the floor. The palms of the hands should be placed on the floor, but not the elbows. Moving to the sitting position, men should turn up the heel of the right foot, while women should keep both feet, soles up, under their bodies. The individual then repeats the previous movement and bends to the floor. Many *hadiths* on prayer are found in the *Muwattah* text. Ritual prayer is distinguished from private prayer or *du'aa* which can just be a reflective moment taken anytime, anywhere (Abu Hamdiyyah 2000:57).

The third pillar is the act of *zakat* i.e. alms giving. A percentage of all earnings and savings must be given in order to redistribute wealth in the Islamic community (Kamal-ud-Din n.d). This need not be in the form of money; it can be resources (e.g. livestock or food (Waines 1995:90)).

Ritual fasting (*sawm*) is the fourth pillar of Islam. Fasting takes place in the month of *Ramadan* (the ninth month of the Islamic calendar) during daylight hours. It was during this month that the Qur'an is said to have been first revealed to Muhammad (Kocturk 2002). Ramadan is used for reflection, endurance and sharing (Lawrence 2006). During this time all fit adults should refrain from eating, drinking and sex during the day time. The infirm and pregnant and menstruating women are exempt. Important in Ramadan is the breaking of the fast. The evenings can be indulgent and celebratory in nature. Muslims take time out to visit each other and gifts are exchanged (Waines 1995). Marranci (2008:25) stresses that family and social cohesion are an important part of this ritual, a key theme in the Islamic tradition.

Finally, the fifth pillar is *hajj*, a pilgrimage to Mecca that every Muslim should undertake at least once in their lifetime should they be in a financial situation to do so (Petersen 1994:47). Pilgrimage to Mecca serves to bring together the Islamic community. This may serve political purposes as well as spread new ideas (Insoll 1999:111). The history of the pilgrimage is thought to date back to Abraham, and Muhammad is thought to have 'de-paganised' it (Abu-Hamdiyyah 2000:48). Adherence to this pillar is likely to be related to

class, financial status and also geographic location. Furthermore, far fewer women than men undertake *hajj* (Morris 2006).

2.2.3 Islamic law and the development of identity

The implementation of *shari'a* law would have impacted on identity in newly acquired regions to Islam. Ruthven (2000:86) suggests that by defining behaviour *shari'a* law leaves a distinct imprint on a way of living. This is probably caused by a concern with orthopraxy or correct behaviour in Islam, as opposed to orthodoxy or belief as in Christianity (Lindsay 2005:22). This has resulted in similarities between Islamic groups the world over. These similarities are likely to be created by adherence to behaviours that fall into the obligatory category, the five pillars and information contained in the Qur'an.

At the same time, interpretation and debate of other sources of law means that flexibility is found in the *Shari'a*. As Ruthven (2000:86) indicates, this has resulted in variations in interpretation and application all over the world, demonstrated by the acceptance of pre-Islamic customs. This created diversity in Islamic groups across the globe, for example, comparing the Whirling Dervish of Turkey to the sunni Muslims of the Taliban. This is something that has not been fully recognised and people tend to regard Islam as very rigid and mono-religious.

Knowing how to be a good Muslim early in the history of Islam would have been problematic. Islam was not fully formed by the time of Muhammad's death (Berkley 2003). Copies of the Qur'an were limited, and laws were still being formed and verified. The Qur'an was only compiled in written form a generation after the Prophet's death (Berkley 2003, Waines 1995:48). Arab armies sweeping out of Arabia were often of recent conversion and may have had imperfect knowledge of the practice of Islam. Furthermore, many individuals recruited to armies would not have been able to speak Arabic, although dual language coins with Arabic language are known to exist from the first 50 years of Islamic rule in al-Andalus (Kennedy 1996). Oral testimony of developing law was therefore

a key guide to being 'Muslim'. This highlights the important role of the oral *hadiths* in the recognition and the development of early Islam.

As Islam came into contact with different cultures and religions, questions about correct behaviour and belief would have arisen. Interactions between Islam and indigenous systems would result in the recitation of *hadiths* related to the compatibility between pre-existing behaviour and those of newly founded Islam. Halevi (2007:11) argues this with the example of funerary rites, stating that the formation of law was both adaptive and reactive. The result of this is that early knowledge of *hadith* traditions are likely to be regionalised due to the diversity of the regions assimilated by Islam. For example, reactions to 'pagan' cultures were different to those of monotheistic regions. It is also argued that in Islam, some behaviour is made permissible, to ease conversion (Horton and Peel 1976). Falsified *hadiths* may have been created to justify pre-existing customs (Bulliet 1994). The potential for further regionalisation of behaviour could occur through consensus (*ijma*) of a local group of scholars (*ulama*). Waines (1995:48) indicates that these judgements could be critical in early Islamic societies as they need not have always referred to the *sunna*.

It is therefore possible to argue that the changes that Islam brought to a region are likely to be related to the compatibility of old behaviours, and how strongly they opposed Islamic law. While there are key features of Islam that will be observable and largely stable throughout the Islamic world (the obligatory categories and five pillars), elements of pre-existing behaviour that fall in the permissible and socially indifferent categories are unlikely to have changed. This results in observable differences between regions of the Islamic empire. Accordingly, being a good Muslim in different parts of the Islamic world (especially in the early medieval period) will have varied. For example, acceptable Islamic female dress would contrast between modern-day France and Iran. An additional factor that requires consideration is whether *shari'a* was wholly or partially accepted in conquered regions. Other law may supersede *shari'a* law and create distinct identities.

Furthermore, it is argued that as *shari'a* law developed over the first three centuries of Islam, changes to law may have resulted from the consolidation of the Islamic empire in the

9th century (Berkley 2003). As the availability of Qur'ans and the transmission of *hadiths* increased through well developed trading and pilgrimage routes, ideas about how to be a good Muslim could have spread. Certain obligatory features of Islam may have become more uniform throughout the Islamic empire. Additionally, further homogeneity may have developed as the link between being Arab and Muslim was broken towards the end of the 9th century (Berkley 2003, Kennedy 1996).

2.2.4 Islam, gender, ethnicity and status

Gender, ethnicity and status are strong themes within Islam (Hopkins *et al.* 2008). While it is clear that Islam infers equality before god regardless of sex or origin, it is apparent that differential interpretation of *shari'a* law has meant that this has not always been (and still is not) the case in practice. Other themes, such as privacy, impact on the application of these ideals. Interaction between Islamic regions and surrounding cultures are likely to dictate how ideals were followed, as is potentially highlighted by the example of the increased freedom of Muslim women was a result of the Christian background in Iberia (section 2.2.4).

Gender

Prior to Islam, many societies in Arabia were patriarchal (Lapidus 2002, Lindsay 2005:180). Minai (1981:9) suggests that Muhammad sought to improve women's rights. Muhammad however did not, or could not, change the patriarchal system as the power of patriarchs proved too much. As a result, Muhammad had to improve the rights of women through providing security (both legal and financial) in society. While in the eyes of the Qur'an men and women are spiritually equal (Minai 1981:13, Waines 1995:95), the Qur'an also states 'men have authority over women because God has made one superior to the other (4:34a). Clearly regarded as different, the roles of men and women are supposed to be complimentary to each other. While technically there is nothing in the Islamic faith that precludes either sex from any role, men are generally assigned the strenuous activities and to provide for the household (Lindsay 2005:180). Females are tasked with maintaining the

household and bringing up children (Waines 1995:95). Waines (1995:95) suggests that as financial stability is solely the responsibility of men, women became subordinated. Lapidus (2002:26) argues that while Muhammad greatly improved the rights of women in the Qur'an, the laws are probably not adhered to as Muhammad had intended. Hillenbrand (1992:122) draws our attention to the writings of Ibn Rushd, a 12th century Córdoba scholar who noted that women seemed to be chained to a life of child bearing and devotion to the husband. Ibn Rushd laments the fact that there is no scope for the development of women's talents.

A very common theme in Islamic societies, and one that is sometimes archaeologically visible through architecture (Insoll 1999), is the segregation of space by sex. Lindsay (2005:181) indicates that the reputation and status of a family is tied strongly to the chastity of the females and the responsibility of men is to maintain this (Jewell 2007:133). Insoll (1999:62) suggests that the concept of privacy has been borne out of the need to protect women from harm. In order to achieve this, women are prevented from being located in harmful situations (public areas). This has created a distinction between public and private space (Shatzmiller 1994, Saleh 2002). Private space is usually regarded as the female space and contains their working and meeting areas. This includes, for example, the kitchen, private quarters and private courtyards. Houses also have public areas: rooms where men can meet, preventing contact with women from outside their family group. While some houses were designed with this in mind, old buildings could be adapted with either permanent structures (Boone 2009) but also with archaeologically invisible ones. For example Insoll (1999:66) remarks on the use of curtains to achieve partitioning. How far however, this was adhered to across the *dar al-Islam* is unknown.

Spatial division has resulted in the common misconception that Muslim women are devoid of freedom and power. According to Jewell (2007:134) women were safest shut in their homes raising children. Insoll (1999:82) quite correctly rejects this statement highlighting that 'gender relations and social 'power' can be negotiated in many ways'. This is also echoed by Shatzmiller (1997). Indeed following Ruthven (2000:91) there are two images of Muslim women: in one they are oppressed and persecuted, and the other, they assert

themselves within the context of the society they are in. Clearly the roles of men and women were influenced strongly by Islam, but we should remember that Islam is not inflexible and that the situation may vary between the region and Islamic tradition examined. Viguera (1992:711) has demonstrated through an examination of poetry that Andalusian women were thought to have a very high level of freedom compared to other parts of the Muslim world. However, poetry is often written by upper-class women, princesses or wives of Caliphs, and whether this freedom was a part of the average woman's life is unknown. Viguera (1992:712) suggests that this freedom was the result of the Christian atmosphere in the region.

Ethnicity

The *umma* is the worldwide community of Islam. Containment within the *umma* is supposed to take precedence over any other affiliation with a group or status. This means that Islam should transcend ethnic boundaries. Early attempts were made to enforce this (Lapidus 2002). A good example of this commonality is the fact that there is a universal language, Arabic, the language of the Qur'an. This however, does not mean that ethnic identities were extinguished, and certainly other new identities formed and old identities re-emerged, such as Persian identity under the Abbasids (Berkley 2003).

Whether this over-arching community superseded other divisions in practice is unlikely. Civil wars between Arabs and Berbers occurred in Spain and North Africa on multiple occasions, and old tribal differences persisted in newly conquered regions until after the 11th century (Kennedy 1996). In early Islam, there were strong links between Islamic identity and Arab identity (Boone 2009, Lindsay 2005). As the birth place of Islam, this connection may not seem that surprising. This association may have been accentuated because the first ruling dynasty, the Umayyads, was an Arab tribe (Hitti 2002). This relationship was thought to initiate early unrest in both Iberia, but also the wider Islamic world, as people of traceable Arab descent were seen as higher class than converts (Berkley 2003). However, religious identities were important as is exemplified by Shatzmiller's research (1994: 331) which suggests that in Andalucía the division of labour was based

both on ethnicity and religion. Muslims, in general, were barred from carrying out tasks that were seen as shameful or degrading, but Muslim Berbers and Muslims of Arab origin were designated different social roles, and this work differed from Jews, Ibero-Romans and converted Ibero-Romans.

Within Arabia, ethnic differences were rife. While early attempts were made to try and transcend old tribal boundaries (Kubiak 1982), unequal treatment of non-Arabs is thought to be part of the success of the Abbasid campaign against the Umayyads in the 8th century. Indeed, settlement in *amsars* (garrison towns) was thought to be along tribal lines (Lapidus 2002). In the 10th century, while the Caliph in Baghdad remained a central figure in uniting the *dar-al-Islam*, regional governors had actual power, and because of this, there were great variations in identities, as well as the preservation and re-emergence of old identities (Berkley 2003). Interestingly, Waines (1995:183) describes how an unnamed Muslim scholar travelled to the far reaches of the medieval Islamic empire in the 14th century and found that although he disapproved of many things (partially Islamised customs), he felt that adherence to scripture and pious nature kept them ‘firmly within the realms of the...*Ummah*’. Islam as a society reached ‘its maturity at this time, where law was heterogeneous and people had their own domains of rule and had multiethnic groupings’ (Waines 1995:101).

Status

While Islam advocates the distribution of wealth and indicates equality in all men, it is argued that status would have impacted on the practice of Islam, as discussed briefly in section 2.2.2.1. In the early years of Islam, religious observance may have been limited to the literate and wealthier members of society. Indeed it could be argued that Islam arrived to many parts of the Mediterranean as a policy of the Arab elite and would therefore have been the practice of the higher status of society (Boone 2009, Crone 1980). The seclusion of women may have been the prerogative of the wealthy. Conversely however, being high status may have afforded more freedom to women as is suggested by the diverse roles of

high status women identified in historic text (Hambly 1999, Shatzmiller 1997, Viguera 1992).

This section demonstrated that although Islam did impact on other aspects of identity, it did not totally control them, as might be suggested by taking a strongly religio-centric approach. However, it is clear that Islam interacts with these aspects to produce unique identities and communities, as has been highlighted by Hopkins *et al.* (2008).

2.3 The Archaeology of Islam

Archaeological examination of Islam has dramatically changed over the last 120 years, moving from description of art, to evaluations of changing social organisation (Geertz 1968, Guichard 1992) and interpretation of new identities through cultural fusion (Boone 2009, Insoll 2004c, Oestigaard 2009). The following section 2.3.1 outlines the theory behind material culture as an indicator of religion and religious identity, how both have been explored archaeologically and how this research in particular moves on from this. Finally, research undertaken specifically in Islamic Spain will be outlined in order to identify the current state of research.

2.3.1 Islam as an archaeologically detectable practice

An understanding of the doctrine and legal aspects of Islam are well developed (Bowie 2000:25). As many Islamic laws are concerned with behaviour and practices, Islam can be seen to emphasise orthopraxy, or relying on the observance of correct behaviour in order to observe god (Lindsay 2005:22). This is easily exemplified by the observance of the ‘Five Pillars’ outlined in section 2.2.2.1. Much other behaviour is ritualised including diet, culinary habits and the division of male and female space. This creates a link between behaviour, belief and practice. It is the material expression of these beliefs and Islam as either items (e.g. prayer beads) or symbols (e.g. gender division) that are recordable in the archaeological record (Alexander 1979). The degree of material observance can therefore be compared against religious documentation and reasons for variation can then be explored.

Considering the size of the worldwide Islamic population and the popularity of archaeology, the archaeology of Islam seems to have somewhat failed to flourish (Petersen 2005:100). Excavations of Islamic places (e.g. Samarqand in modern Uzbekistan) in the late 19th century tended to focus on artefact recovery rather than the nature of Islam (Vernoit 1997:1). The Archaeology of Islam has a long tradition in contributing to art history of the Middle East (Vernoit 1997); however contributions to overall Islamic history are recent phenomena (Waines 1995:2, Walmsley 2007:15). Multiple reasons have been posited to be the cause of this. Early excavations were a result of the expansion of European economic and political interests in Africa and Asia (Milwright 2010:13). Gaining knowledge about Islam specifically was not an agenda. As with all branches of archaeology, Islamic sites suffered from treasure hunting. Many large sites in the later 19th early 20th century were poorly funded and excavated in order to obtain artefacts for museums and personal collections (Vernoit 1997:4).

A further problem was that Islam is still a living tradition/religion, which some argued did not need investigating. Ancient traditions/cultures were of greater interest to the public and, as a result, their antiquities were more prized and Islamic archaeological material often was ignored. This certainly occurred at Kom el-Dikka, Egypt, where more prized Roman material lay below Islamic levels. Although Islamic layers were identified at Tal al-Safīyya, Gaza, little attention was paid to the material in the early 20th century report (Milwright 2010:11).

Political reasons also impact on the investigation of Islam. Archaeology has frequently been used to define and reinforce national identities (Diaz-Andreu 1996). At times, racist attitudes towards Islamic societies prevented Islamic archaeology from becoming a significant research area. For example, study of the Islamic past of Spain was largely neglected until the 1970s as it did not fit with the modern Catholic Spanish identity, which was thought to be descended from the pre-Islamic Roman and Visigothic periods (Carvajal Lopez and Jimenez Puertas 2011, Diaz-Andreu 1996). Study of Islam was actively discouraged until the end of the Franco era and the regionalisation of the Spanish state (De Meulemeester 2005:837). An opposite situation is identified in Iraq where, in archaeology,

emphasis was placed on features of Arabness and Islamic identity in order to create a unified Iraqi identity (Haider 2001).

Another interesting phenomenon is the use of archaeology to reinforce religious belief. Unlike biblical archaeology, Islamic archaeology has not suffered from this preoccupation with Petersen (2004:859) presenting just a handful of cases from Palestine. Debated land claims in the Middle East may play a role in some archaeology undertaken in that region. A lack of interest in Islamic archaeology in this respect could relate to ideals that within Islam there is no need for god to justify himself or prove his existence. In fact very few scholars of Islamic archaeology are Muslim.

One of the most persistent problems preventing rich and holistic studies of Islam lies within the academic sphere. First, most of the world's largest research institutes are situated in the West, and Islam has not been within their immediate scope. Secondly, Insoll (1999:4) suggests that scholars of Islam are often highly specialised and divided into different departments. For example, experts in Arabic may work in a language department and links between them and archaeology *per se*, may not be well established. Connections between archaeology and history have not always been strong, leaving material without a historical context and *vice versa*. Furthermore research into Islam has tended to be unifocal, focussing on a single type of evidence such as buildings (Stiernlin 1996), ceramics (Edwards 1999), linguistic (Corriente 1992), artistic (Jayyusi 1992) or faunal (Lentacker and Eryvynck 1999). This is not an efficient method of data analysis and subsequently fails to maximise knowledge of Islamic society and development, particularly when we consider that Islam may impact on material culture in different ways, depending on its link to religious ideology. Other problems include poor publication, or complete failure to publish, a problem not limited to Islamic archaeology alone. Vernoit (1997:8) highlights this as a problem in Iran and Walmsley (2007:19) at Baysan in Palestine.

Islamic Archaeology is now a maturing discipline (Milwright 2010:20). Archaeologists are beginning to work with historians to provide context to the material. Studies have begun to move away from purely identifying Islam in the material record, to looking at the social

impact of Islam on newly conquered regions. This is essentially a shift from identifying the existence of Islam as a set of material-cultures to one that explores Islamic identity. This has been achieved through analysis of material culture changes, their adaption over time and how this reflects changing social organisation (e.g. Carvajal Lopez and Jiminez Puertas 2011, Edwards 1999). Walmsley (2007:29) highlights that Islamic archaeology is no longer being considered as a 'gap filler', seemingly between more important periods of history, and original research questions and themes that address the Islamic world and its wider impact are being produced (Vernoit 1997:8, Whitcomb 2004:7).

Insoll's (1999) *Archaeology of Islam* is one of the first books dedicated to the investigation of Islam in the archaeological record beyond the analysis of architecture. Greatly influenced by Alexander's (1979) work, Insoll highlights how the religion of Islam is accessible in the archaeological record. He discusses how all material culture is shaped and changed by Islam based on the notion that religion (and in particular Islam) can be used as a key structuring principle through which to view material culture. While this is true, we need to be aware that societies are not the sum total of religion. Indeed other scholars do take a less religiocentric approach, seeing Islam more as a part of a wider cultural package (Boone 2009, Milwright 2010). The importance of Islam on the development of material culture, and therefore as the expression of Islamic identity, is still recognised.

2.3.2 Material culture and the study of Islam

While all of the research discussed in the following section makes it clear that there are certain features, which are visible archaeologically, that are strongly linked to Islamic identity, it is obvious that temporal and regional variation in the form of these features can be considerable. The following section reviews how material culture has been examined by scholars to study Islam and Islamic identity.

Architecture

Many of the wonders of the Islamic world are mosques, for example the Dome of the Rock in Jerusalem and the Umayyad mosque in Damascus. The Arabic meaning of the word mosque or *masjid* means ‘places of prostration’ (Waines 1995). Muhammad is recorded in tradition as saying ‘The earth is a *masjid* for you, so pray wherever you are at the time of prayer’ (Ali 2011:S2). Insoll (1999:26) states that mosques are ‘a material personification of one of the pillars of Islam’ and as such can be used as an indicator of an Islamic community.

The first mosque is believed to have been built by Muhammad for his followers in Medina in AD 622. Stierlin (1996:29) suggests that Muhammad’s first mosque had a courtyard, an oblong hall, a *minbar* from which the Prophet addressed the congregation and later, a *minaret*. Although, largely for congregational prayer, mosques also functioned as meeting places, courts and schools. *Hadith* traditions were taught in mosques, demonstrating their educational role (Lindsay 2005:194). Prayer should be directed towards the *ka’ba* in Mecca, and a wall should be orientated towards that direction (*qibla*). It should be remembered that in the first few years of Islam, prayer direction was towards Jerusalem (Insoll 1999, Johns 2003). The *mihrab* is also a key feature of a mosque. This is a symbolic door located in the *qibla wall* which represents the gateway to the afterlife. Insoll (1999:28) suggests that the *qibla* is the only essential component of a mosque. The lack of strict regulations beyond this has led to a large variation in mosque forms all over the Islamic world. The first mosques were crude and temporary in order to serve the newly converted and troops.

Mosques have been studied in a number of ways. Most simply, their presence has been used as an indicator of an Islamic community. As communal prayer is one of the pillars of Islam and part of required behaviour, mosque construction has to be one of the first priorities of any new Islamic community. This was important to emphasise community ties, especially in newly conquered regions where Muslims were a minority (Berkley 2003). Moving on from this, the size and permanence of the mosque has been seen by scholars as

an indicator of the size of the congregation. One characteristic of the mosque is the ability to expand (Milwright 2010:125). For example, the numerous additions to the Great Mosque in Córdoba were required to meet the requirement of increasing numbers of Muslims attending Friday prayer (Fletcher 1992:38). Thus this could be used as a measure of the conversion of the local populace in the area (Insoll 1999:36).

The size and ornamentation of mosques has also been used to examine the piety and wealth of local leaders. According to *hadith* tradition Muhammad said ‘Anyone who builds a mosque for Allah, He will build a house for him in Paradise’ (Waines 1995:199). The Great Mosque in Córdoba underwent many changes with rulers (Hillenbrand 1992:119). Increasing complexity and grandeur can be seen as an indicator of leader prosperity such as at Córdoba, where the mosque’s frequent extensions could be an indicator of the Caliph’s prosperity in al-Andalus (Milwright 2010:125). Scholars have also examined the evolution of mosque decorative styles to assess changes to the requirements of mosques. For example mosques later became, and still remain, important political centres, law courts and community centres as well as places for communal prayer (Ali 2011, Carver 1996:187, Dickie 1992).

The analysis of spatial organisation and Islam

Insoll (2001:137) suggests that community environment is imbued with religious significance and town planning was influenced by a number of key principles in Islam. In particular, the separation of public and private space impacted on the construction and/or modifications to buildings (Magness 2004, Boone 2009). However, it is unlikely that people would have rebuilt property to satisfy this ideal, and in fact a number of modifications to old structures through permanent adaptation are visible archaeologically (Boone 2009), and it is postulated through ethnographic work that the use of soft furnishings and screens would have been one negotiating mechanism (Insoll 1999).

A second factor dictating town space relates to notions of purity and impurity, which, in theory forced certain urban features to be placed in designated areas e.g. tanners and kilns

were located away from living and religious areas (Shatzmiller 1994). Again a number of examples exist where this ideal was also not observed. Milwright (2010) demonstrates how adaptations to buildings can be used to permit intramural use of kilns. In Fustat, many kilns exist within the intramural area including next to religious centres and high status areas. Cemeteries too were ideally positioned outside city walls or city limits (Shatzmiller 1994). However, numerous examples of intramural cemeteries are observed in Spain at Écija and Murcia (Romo Salas n.d.) and Egypt (Kom el-Dikka). Milwright (2010:86) suggests that Islamic burials were often placed in disused locations, as exemplified by burials discovered in disused amphitheatres in Egypt and a Visigothic cemetery in Spain (Romo Sales n.d). In fact, Halevi (2007) suggests that in very early Islam, little attention was paid to where the dead were buried as tradition was still forming. In garrison towns, which were not intended initially to be permanent settlements, cemeteries may have initially been segregated, but with increasing use, expanded into living areas (e.g. at Kufa (Halevi 2007:148)). Therefore local factors, temporality, demand and efficient use of space, dictated the observance of religious ideals.

Other features considered typical of Islamic towns include narrow winding streets (camels made wide streets unnecessary), but this depends on how the settlement emerged. For example, cities formed on Roman/Byzantine foundations tended to have wide organised streets with large open spaces, remnants of which can often still be seen after the arrival of Islam. In Egypt and Syria, many towns formed as *amsars* (Kennedy 1996) and these cities often grew haphazardly (Halevi 2007). These settlements were also largely divided on ethnic lines (Lapidus 2002), a further factor dictating space. An additional factor that needs consideration is the origins of settlements. For example, unlike Egypt and Syria, in Africa and Spain, Muslims tended to settle more as they pleased, rather than in garrison towns (Kennedy 1996).

Such a variation in form across the Islamic world clearly demonstrates that it is impossible to define what a typical Islamic town should look like, despite the arguments of others (Insoll 2001:36). Therefore, it seems clear that Islamic features present will depend on a mixture of environmental, demographic, cultural and economic situations (Milwright

2010:84). The extent to which attempts were made to adhere to Islamic ideals as far as physical constraints permitted, would demonstrate how critical religious ideas were in the organisation of space.

Decoration

It is widely accepted that pictorial representation of animals and figures is forbidden in Islam, particularly in religious contexts (Alexander 1979). However, there is nothing specific in the Qur'an prohibiting such images, but there is general consensus of aniconism (Grabar 2000:39). Nonetheless, images of people and animals are known in the Islamic world. An early example (AD 710–715) can be found at Qusayr Amra, a Syrian palace imbued with pictures of animals and people (Walmsley 2007:16). A late eighth century statue of a topless woman with a fruit basket was found at Khirbat al Mafjar, Jericho (Enderlein 2000). Some iconoclasm resulted in the destruction and prohibition of many figural representations in religious contexts all over the Islamic world (Grabar 2000). This may have coincided with the consolidation of Islamic law in the centuries after Muhammad's death. The variable nature of the destruction of images (from careful adaptation to complete obliteration) could be related to more regional sentiments that evolved from the interactions between Islam and pre-existing cultures. The strong use of religious figural representation in Christianity may have been responsible for the banning of such imagery in Islamic Mediterranean (Grabar 2000). A similar argument could be made for India, where many Hindu gods were worshipped as images and statues. Regardless, human and animal pictorial representation was, and is still found in secular contexts.

As faith could not be expressed pictorially, a different mode had to be formed. This led to the development of distinctive Islamic calligraphy and geometric art work (Grabar 2000). The analysis of the evolution and spread of decorative styles has been used to explore changes in religious identity. Famed for their stucco and carving, many high-status Islamic buildings are intricately decorated from floor to ceiling. Furthermore, distinct styles originated in certain regions, such as *Mudéjar* styles in Spain, where many Christians hired

Mudéjars (Muslims living under Christian rule in Spain) to design and decorate their buildings and palaces (Imamuddin 1981:214).

Diet

Islamic doctrine on culinary habits and food taboos has lead to research into the obedience to these laws. This has been achieved through the direct analysis of diet but also through associated vessels and architecture.

The Qur'an says 'Partake of what is lawful and good on this Earth' (2:168;16:44). There are three categories of food in Islamic law, *halal* (lawful), *haram* (prohibited) and *makruh* (reprehensible). Dogs, carrion, excrement, milk of prohibited animals and alcohol are *haram* (MacClean and Insoll 2003, Lindsay 2005). Akin to Judaism, the consumption of pork or pig meat is also forbidden by the Qur'an (al-Shahri *et al.* 2007, Hussain 2003). Archaeologically, this means that one would expect to find limited evidence of pig bones in the remains of communities thought to be Islamic. While studies have shown that this food taboo certainly existed in early medieval Murcia, Spain (e.g. Lentacker and Ervynck 1999) and the Banda islands in Southeast Asia (Lape 2000), there are a few examples of sites where pig remains were identified, including in an 11th century Carmathian context (Insoll 2007:320) and a different site in the Banda Islands (Lape 2000). This indicates that the practices of Muslims can be influenced by external and previous traditions. It should however be remembered that Insoll's (2007) example was a pig tooth, and does not necessarily indicate dietary consumption. In addition, pig remains may represent a surviving community of Christians (Lentacker and Ervynck 1999:152). For zooarchaeologists to infer identity, they need to use a substantial bone sample size as well as a secure context with supporting information if possible. However, the apparent renouncement of pork would be an important and significant public display of identity (Lape 2000).

Drinking of intoxicating liquids is also prohibited (al-Shahri *et al.* 2007). While only wine is specifically mentioned in the Qur'an, in *hadith* tradition, foods with intoxicating effects

are warned against (Koçturk 2002), for example, in book 42 of the *Muwattah*.

Archaeologically this may be visible through the analysis of pottery and ceramics associated with alcohol use. Through the examination of ceramic assemblages Edwards (1999:102) demonstrates that in the first few centuries of Islamic dominance in the Middle Nile alcohol consumption continued. Numerous allusions to alcohol consumption exist in historic literature in Spain, with examples cited in research by Fletcher (1992), Kennedy (1996) and Lapidus (2002). In relation to this, Boone and Benco (1999) discuss how the adoption of Islamic social customs, such as communal food consumption, can be seen through the appearance of distinctive food vessels such as large bowls.

Burial

Bodies are interred rather than cremated in Islam (al-Shahri *et al.* 2007). This is because the body will be physically resurrected on the day of judgement (Lindsay 2005:201).

Muhammad urged burial to take place rapidly after death and ideally on the same day (Chaudhry 1988). According to Islamic law, there should be no difference between the burial of the rich and poor (Insoll 1999:168). Adherence to this varies depending on locality, in addition to surviving customs from pre-Islamic groups. It is ideal to avoid the use of a coffin in favour of a shrouds as this is how Muhammad was buried (Chaudhry 1988, Lindsay 2005:201).

Archaeologically, it appears that there are some fundamental features of burial that are strongly adhered to regardless of geographic location in the Islamic world. However, great variations in burial rite exist. Possibly the most adhered to rites is direction of burial, facing the *ka'ba* (the black stone in Mecca). The body is nearly always placed on the right side with the face looking towards Mecca, the centre of the Islamic world (Alexander 1979, Insoll 1999). Akin to the direction of prayer discussed on page 27, burial orientation may have initially focused on Jerusalem.

Grave ornamentation and commemoration of the dead varies across the Islamic world (Alexander 1979, Halevi 2007). In theory, only a small marker should indicate the position of the head after burial (Insoll 2001:130). However, numerous examples of commemorative

structures exist in a variety of forms. This ranges from nothing, to the Taj Mahal in India. In early Islam, it is thought that commemoration of burial may have amounted to idolatry and worship of false gods. Nevertheless, some important graves are commemorated with shrines, ostentatious grave markers and buildings, for example those of Muhammad or famous rulers (Stiernlin 1996).

As people are buried in equality, it is unusual for grave-goods to be found in burials (Alexander 1979). As well as removing the status of the individual, worldly possessions are not required in the afterlife. While few grave goods were found at Écija in the Plaza de España cemetery in Spain, at Wasit in Iraq, burials contained silver coins bearing Muslim names (Milwright 2010:129). At Tel al-Hesi in Israel, grave goods included jewellery, ceramics and other items (Eakins 1993:57-70). The coins at Tel al-Hesi are thought to have been made into jewellery and were favoured items for Bedouin women (Eakins 1993:62) and may represent the continuation of a pre-Islamic custom, and the importance of other identities in addition to being Muslim.

The analysis of funerary rites can also be used to explore the transcendence of Islam over other aspects of identity. For example, separate areas for the burial of women and children are commonly observed in cemeteries maintaining the persistent gender ideology (Insoll 1999). At Écija (Romo Sales n.d.) and Tel al-Hesi (Eakins 1993), there were clearly demarcated regions for men and women, but at Écija this was only recorded in the later periods of the cemetery use (Romo Sales *pers. comm.*). Furthermore, the ideal of Islam transcendency over ethnic boundaries was not always strictly adhered. Insoll (1999:175) provides a modern ethnographic example in Timbuktu where separate cemetery areas were created for different ethnic groups. Similar cemeteries are suggested at medieval Basra (Halevi 2007). Halevi (2007) also argues that elaborate grave markings with inscriptions are likely to be the prerogative of the rich or elite, suggesting that status may have impacted on the way religious traditions were interpreted or ignored.

Human osteology and the study of Islam

Osteological study of Islam is limited. This is partly due to the restrictions on the study of human skeletal remains. Burial grounds are protected under Islamic law (Insoll 1999:169)

and as such are only disturbed in rescue situations, or in regions where *shari‘a* law does not take precedent over other laws. Usually human remains are immediately reburied.

Regardless, some large scale excavations have taken place at Tel al-Hesi, Israel (Eakins 1993), Kom el Dikka in Alexandria (Prominska 1972, 1976), and at various locations in Spain. When remains are available, osteological studies often describe the physical remains and any unusual skeletal traits rather than considering the cultural role that the bodies may have had in life. Research also focuses on DNA or isotopes, which can arguably inform us little on Islam itself (see section 2.4 page 47). A further problem is the poor integration of osteological data into mainstream literature and that bone reports are either not fully published or are not published in multiple languages. While the role of Islam in social organisation has been realised (albeit limitedly), for example gender differences in musculoskeletal stress markers (entheseal changes) by al-Oumaoui *et al.* (2004), there has been no discussion of how Muslims may have physically constructed Islam through adherence to rites. Studies tend to focus on burial rites rather than the people themselves. To date, the potential for human remains to assess the relationship between Islam and its role in identity construction has not been fully explored.

2.4 The Archaeology of Islam in Spain

The following section examines how Islam and Islamic identity have been approached in Spain, the research questions posited and how these have been answered in a chronological order of historical events. This will place the present research in the context of the ongoing investigation of the Islamic period in Spain and how this research can contribute to the discussion.

The archaeology of Islam in Spain dates back to the nineteenth century. Akin to Islamic archaeology studies in other regions, De Meulemeester (2005:837) suggested that research was borne out of art-historical studies. Nonetheless, the role of Islam in Spain, its impact on Spanish history and identity has taken a long time to develop, and as a result, Islam’s role in the development of Renaissance Europe is unacknowledged (Morris 2006).

Traditionalist views of Islam in medieval Iberia

One of the largest problems facing the archaeology of Islamic Spain was a political one. As discussed in section 2.3.1, an Islamic past did not fit into the ‘normal’ trajectory for the European Christian states (Ballard 1996, Diaz-Andreu 1996). Accordingly, discovering the Islamic past of Spain was not considered a priority. Instead of focussing on the role of Islam in the development of the nation, Diaz-Andreu (1996:69) suggests that scholars acknowledged the roles of Isabella and Ferdinand in the unification of Spain and the final removal of the Muslims. Furthermore, before and during the rule of Franco, the study of Islam was not advocated, as it failed to fit with the political ideology of the time. In fact, Boone (2009) provides the example of an ‘anonymous Spaniard’ still describing the Muslims as ‘foreigners’ today. In terms of Spanish identity, Islamic rule in Spain was seen as a hiatus between the Visigoths and the Reconquista. Islam in this respect was very much treated as a foreign element that did not make any impact on Iberia (e.g. Olague 1967). The testimony of countless Islamic buildings, *Mudéjar* architectural styles and persisting traditions dispels these ideas.

Islam in Iberia: Islamic invasion and demographic replacement

The end of the Franco era opened up an opportunity to study Islam in Spain (Carvajal Lopez and Jimenez Puertas 2011). Diaz-Andreu (1996) argues that with the general decline of cultural nationalism, opportunities to study history without preordained national objectives opened up the avenues to explore Islam. Boone (2009:15) draws attention to two articles, one a structural approach by traditionalist Olague in 1967 (‘Les arab n’ont jamais envahi l’Espagne’), and its direct opposite by Guichard (1974) ‘Les arabes ont bien envahi l’Espagne’. While traditionalists aimed to prove the non-existence of Islam in Spain, Boone (2009:17) suggests that all Guichard had to do was prove that Islam did arrive in Spain. Guichard (1974) in fact, demonstrated the arrival of a substantial Islamic population, and of numbers far greater than suggested before. He focused on the changing use of space with the arrival of a new social system. Guichard (1974) also suggested that there was a much greater break in the structure of al-Andalus from that of the pre-Islamic past. DNA (Pereria *et al.* 2006) and isotope analysis (Prevedorou *et al.* 2010) has subsequently identified the

presence of individuals who have their origins in other regions of the *dar al-Islam*. This approach however still views Islam as something that was bought into the region.

Although Guichard (1974) demonstrated the presence of Muslims as a significant demographic group, one of the largest criticisms of Guichard's hypothesis was the failure to consider what would have happened to the indigenous population (Boone 2009:17). Writing in 1992, Guichard (1992:681) himself later suggested that historians had produced an event-based history which lacked understanding of the social changes and implications for the population of Iberia. Syncretism, conversion and identity were not considered as part of the demographic displacement theme. While this was probably symptomatic of archaeology as a whole at the time, it was something not addressed until recently in Spain.

Indigenous conversion

One of the most significant studies of Islam in Iberia was undertaken by Bulliet (1979). As a historian, Bulliet examined levels of conversion to Islam, as well as other parts of the new Islamic empire. To achieve this, he examined the adoption of Arabic/Islamic names in the Iberian Peninsula, and approximated name changes to the acceptance of Islam by a family. It was thought likely that conversion initially was slow where contact with Muslims and indigenous peoples were limited, but increased exponentially until the maximum available population converted. The greatest period of conversion was during the 9th and 10th centuries AD. This, Bulliet (1994:38) suggests was the bandwagon phase, where people become Muslim only subsequently to find out what it truly meant after conversion. In a similar study based on evidence from tax returns, Barcelo (1997) suggested that 70% of the villages were Muslim by AD 800 – 900, a greater percentage than that proffered by Bulliet (1979:124), who proposed around 20% in AD 800 and up to 40% by AD 916, but supported by Glick (1995) who cites that around 80% of the population were Muslim after the mid 10th century AD. Conversely, Kennedy (1996:67) suggested that Christians living in a Muslim village may not have been counted on tax returns, resulting in an over estimation of Muslim numbers.

There are many practical and methodological problems with Bulliet (1979) and Barcelo (1997) research. Bulliet's work examined an urban population. Little knowledge of the adoption of Islam in the countryside exists, and it is not known how quickly and readily people converted. In fact, conflicts in literature exist over whether rural people actually converted (see Imamuddin 1981 and Guichard 1992). Regardless, Bulliet's (1979) research was one of the first attempts to demonstrate that Islam did have an effect on the indigenous population.

Quantification of conversion is problematic and arbitrary because historic evidence does not tell us whether the people were actually taking up the practices of Islam. People may have converted in name to take advantage of the lower taxes imposed on Muslims (Boone 2009:135, Kennedy 1996). Furthermore, analysis of conversion in Iberia is a complicated process that involves more than just a change of faith. It is argued that conversion was just part of a wider process of Islamisation of the Peninsula that gradually took place in the early medieval period.

Islamisation

It is only in the past two decades that more detailed examination of the identity of Iberian Muslims and their unique culture has been explored. This was achieved through examination of the process of Islamisation. Boone (2009:128) describes Islamisation as a 'cultural process employed to describe the gradual, fitful, but sweeping changes that occurred in the two and a half centuries following Arab conquest'. Researchers assessed the degree of Islamisation in the population by comparing evidence of Islam from material culture, including architecture (Boone 2009, Boone and Benco 1999), history and diet (Lentacker and Eryvynck 1999), and what would be expected to be seen in an Islamic society. Demonstration of a dramatic impact on Iberia is clear from these works, however, problems with these types of study include using a checklist to observe Islam in the archaeological record, implying homogeneity in Islam. While most would argue that the presence of a mosque could be seen as unequivocal evidence for Islam, the presence of alcohol paraphernalia does not mean that a population is not Islamic. Very simply it may

indicate that a Christian population existed, or more complicatedly, it may suggest that this part of Islamic tradition is not part of a regional society's major concerns and identity.

While investigations of Islamisation do recognise the importance of Islam in Iberia, they fail to highlight the importance of pre-existing factors on the development of Iberian identity. Islamisation is seen as a process that happens and the end result is Islam, particularly as it is perceived today. As indicated in section 2.1, not all Islamic regions will conform to and reach this one blueprint. This idealised form of Islam may also be symptomatic of the current political situation where research is striving to provide examples of successful Christian-Islamic relations. Accordingly, the term Islamisation may be particularly misleading. First because the Islamic identity based on modern perceptions would not have existed in the past and second, it is possible that each region in the Islamic world may have produced its own unique Islamic identity.

Other scholars have argued that the term Islamisation is further misleading as it suggests that all changes that took place in Iberia were related to that of religion. Glick (1995) infers there was a process of cultural change as well as religious change. As such, other important influencing factors impacted on social organisation in Iberia. One aspect identified by a number of researchers is Arabisation (Boone 2009, Glick 1995, Lapidus 2002). Early Islam was strongly linked to being Arab, and as Islam was still being formed when it arrived in Iberia, many people took on Arab customs prior to Islamic traditions. In a similar fashion, Berber culture and identities could have migrated to Iberia. This highlights the importance of taking into consideration other social factors and identities when exploring emerging religious identity.

Syncretism and the development of Islamic Iberian Identity.

Syncretism has been described by Eriksen (2007:172) as 'the amalgamation of the formally discrete world views, cultural meanings, and in particular religion'. Syncretism has been used by archaeologists in culture history to explain the development of new identities or culture forms. In archaeology, syncretism has been used to explain the varying nature of Islam in parts of North Africa (Edwards 1999, Insoll 2004b:199), Arabia (Insoll 2007) and Egypt (Oestigaard 2009). All demonstrated through material culture how previous

traditions survive through adapting to a new situation, in this case Islam. From this, it was highlighted how Islamic identity varies from region to region. This further demonstrates the heterogeneous nature of Islam and that religious identity is malleable, like all other aspects of identity. Importantly Berkley (2003:251) stresses that syncretistic behaviour is more likely to be found in the common people, who likely made up the largest portion of the population, and were possibly the most influential. There are no archaeological syncretism studies on Islamic identity in Iberia. Historic research, however, identified the role of syncretism in the development of a unique Islamic identity in Europe, for example, Menocal (2002) and Lopez Gomez (1992). These studies, however, have been criticised as producing over-romanticised versions which infer al-Andalus was peaceful and tolerant place where Islam and Christianity fruitfully co-existed (Boone 2009, Fernández-Morera 2006). Syncretistic studies however risk not considering non-religious influences on Iberian Islamic identity.

In summary, archaeological research in Spain has focussed more on trying to identify the foreign element of Islam, rather than something that could be regarded as native, despite the fact that it appears that most Muslims in Iberia would have been indigenous by the 10th century (Bulliet 1979, Fletcher 1992, Garcia Baena 2006). This research therefore will explore Islamic identity as regional phenomenon, by exploring the role of agency encouraged by other social factors. In this respect, a more fruitful focus would be to assess what it meant to be an Iberian Muslim, rather than a Muslim in Iberia.

Chapter 3: Socio-historical context of Al-Andalus

3.1. Introduction

Before an analysis of the development of Iberian Islam can be undertaken, it is critical that the socio-political structure and history of Iberia was presented. This was important because, as presented in chapter 2, these factors will impact on how Islamic tradition was negotiated, and, therefore, how Islamic identity was expressed. As such section 3.2 outlines Visigothic Iberia, its government structure and historical background. Section 3.3 then presents detailed information on the arrival of Islam and major historical evidence of Islamic rule in Iberia. An account of labour and law are then presented, as all have the potential to affect the body and other material culture through the re-organisation of the population.

Table 3.1 provides a brief summary of some of the major events that impacted on the population of Iberia and taken into consideration during this research. Greater detail is provided in sections 3.2-3.3.

Table 3.1 Important dates during Islamic rule in Spain. Green events are Pre-Islamic, yellow are early Islamic and Umayyad, pink represents the post Umayyad period.

Visigoths enter Spain under Rome	416 AD
Visigoths invade and settle in Iberia, overthrowing the Suevic Kingdom	456 AD
Visigoths convert to Catholicism from Arianism	589 AD
First Islamic raids on Iberia	709AD
First conquering (mainly) Berber force arriving in Iberia with Tariq ibn Ziyad	711 AD
Second invasion army mainly consisting of Arabs arriving with Musa ibn Nusair	711 AD
Battle of Écija brings Islam into the region	711 AD
Most of Iberia controlled by Caliphate in Damascus	716 AD
Civil war and arrival of the Syrian army	741 AD
Arrival of Abd al-Rahman I. Beginning of independent emirate.	756 AD
Succession of Abd al- Rahman III (peak of power).	912 AD
Declaration of the independent Caliphate	929 AD
Al-Andalus' most prosperous era	10th–11th century
Collapse of the Caliphate/Berber revolt	1008 – 1031 AD
Taifa states	1031 – 1091 AD
The Almoravid Era	1086-1130 AD
Almohad intervention	1148-1173 AD
Córdoba falls to Castile and Leon	1236 AD
Conquest of Seville by Ferdinand III of Castile	1248 AD
Siege of Granada and end of Islamic rule in Spain	1492 AD

3.2 Pre-Islamic Iberia

3.2.1 The arrival of the Visigoths

Prior to the arrival of Islam, Iberia was largely under Roman and Visigothic rule, with some Byzantine influence in the south (Dieguez-Ramirez 2011). Although Fletcher (2001) suggests that the Visigoths were highly Romanised, in that the population followed Roman social and cultural processes, James (1980) suggests that this varied throughout the region. In particular, northern parts of Iberia were less influenced by Roman rule, whereas urban places, such as Écija in the south were more so. However, in general, administration and law followed previous Roman rule for the majority of Visigothic control (Collins 2001). It was not until the 7th century AD that new influential Visigothic laws were consolidated and brought into effect (Heather 1991:191).

Expanding from Dacia-Gothia and the Southern Balkans, the Visigoths first arrived in the Peninsula early in the 5th century AD (Mathisen 1997). With the decline of the Western Roman Empire, Germanic tribes, including the Alans and Vandals, installed themselves in the region. Eager to regain control of the province, the Romans enlisted the help of the Visigoths who, after successfully removing the other Germanic tribes, were rewarded with land in Gallica. The Visigoths slowly extended into the peninsula, eventually gaining majority control by AD 486 (Collins 2001:39).

3.2.2 Structure and government of Visigothic Iberia

The Visigoths are noted for their war-like qualities rather than their contributions to culture or science. Mathisen (1997) suggests that war was the chief occupation of the Visigoths. Literacy and education were not priorities within society (Fletcher 2003:50) and the major preoccupation of the king was to maintain and expand the borders of the kingdom (Collins 1995:107). Therefore the long-term success of the king depended on military accomplishment. Accordingly, political instability was a persistent problem, resulting in many leaders having their reign curtailed (Collins 1995:107). In particular, succession to the throne proved to be a substantial problem. The monarchy was formed on an elective basis rather than a hereditary one (Dangler 2006). To become ruler, it was crucial to obtain the support of the nobility and elites particularly as the army was

formed from the powerful landowners; no standing army existed (Collins 1995, Dangler 2006:2). In turn, Collins (1995:113) indicates that success of the king was critical to those who had supported his accession to the throne. On a number of occasions the followers of a dynasty were murdered following the disposal of a king. In order to protect their interests as ruler and their dynasty, some kings tried to secure the secession of their heirs through the introduction of secular and ecclesiastical laws which aimed to protect them, their kin and supporters (Watt and Cacha 1965:11). Institutional failure, including ecclesiastical, to enforce legislation rendered this protection ineffective. It was argued that the church often failed to intervene, citing that god's will was inevitable, when it suited ecclesiastical agendas (Collins 1995). This meant that the monarchy remained unstable and government turbulent throughout the Visigothic period.

Domestic instability resulted in a preoccupation with controlling internal struggles rather than actions that would increase the economic and social stability of the region. Factions with differing loyalties probably existed (Collins 1995:113), and attempts to create separate kingdoms occurred on multiple occasions. In fact, descriptions of the peninsula are usually of an under-exploited, disorganised land in social decline.

Like most parts of Europe during the early Middle Ages, Visigothic Spain was in an economic and demographic downturn (Kennedy 1996). Archaeological evidence for reduced trade and building disuse generally supports this trend. In contrast, however, economic continuity, and even prosperity is suggested by the registering of new constructions including churches, hospitals and public buildings, which were paid for by bishops and the nobility (Collins 2001:46). A good example, as highlighted by Collins (2001:46), was that Merida remained prosperous after the decline of the Western Roman Empire. Some new cities were erected including Reccopolis, built by King Leovigild (Fletcher 2001:22). Nevertheless, evidence for prosperity is limited and does not appear to be the case for most towns. Land was under-exploited, with buildings falling into disuse or becoming multiple occupancy (Collins 2001). Furthermore as Heather (1991:203) points out, Merida was the richest see in Spain and therefore atypical. While there is evidence for trade, it was localised and limited (Dangler 2006:2). The use of coinage appears to be infrequent (Kennedy 1996:2) and trading of goods was usually by direct exchange. Écija was a commercial trading point in the Visigothic period (King 1972:197).

The inhabitants of the peninsula were a combination of Germanic, Roman and local people or Hispanics (Kennedy 1996). A sizable Jewish population existed (Hole 1958:46), who played an important role in the economy of the region (Glick 1995), but most of the population were Christian of either Arian or Catholic denomination. Unlike Catholics, Arians did not believe in the equality of the son in the Holy Trinity. It was not until AD 589 (see Table 3.1) that the Visigoths became, in law, a totally Catholic people, following King Reccared's conversion to Catholicism just two years previously (Dangler 2006, Fletcher 2001, Kennedy 1996). Arianism was subsequently outlawed at the third Council of Toledo in AD 589. Conversion to Catholicism unified the peninsula and also ensured the monarchy with the backing of the Catholic Church. This proved beneficial to the king, as he was able to choose bishops, which gave him substantial control over the church (James 1980:161).

In Christianity, religious observance focuses strongly on the correctness of belief (Lindsay 2005). For example, it was critically important, especially after the outlawing of Arianism, that the trinity was acknowledged. Rituals strongly focussed around the church which tried to incorporate the uneducated masses by providing simpler texts (James 1980:34). The church was involved in all major life events, including baptism, marriage and death. Historic sources demonstrate that the observance of major religious festivals (Christmas, Lent, Easter) was known to have taken place. For example, Egeria an Iberian whose late fourth-century writings are found in the *Itinerarium Egeriae* (Travels of Egeria), focuses on the similarities of practice of Easter between her homeland and Jerusalem.

This suggests that religion should have been a pivotal part of Visigothic life and, indeed, Jewell (2007) suggests there was no distinction between the religious aspects and secular aspect of life. How far people thought about religious implications during their daily activities is unclear. However, King Egica (ruling AD 687-701/3) boasted that the Visigoths were notorious throughout the Catholic kingdom for the fullness of belief (James 1980:44). In the 7th century, Jews in particular were not tolerated (Kennedy 1996). Religious intolerance is thought to be an initiating factor behind the arrival of the Berbers (see section 3.3.1).

Most of the surviving written evidence on the daily lives of the inhabitants of Iberia during the Visigothic period is canon, secular law and theology (Collins 1995:107). Where other types of historic evidence exists, it is usually concerned with the actions of kings and the nobility, not the average person. Finding out about the lower echelons of society is therefore difficult, although not impossible. An insight into the priorities and structure of Visigothic Spain is provided by literary evidence.

The land was owned and run by bishops and wealthy nobility (Dangler 2006). Peasants lived on and worked the land, and owed loyalty to the landowner. It was then the responsibility of the nobility to provide an army to the king (Kennedy 1996:2) and this would often have been rewarded with gold or silver. This provided the nobility and bishops with substantial political power.

Through the analysis of legal texts, King (1972) suggests that evidence from law shows that Visigothic Spain was stratified in a number of ways. It was not until the introduction of the *Lex Visigothorum*, the first set of Visigothic law, in AD 654, did the same laws apply to Visigoths and Romans. Collins (1995:103) and King (1972) highlight that different punishments were accorded for offenders from upper or lower classes. In general, the population was divided into slaves, freedmen and nobles, and although you were born into your social group, it was possible to move between classes (King 1972:160). Imamuddin (1981:10) suggests that two classes existed, the ruling landed class (nobles, clergy and the king) and the subject class including slaves, Jews and burgesses. Kennedy (1996:2) also suggests a further division between the military and non-military classes. On the whole, much of the general population was involved in farming the land. Other occupations included carpenters, fishermen, blacksmiths, and weavers (Imamuddin 1981:11). It is entirely possible that under-exploitation of the land meant that there was little surplus population to undertake specialist trades such as those seen in pre-Visigothic or later Islamic Spain. For example, Shatzmiller (1994:341) argues that agricultural intensification during the 10th century in Islamic Spain led to a surplus of men and raw materials which boosted the industrial and commercial capacity of cities.

Evidence of the lives of Visigothic women is sparse. Documentation frequently pertains to noble women and the role they played politically as wives in advantageous

marriages. There is some evidence of the position of women in the 7th century in Gothic law as the *Forum Ludicum*, dictates that women were allowed to own and run their own land. Unlike other barbarian groups, inheritance laws for Visigoths meant that women could receive property (Bitel 2002). The *Lex Visigothorum* suggested that the ideal age of marriage for a female was 15 years of age, but at 20 years of age, they could decide their own marriage partner. By 14 years of age, women could bear witness in court. Again, this type of evidence is dogged by our inability to know how much people adhered to law.

Women could be employed in a number of positions. Women certainly had religious roles as nuns, and one cannot fail to mention Egeria, who travelled in order to seek religious knowledge (McConnell 2005). However, the involvement of women in religious direction and rituals steadily decreased from the 5th century. After the Council of Tours in AD 567, many women lost their positions within the church (Bitel 2002) and were no longer allowed to be bishops, or to give sermons.

It is thought that women generally stayed at home (Bitel 2002); however evidence suggests that women would have taken part in pastoralism (Jewell 2007), which was practiced in Iberia from at least the Roman period (Imamuddin 1981). In the countryside, women worked alongside men. They looked after geese and other livestock, milked and made cheese. They were also involved in milling. Females in early medieval Europe dominated the weaving and cloth-making industry (Bitel 2002).

3.3 Islamic Iberia

3.3.1 The conquest of Iberia

The Muslims arrived in a region that was divided by civil war initiated by another succession struggle (Reilly 1993). Achila, a nobleman was claiming the north, while newly installed King Roderick was situated in Toledo (Reilly 1993, Watt and Cacha 1965). Discontent within the general population may have meant that civil opposition to the conquest was indifferent (Payne 2004:1). The first raids into Iberia in AD 709 proved fruitful in terms of booty gained. In April AD 711 a full-scale operation was ordered by Musa ibn Nusayr, Governor of North Africa (Reilly 1993). This was led by

Tariq ibn Ziyad, the Governor of Tangier, who brought an army consisting mainly of North African Berbers (Kennedy 1996:10, Lapidus 2002). It is speculated that the invasion was assisted by Count Julian of Ceuta, seeking to take revenge on King Roderick for the rape of his daughter (Collins 1995:155, Kennedy 1996:8, Watt and Cacha 1965:13). Furthermore, it is thought that the Jews actively sought the help of the Berbers and Arabs in North Africa to ease their oppression under the Catholics.

The Berber forces appear to have been met with little resistance and moved rapidly through the peninsula (Collins 1995). King Roderick, fighting Basques in the north, was forced to rush to meet Tariq ibn Ziyad and his army in July AD 711 (Kennedy 2007, Reilly 1993). Roderick was defeated and killed in battle. On route to Córdoba a decisive battle was fought outside Écija, exposing the city early to Islam (Hitti 2002, Kennedy 2007, Reilly 1993, Watt and Cacha 1965:14). Toledo then fell rapidly to the Muslims in the same year. Far less is known about King Roderick's opponent Achila, but it is thought that he was killed a couple of years later (Fletcher 2001:289).

Hearing of Tariq ibn Ziyad's successful campaign, Musa ibn Nusayr brought a second army into Iberia just six months later. This army consisted mainly of Arabs (Kennedy 1996:12), greatly increasing their number in the region. Sevilla was quickly subdued by Musa ibn Nusayr and his men. Just about all of the Iberian Peninsula was under control of the Umayyad Caliphate by AD 716. The region was renamed al-Andalus by the Arabs (Watt and Cacha 1965:17). The rapid conquest of the region was likely due to the inability of the Visigothic nobility and leaders to mount a unified defence (Collins 1995).

3.3.2 Early al-Andalus

The peninsula was now technically part of the Umayyad Caliphate and part of the Islamic world (*dar al-Islam*). As it would have been difficult to rule Iberia directly from Damascus, the region where the Caliphate resided, Iberia was controlled by governors appointed by either the governor of North Africa or the Caliph himself (Kennedy 1996:18). As very little changes to bureaucracy took place until the 9th century, it is difficult to ascertain exactly what happened in terms of settlement processes, but unlike other conquered regions, the Muslims tended to settle wherever they wished rather than

in garrison towns (Dangler 2006). Boone (2009:67) states that settlement instead tended to be in fortifications along important communication routes. This made it difficult to install a centralised command. Conquering forces tended to settle in their pre-existing ethnic groups, for instance, Sevilla was settled by Berbers where as Córdoba was one of the four largest centres of Arab immigration (Hillenbrand 1992) and was strongly Arab (Garcia Baena 2006). The capital of the region was promptly moved from Toledo to Córdoba and was made the seat of the head Islamic judge (*qadi*) of al-Andalus (Hillenbrand 1992) (this places Écija close to the centre of Islamic Spain and was now one of the nearest towns to Córdoba). A number of reasons surrounded the choice of Córdoba. Dangler (2006:16) highlights that it was a central point in the landscape between many important places. Additionally, the agricultural land surrounding the town was far superior to that of Toledo, the Visigothic capital (Dangler 2006:16, Kennedy 1996:16).

Although the Qur'an teaches equality to all Muslims, tensions between Berbers and Arabs in North Africa began to reach breaking point in AD 740. The Berbers, despite fully embracing Islam, were treated as second-class citizens relative to their Arab peers (Fletcher 1992:27, Reilly 1993). This many have stemmed from early links between Islamic identity and Arab identity. Taxes were introduced by the North African governor to pay for the Syrian army (Kennedy 1996). As a result, a Berber revolt broke out in North Africa (Fletcher 2001:27). A Syrian army led by Balj ibn Bishr al-Qushayri, was sent by the Caliph in Damascus to restore order in North Africa, but unable to quell the Berbers, the army retreated and remained in Ceuta (Hitti 2002, Kennedy 1996).

Discontent in North Africa spilled over into al-Andalus. Similar feelings of inequality were being felt by Berbers who, just a year later, marched on Córdoba (Kennedy 1996:25). The governor of al-Andalus turned to Balj ibn-Bishr al-Qushayri and the stranded army in Ceuta for assistance. The army was rallied from Africa on the pretence that they should return home after Córdoba was regained. However, the lush lands of al-Andalus seemed far more inviting than those in harsh North Africa and a further civil war ensued. The Syrians quickly took control of Córdoba. Order was only restored through the intervention of the Caliph in Damascus, who sent an additional army to quell Berber revolts, restore order to the Arabs, and install a new governor (Collins

1995:165, Reilly 1993). It was clear that the Syrians needed to be settled in Iberia in order to achieve peace. This further increased the number of Arabs in al-Andalus.

Greater problems were unravelling in the centre of the Islamic world which would have significant repercussions for al-Andalus. The Umayyad dynasty, an Arab dynasty originating from the *Banu Umayya*, came under attack by the Abbasids who took control of the Caliphate (Fletcher 2001, Kennedy 1996). Many of the Umayyad members were executed or forced to leave Damascus. Abd al-Rahman made his way to North Africa with the intention of conquering Ifriqiya. After unsuccessful attempts to do so, he focussed on al-Andalus, where he took a small army and marched on Córdoba. Abd al-Rahman was made the first Amir of al-Andalus in AD 756, which effectively ended the authority of the Caliph in the east (Hitti 2002, Reilly 1993). Abd al-Rahman went on to rule for 33 years providing a secure start for the Umayyad Iberian dynasty. This marked the beginning of the most stable and prosperous period in al-Andalus.

3.3.3 The Umayyads in al-Andalus

The rulers from Abd al-Rahman I to al-Hakem II were the most successful in al-Andalus (Collins 1995:170, Hitti 2002). They popularized learning and cultivated piety (Collins 1995:171). The pursuit of knowledge is encouraged by the Qur'an (Abu Hamdiyyah 2000:38) and was therefore supported by the government. Men of learning were brought in from the east, which spread technological and intellectual works to Europe (Hillenbrand 1992). Vast libraries were constructed. Many buildings were extended and new ones were created. The construction of the Medinat al-Zahra in the 10th century is an extraordinary example of the wealth and power of the Caliphate in its ultimate years; a new, purpose-built city on the slopes outside Córdoba supported the king, his army and all the serving population (Boone 2009, Milwright 2010). In addition, the great Mosque of Córdoba was consistently extended by each successive ruler. This may indicate both a growing Islamic population and the expression of wealth and piety (Milwright 2010).

Abd al-Rahman III became ruler in AD 912, and is seen as the most successful ruler of al-Andalus, reigning for over 50 years. Initially coming to the seat as an Amir, he declared himself Caliph of Córdoba in AD 929 (Collins 2001). This broke all ties with

the Caliph in the east (Baghdad), and is thought to have strengthened his authority (Fierro 2005). It was during the reign of Abd al-Rahman III and his son al-Hakem II, that al-Andalus reached its cultural and economic peak (Collins 2001:65). Both Caliphs had a strong interest in books and learning, amassing large libraries. Many texts were translated, including works that had been lost to the west such as Dioscorides and Homer (Fletcher 2001:147). Córdoba was recognised throughout Europe as a great centre for learning, and many elites and notable scholars of the era spent time there. It is this explosion in learning that many, including Menocal (2002:206) and Fletcher (2001:8), believe was a crucial, yet understated precursor to the Renaissance in Europe.

Following the successful reigns of Abd al-Rahman III and al-Hakem II, al-Hisham II came to the Caliphate in AD 976 at just 15 years of age. Lacking in military and political experience, it was only natural that strong political men would vie for the opportunity to challenge as leader. This was achieved by al-Mansur and effectively ended the rule of the Umayyads in Iberia. Al-Mansur was a successful military leader who relied on the support of Berbers. Kennedy (1996:115) suggests that the period of al-Mansur's reign (AD 981-1002) was stable, prosperous and the peak of Muslim power in Iberia. A large formal army was constructed from a variety of backgrounds in an attempt to prevent internal revolts. It is thought that taxes enforced to pay for this army resulted in unrest in the penultimate years of al-Mansur's reign. The land became impoverished and the armies unhappy. The Syrians that had arrived early in al-Andalus were reduced to tax payers, losing control over the lands they had received in payment for the 8th-century conquests (Kennedy 1996:118). After al-Mansur's death, his son Abd al-Malik succeeded him. It is thought that his neglect of administration for military campaigns initiated the early problems that led to the breakdown of al-Andalus.

3.3.4 The fall of the Caliphate and later al-Andalus

Kennedy (1996:124) suggests that a number of mistakes were made by Abd al-Malik, including over-reliance on Berbers and breaks with Umayyads. Consequently, conspirators took the opportunity to try reinstating an Umayyad in Abd al-Malik's place at the first opportunity. The years up until AD 1031 were chaotic with multiple rulers, which ultimately resulted in the end of the Caliphate and the collapse of the Córdoba

state. Al-Andalus broke down into independent states, known as the Taifa states, following a civil war. These states were ruled by a number of princes and were broken up into Berber- and Arab-controlled regions. Lapidus (2002:313) indicates that Arab regimes were founded at Sevilla, Córdoba and Zaragoza while Toledo, Badajoz and Granada were Berber dominated. The level of disorganisation in the Taifa states is disputed. Lapidus (2002:313) argues that while the states were divided politically, Islamic identity was still strong and a flourishing trade network ensued.

Gradual gains by the Christian north subjugated some Iberian Muslims to Jews and Christians. Under *shari'a* law, it is not lawful for a Muslim to be subject to either (Fletcher 1992). Taifa state princes were also accused of becoming influenced by Christians, i.e. consumed by luxury, alcohol and a lust for booty. However, the inability to mount a unified defence is argued by some to have allowed the Christians to make inroads with the Reconquista (Kennedy 1996, Fletcher 1992). In order to slow the loss of Iberia, intervention from elsewhere in the *dar al-Islam* was inevitable. Assistance came from two fundamentalist regimes from North Africa; the Almoravids, and subsequently, the Almohads. Both were of Berber origin, which brought new influxes of Berber immigrants in to the region (Cases *et al.* 2006). It seemed that the Berbers were welcomed into fragmented al-Andalus (Hitti 2002, Kennedy 1996:167).

The Almoravids arrived first. They were an orthodox Islamic dynasty from southern Morocco who ruled briefly from AD 1090 – 1147. Described by Fletcher (1992:105) as Islamic fundamentalists, initially the Berbers of Morocco had received very little tuition on how to follow the Islamic faith. Abd Allah ibn Yasin sought to change this and to return the people of the northern Sahara to a more pure and original form of Islam through strict observance of orthodoxy. According to Lapidus (2002:306), Ibn Yasin returned to Morocco from Mecca to teach the Qur'an, *hadith* and law; he further abolished illegal laws, destroyed taverns and reinstated the distribution of wealth. He was recorded as flogging people for praying incorrectly (Kennedy 1996).

The Almoravids initially entered Iberia under Yusuf ibn Tashfin to assist the Taifa rulers after Alfonso VI took Toledo (Hitti 2002). However, like so many times before, where outsiders were used to restore order, the Almoravids overstayed their welcome and took al-Andalus under their control. This, in effect, restored unity to Iberia but the lenient attitudes towards Christians were lost. Unpopular in al-Andalus, it was difficult for the Almoravids to take permanent hold of the region. The presence of the

Almoravids was thought to be largely urban and military. The Almoravids interfered little with the *qadis* running of daily administration (Kennedy 1996). It is also suggested that they indulged too much in the luxury of the region and failed in the task they initially set out to achieve, the prevention of Christians encroaching on the region (Fletcher 1992: 118, Hitti 2002).

Inevitably the Almoravid regime broke up in Africa and Iberia, resulting in a brief period of regionalisation in Spain (Hitti 2002). In Morocco, the Almoravids struggled to contain the new Almohad fundamentalists. The movement was founded by Muhammed ibn Tumart in the early 12th century, creating a Unitarian group born from the notion of the unity through god. Fletcher (1992:119) suggests that everything was ‘plunged in God’ in so much as god and religion should be the sole focus of Muslims. The Almohads sought to return the Muslims of North Africa to the strict orthopraxy from which they had apparently strayed. Inevitably, the Almohads arrived in al-Andalus as a natural extension to campaigns in North Africa, but were actually invited after further conquests by the Christian North (Kennedy 1996). The Almohads had a longer and more successful period of rule in al-Andalus (AD 1170 until 1269) than the Almoravids.

During the rule of the Almoravid and Almohad regimes, what remained of al-Andalus was reunited. Teachings were transmitted into Iberia from the Islamic world with the arrival of both dynasties. There were also improvements in religious and economic relationships between the Mahgreb and al-Andalus. The arrival of the stricter more zealous forms of Islam was disastrous for relationships with the Christians. Kennedy (1996) highlights how the Christians moved to a campaign of crusade to regain what they viewed as their lost territories in Iberia. Regardless of some military victories over the Christians, the loss of most of al-Andalus was inevitable. Lapidus (2002:314) suggests that after the defeat of the Almohads in AD 1212, the now independent states were helpless (Hitti 2002). The organisation and joining of the Christian powers proved to be too much for the Islamic leaders to resist. Córdoba fell to the union of Castile and Leon in AD 1238 and Seville to Ferdinand III in AD 1248 (Fletcher 2001:87). In all but Granada, where the Nasrids remained until AD 1492, Islamic rule had come to an end.

3.3.5 Becoming Muslim in Iberia: Conversion

The Islamic conversion of Iberia was not one swift action. People were not simply given the choice to convert or face the consequences. Fletcher (1992) indicates that only pagans could be forcibly converted. Islamic law states that People of the Book were to be tolerated as they had been given partial revelation by god (Fletcher 1992:35, Kennedy 1996). Historical evidence indicates that Christians and Jews paid an annual poll tax to remain in their faith, becoming what was known as *dhimmi* (protected people). Forcible conversion of the Christians and Jews would have resulted in less revenue (Kennedy 1996:69). Additionally, Fletcher (2003:21) suggests that it was beneficial to remain on positive terms with Christians of conquered lands as they had the expertise to run the government and land. Christians and Jews also substantially outnumbered Muslims until the 9th century (Fletcher 2001:37). Imamuddin (1981:26) indicates that by showing tolerance, Muslims raised their status with the indigenous population. Keeping the population happy, would have eased the take-over of the region, particularly with the population disgruntled with the previous government. As the conquering parties were only recently Islamised themselves, because Islam had only existed for around 100 years, clear ideas of Islamic behaviour would not have existed, so how different the conquering parties, who shared similar Roman and Byzantine backgrounds, were to the local populations of Iberia is debatable (Boone 2009).

The uptake of Islam was in fact, initially quite slow (Glick 1979), only gathering momentum approximately 100 years after the arrival of Islam (Fletcher 1992:37). The process of conversion has been debated in archaeology, with discussions focusing on whether the population was actually converted or whether they were displaced (see section 2.4). It is not known how many Berbers and Arabs actually arrived in Iberia although osteological evidence indicates that they did come (e.g. Prevedorou *et al.* 2010). Figures from historical sources may both over- and underestimate the number depending on the agenda of the source (i.e. victors may underestimate numbers to increase the monumentality of the task they achieved). Arab sources suggest that initially 7000 Berbers arrived with Tariq ibn-Ziyad with the additional 5000 troops later in the year (Glick 1979, Kennedy 2007, Payne 1973, Watt and Cacha 1965). Therefore it is very difficult to quantify and track conversion, and a number of different estimates have been provided.

It is thought that most people in towns eventually converted to Islam and those who retained their faith resided in the countryside (Fletcher 2003:36) or were more distant from Córdoba (Collins 2001:65), although this is debated (Guichard 1992). Many reasons made conversion worthwhile, including tax exemption and job opportunities (Fletcher 1992:35, Kennedy 1996). Boone (2009:136) suggests that conversion is a complicated process. During the early years of Islam, and up until the mid-8th century AD, the only way to enter Muslim society was to submit to an Arab tribe as a client (Boone 2009, Kennedy 1996). Boone (2009:137) suggests that it was over a century after the initial conquest that the importance of the *ummah* (the worldwide community of Muslims) was realised. Maliki law, made regional law by al-Hakem I in the early 9th century (Payne 1973), saw converts as clients to the *umma*, rather than specific Arab families (Boone 2009:137). This suggests that religious identity in Iberia began to take priority over Arab identity and, as Lapidus (2002:309) suggests, that by the 9th century, an Arab-Hispanic identity had emerged, and the link between being Arab and Muslim was blurred. This means the number of non-Arab Muslims in the populations of Écija and Iberia increased.

Another interesting and unknown factor was the role that women played in conversion. While stable isotope analysis has identified female migrants into Iberia from other areas of *the dar al-Islam* (Prevedorou 2010 *et al.*, Zakrzewski 2010), how many women accompanied the Muslim armies arriving into Iberia, and what their level of conversion was is unknown. It is interesting that in many Islamic regions today, women have been identified as those that continue to carry out many pre-Islamic customs (Morris 2006:83). For example, in Egypt, Muslim women undertake fertility rituals entailing the breaking of pottery at historic sites (Sarah Inskip *pers. comm.*). Similar situations were documented in al-Andalus, where women were prosecuted for celebrating Christian festivals (Fierro 2005). Edwards (2005) suggests that tradition in Islam is divided into two types; women are involved in customary traditions, while males focus on religious traditions. This may mean that men might have publically and visually converted by undertaking religious rituals, but females might be more important in the emergence of unique regional Islamic identities through the incorporation of other customs.

Bulliet (1979) has explained the curve of conversion as a result of contact between Muslims and non-Muslims, something that Glick (1979) echoes. Both propose that

contact between the individuals of Islamic and indigenous faith was initially low, but as the Islamic population enlarged, this contact increased, causing exponential conversion (Boone and Benco 1999:65). Fletcher (1992:36) suggests that intermarriage may have encouraged other members of the family to convert. If the child of a Muslim was born to a Christian mother, it still had to be raised in a Muslim tradition. Conversion may also have picked up momentum due to other social factors, not just the tax benefits it bought. For example, it was preferable for Muslims to take up certain occupations due to perceived scorn of other Islamic groups outside of Iberia (Kennedy 1996).

Conversion, therefore offered more employment opportunities (Glick 1979, Fletcher 1992:36) and the ability to get involved in government politics (Kennedy 1996).

Regardless of the debates surrounding the speed of conversion, many changes were brought with conquerors, altering the landscape, economic worth and social structure of Iberia. As Islam was a new faith when it arrived in the peninsula, debate surrounds the degree of Islamisation and that, initially, Arabisation actually took place (Boone 2009, Glick 1979, Lapidus 2002). Members of the indigenous population took on many Arab features, including dress and names (Kennedy 1996). Once Islam established laws and traditions, a process of Islamisation of both the conquerors and the indigenous population probably took place (Lapidus 2002). Payne (1973) argues that this would have occurred following the formation and imposition of Maliki law. Important religious introductions include the observance of food taboos (e.g. pork consumption) (Lentacker and Eryvynck 1999), or the observance of gender divisions, the construction of mosques, but also the adoption of the Arabic language as the language of Islam. However, many of these features were observed prior to the arrival of Maliki law. Arabic language became the language of bureaucracy in the 8th century as demonstrated by the minting of Arabic-only coins (Kennedy 1996) and law texts. Furthermore, debates surrounding the correct observance of *haji* and prayer are recorded in the early 8th century judgements of Córdoba (Marin 1992). This supports the idea that Iberian Islam was forming in Iberia as soon as it arrived.

3.3.6 The ‘Golden Age’ of al-Andalus

One of the greatest disputes surrounding Islamic Spain is the ‘Golden Age’ during the 10th – 11th centuries. Scholars have portrayed this era as being peaceful and plentiful

(Kennedy 1983, Imamuddin 1981, Menocal 2002). It is argued that the fusion of Christianity and Islam resulted in the success of Iberia. The peaceful amalgamation of Christian and Islamic cultures resulted in an explosion of ideas and technologies (Menocal 2002). It is almost certain that the combination of regional entities and incoming Islamic/Arabic influences did occur (e.g. return of lost literature, improved irrigation and *Mudéjar* décor) and a degree of acculturation was operating in the population. This is evident today in modern Spanish culture which retains some of the Arab features of old such as, for example, the origins of Flamenco, Arabic-influenced vocabulary and the many Arab dishes that are still found in Spanish cuisine.

The greatest issue surrounds the assertion of a tolerant multi-faith society as the catalyst for the success of the period (Fernández-Morera 2006). Glick (1979) suggests that one of the biggest fallacies is that acculturation was equal to assimilation. An article published by Safran (2001:576) acknowledges that acculturation existed in al-Andalus, but demonstrates that mixing was a concern for early Muslims in Iberia. Islam warns against innovations (*bid'a*), religious ideas or practices that are not enforced by Islamic law. A number of authors have demonstrated that the trial of innovators was not uncommon in al-Andalus (Fierro 1992, Safran 2001), something not unsurprising given that some argue that Malikism was staunchly observed (Payne 1973, Lapidus 2002). The maintenance of religious identity therefore was a concern for Muslims, particularly considering al-Andalus's fringe location and proximity to Christian states. Learned men (*ulama*) travelled in order to bring back Islamic knowledge from all over the *dar al-Islam* to ensure adherence to the faith (Safran 2001). It could be argued that as laws were being created and in some cases, enforced, cultural mixing represented a true concern for Muslims in al-Andalus at the time, especially in the later periods during the 11th and 12th centuries (Fierro 1992). Fernández-Morera (2006) suggested that historic documentation, including judgements and biographies, detail numerous examples of religious tension in the region. Christians were executed on a number of occasions for denouncing Muhammad as a prophet (Fierro 1992, Melville and Ubaydli 1992).

A second, hotly debated topic surrounds the 'Green Revolution'. Watson (1974) argued that the success of the Muslim world could be linked to the spread of Arab innovation and irrigation techniques from Arabia, through Africa and into Iberia. It is thought that cultivation improvements did create enough food to support a large and expanding

population. For example, improved irrigation systems such as the *saqiya* (an animal-driven water wheel arriving in the 9th century) (Fletcher 2003:55), and the introduction of new foods, including rice, dates, bananas, sorghum, durum wheat and citrus fruits (Fletcher 1992:63, Lapidus 2002, Reilly 1993), increased the productivity of the land, freeing up larger numbers of the population to undertake more specialist crafts and trades. This could have led to increased prosperity and encouraged demographic growth.

However recent scholars have used botanic evidence to argue that some of this food was already present in some regions prior to the arrival of the Muslims and Arabs (Decker 2009). Even if introduced Bulliet (1994) infers that the calorific impact of the foods was not sufficient enough to enhance population health. However, we need to consider that the calorific value of food is not its sole importance; essential amino acids are vital for a healthy body. The introduction of citrus fruits, for example, would greatly reduce the impact of scurvy while having little calorific impact. It is possible that improvements in agricultural techniques could have fuelled improvements in population growth in Iberia, but how dramatic and rapid it actually was is difficult to say and is beyond the scope of this investigation.

Regardless of the feelings between Christians and Muslims, or whether food was previously grown in the region or imported, there was an important social change in al-Andalus that initiated a prosperous period during the 10th-11th centuries. While these changes might not be directly related to the arrival of Islam as a faith, Islam was an important factor in the period as it made up part of the cultural milieu. The changes that took place in the region at the time were either acceptable to the general populace under Maliki law, or had to be negotiated with Islamic law, thereby meaning they became part of Iberian Islamic identity.

3.3.7 Labour in medieval Iberia

A gender division was evident in al-Andalus (Shatzmiller 1997). Furthermore, Shatzmiller (1994:331) argues that for both sexes, labour was divided by the three main ethnic and religious identities in medieval Iberia, Arabians, North African Berbers and indigenous individuals, split into those that were converted and those that were not.

Considering the men, Arabs tended to take roles not requiring heavy manual labour, or work that was thought to be degrading (Lindsay 2005). In an extensive study on economic resources, Shatzmiller (1994:331-5) indicates that Arabs undertook service roles of teachers and transcribers as well as most religious roles. They did not work in the extractive (mining/fishing etc) and manufacturing sectors. Berbers that lived in the country looked after cattle, grew crops and produce, whereas those in towns tended to manufacture goods. Converted Ibero-Romans were also involved in livestock, boat building and wood cutting. Finally the Ibero-Romans undertook all jobs that were seen as degrading or polluted in the eyes of Muslims. This includes tanning, leather working, burying the dead, looking after the sick, among many other roles (Shatzmiller 1994:331-335).

It does, however, seem unlikely that these religio-ethnically prescribed roles were rigidly adhered to, and one might expect there to be some vocational cross-over between groups. Also, it is not known how the role of a non-converted Iberian might change with subsequent conversion. It does however remain a good guide as to what the ideal situation may have been. Variation may have occurred with the loss of the link between being Muslim and Arab after the 9th century. For example, in the first 200 years, the ability to teach, work in religious and bureaucratic roles, may have been related to the ability to speak Arabic which was always the official legal language of Muslims (Guichard 1974). This would have given Arabs preferential access to these jobs.

Another important issue relates to the economic roles of women in Islamic Spain. Strict gender ideology exists in the Qur'an and *hadith*, which suggests that men should financially support families and women should raise children (Jewell 2007:134). The responsibility placed on men has created an emphasis on the security of paternity, which is thought to have resulted in the restriction of female movement (Ruthven 2000). Viguera (1992) suggests that in al-Andalus women were confined to the household, something documented by Ibn Rushd; a 12th-century Iberian scholar (Hillenbrand 1992). Despite this, in a large scale study, Shatzmiller (1994:6) demonstrated that although women were mentioned infrequently, women did have an economic role to play and could own their businesses (Shatzmiller 1997). Furthermore, Islamic law states that women were allowed to earn a wage (Minai 1981), which they were often allowed to keep. Females were never recorded as being involved in manual labour or extraction

(Shatzmiller 1994:348) and tended to produce house crafts, such as making domestic pottery and cloth. One area that Shatzmiller (1994, 1997) and Hambly (1999) highlight as being dominated by women was domestic weaving.

Another significant area of female work was the service industry (Shatzmiller 1994). Women were employed to help other women either with domestic tasks or as hair dressers, midwives or wet nurses (Hambly 1999). They could also be employed as servants or work as slaves. In early Islam, Hambly (1999) and Hillenbrand (1992) record women as being secretaries, teachers, translators and poets, but one cannot help wonder how accessible these roles were to those outside the aristocracy and elite. As such, they might not really be applicable to the generic population and status differences may have existed.

3.3.8 Islamic Law in al-Andalus

Al-Andalus was Sunni by tradition. Initially, the Syrian school of Awza'ī arrived first in al-Andalus largely because of the connection with Syrian conquering forces (Imamuddin 1981, Fierro 1992, Lapidus 2002). However, Andalucians began to follow the Maliki school of law during the reign of Hisham I (AD 788-796) which became established as the official school of law by AD 850 (Fierro 1992, Imamuddin 1981, Melville and Ubaydli 1992:28). The origins of the Maliki school of law were in Medina and established by Abu Abdallah Malik ibn Anas, with his most notable work being the *Muwattah* (Imamuddin 1981, Safran 2001, Waines 1995:67). Maliki traditions were brought to al-Andalus by scholars that travelled east during Malik ibn Anas's lifetime. A leading figure in this transmission was Yahya ibn Yahya al-Laythi (Marin 1992, Safran 2001), but other notable figures include an individual known as Shabatun, and Qays the son of al-Gahzi, who was thought to have bought a copy of the *Muwattah* to al-Andalus (Imamuddin 1981). Maliki teaching was strongly related to Islamic jurisprudence found in the Qur'an (Fierro 1992). Reilly (1993:69) indicates that it tended to be literal in its interpretation of the Qur'an. Malik ibn Anas was particularly influenced by the traditions of the Prophet and, as such, Maliki law covers obligations to Allah and behaviour of individuals (Waines 1995). Rituals to Allah are covered in the *Muwattah* extensively; for example, prayer is covered first, followed by fasting (Waines 1995:67).

Since al-Andalus appears to have been a stronghold for Malikism (Fierro 1992, Safran 2001), it has been noted by Safran (2001), Fierro (1992) and Lapidus (2002), that it was both difficult and time-consuming to get other law integrated into al-Andalus. There was staunch opposition to ‘innovators’, individuals and laws that could be seen a threat to established Maliki jurisprudence (Reilly 1993). In the 10th century, when Abd al-Rahman III declared himself Caliph, ruler of all Muslim peoples, he strongly asserted that the Maliki school of teaching was the correct school of thought, a view that continued after his death (Safran 1998:192). It was at this time that the Shafi‘i doctrine emerged in the region, but appeared to be controlled (Fierro 1992, Lapidus 2002). Shafi‘i was concerned with rooting out ‘innovations’ or changes to the law and insisted that all *isnads* needed to be traceable to the Prophet (Waines 1995). Judgement (*qiyas*) and consensus (*ijma*) were also used to produce law under Shafi‘i. While initially treated with hostility and sometimes as heresies, later Shafi‘i *hadiths* did become accepted in the region (for further details see Fierro 1992).

It is not clear how fully Islamic law was followed in al-Andalus, although it appears to have been staunchly supported and implemented. Some administrative systems did remain in place (Kennedy 1996), which may have resulted in the retention of old laws or customs. Christians and Jews remained under their own religious laws, unless it involved a crime, or if one of the parties involved was a Muslim (Glick 1979).

3.3.9 Socio-historic factors and the development of Islamic identity

It is clear that the history of al-Andalus was complex. Any study of identity needs to consider all aspects outlined above and how they may have impacted on its expression. The following paragraphs highlight some of the major considerations for this research.

Islam arrived very early in its history into Iberia. It was not a cohesive body of law that was simply imposed on the region in AD 711. *Shari’a* law was still developing. As the use and production of *hadiths* is related to regional problems, indigenous traditions and cultures would have been important in the production of Islamic law, which can be seen as both adaptive and reactive (see section 2.2.3). We do however have to consider that in the late 8th century, Maliki law, strongly advocating the jurisprudence in the Qur’an,

became the school of thought for al-Andalus. This meant that regional situations had to be negotiated with this in mind.

Distance from the centre of the Islamic world and the proximity to the Christian north would have had more than one influence on identity. Strong expression of Islamic traditions could be an attempt to maintain a visible difference between peoples. This expression may have intensified as Christians began to conquer and settle in parts of al-Andalus. At the same time, contact between Christians and Muslims allowed transfer of culture and ideas between faith possibly resulting in syncretism and acculturation, also impacting on Islamic identity.

Changing political situations influenced the development and expression of identity. There were changes in authority in the capital of the Islamic world in AD 750 and later in the overall control in Iberia (see table 3.1). The leaders that controlled the region would have had to have made choices as to how and whether certain laws were enforced, for example, stricter enforcement of *shari'a* law during the 11th and 12th centuries during the Almoravid and Almohad era. As the priorities of different ruling classes will have differed, temporal variation in identity may also be expressed during the Islamic period.

Finally, consideration has to be taken of what existed before the arrival of Islam and whether these customs and traditions were integrated into a new Islamic identity. The absorption and prohibition of customs are likely to be related to their compatibility with Islam as Muslims attempted to reconcile pre-existing systems with a new social system (Berkley 2003, Halevi 2007).

Chapter 4: Human Skeletal Remains as Indicators of Past Activity and Identity

As this research aimed to use physical aspects of the body to access identity, it was important to outline how bodies, in particular markers of activity on bone, can be used as an indicator of social change, and therefore shifting identity. Accordingly, section 4.1 outlines the theory behind activity modification to bone and the general types of questions that have been answered through this approach. Following this, sections 4.2-4.5 detail specific types of activity related skeletal modifications (ARSM), and review how bioarchaeologists have used these modifications to directly explore activity-patterns of past populations and, subsequently, social organisation.

4.1 Activity-related skeletal modifications as an indicator of social change

4.1.1 Bone remodelling and activity

Bone remodels throughout life, an ability permitting growth and reparation to the skeleton (Mays 2010). Integral to the analysis of ARSM and the reconstruction of past activities is research initially published by Wolff (1892). Bone reacts to mechanical stimuli, redistributing in the areas of functional demand. This is known as the law of bone remodelling or ‘Wolff’s Law’. Bone morphology therefore reflects the functional demand placed on it during life. This feature was famously exemplified by humeral asymmetry and hypertrophy in professional tennis players (Jones *et al.* 1977). While there is confusion between the general statement of Wolff’s law and a more strict, mathematical model, proven to be flawed (Ruff *et al.* 2006), the general statement of Wolff’s law is solid and is now known as bone functional adaptation (Ruff *et al.* 2006). It is suggested that bone morphologically adapts due to a cycle of stress and unstress (Ruff 2008, Knüsel 2000). Ruff (2008:184) suggests that mechanical deformation of bone due to strain stimulates new bone growth to relieve that strain. While the full process of bone remodelling is still debated, the results of activity on bone are clear and have been demonstrated in many clinical and archaeological studies (Mays 2010, Ruff *et al.* 2006, Stock and Pfeiffer 2001, Wanner *et al.* 2007). The fact that bone morphology will, to some degree, reflect

mechanical activity during life means that it can be used as a proxy for assessing lifestyle differences (Pearson and Buikstra 2006, Ruff 2008). As people's activities are largely defined by social norms, assessment of activity patterns on a population scale provides a mechanism for looking at social change. It is for this reason that so many studies on bone morphology have been undertaken.

4.1.2 The use of activity-related modifications in archaeology

The impossibility of identifying an individual's occupation solely from the skeleton is widely accepted (Capasso *et al.* 1999, Larsen 1997, Robb 1998b, Roberts and Manchester 2005), since a multitude of activities/occupations can be undertaken using the same physical action. Without the aid of direct documentary evidence (i.e. forensic evidence or known occupation from census records) it is unwise to infer specific occupations (Groves 2005). Just a handful of archaeological cases have successfully attempted to do this. For example, Turner and Anderson (2003) argued that dental modifications formed from holding iron nails in the mouth were the likely result of being a blacksmith. In a similar fashion, Ciranni and Fornaciari (2003) demonstrated that significant skeletal changes were the result of habitual cello playing in a known individual. Whether the changes in isolation, without knowledge of the individual's occupation, could be attributed to cello playing is doubtful.

Population-scale analyses offer osteoarchaeologists a different level at which to explore activity. Unlike analyses of individuals, ethnographic and historical data provides a baseline from which to interpret ARSM. Patterns of activity-related change have been used to identify major changes in human lifestyle patterns. This ranges from assessing the impact of the development of agriculture (Larsen 1997), assessing gendered divisions of labour (Sofaer Derevenski 2000), changing social organisation (Munson Chapman 1997) and changing use of technology (Peterson 1998). However, population studies of ARSM have had mixed success. Many authors claim that differences between groups, both intra- and interpopulation, can be seen (e.g. Boule 2001a, Carver 1996, Lieverse *et al.* 2007, Weiss 2004), while some maintain that these are artefactual, or not observable at all (Waldron 1994). In some cases, where authors cannot observe differences, the problem could result

from methodological difficulties, including inconsistency between researchers and incomplete understanding of modification aetiology. Furthermore, it may be possible that there truly were no differences between the populations. These issues, to some extent can be controlled through selecting an appropriate methodology, inter-observer error tests and the use of statistics. Problems relating to specific ARSM are discussed in more detail in the relevant sections for each type of marker.

4.1.3 Types of activity-related skeletal modification

Bone can be modified in three different ways; to make new bone, destroy bone or a combination of both. Furthermore, as bone is not the only body tissue involved in movement, changes to muscle and cartilage attachments can be observed through bone analysis. Accordingly, a range of ARSM exists and, as they vary as to their aetiology, they provide different clues to activity. This includes articular modifications (Molleson 1989, Ubelaker 1979), enthesal changes (al-Oumaoui *et al.* 2004, Peterson 1998, Weiss 2007) and geometric variation (Ruff 1994, 2008, Stock and Pfeiffer 2001). Additionally, clinical studies of osteoarthritis have demonstrated that people engaged in repetitive manual labour are prone to certain patterns of the disease (Larsen 1997). However, it is problematic to assume that results from modern studies can be applied to the past, especially as changes in other environmental conditions can strongly influence the expression of disease. In addition, the use of comparative data collected from living individuals as a model for understanding archaeological material is problematic. For example, an individual may suffer with only soft tissue manifestations of osteoarthritis and it can be diagnosed as such. Individuals suffering with soft tissue symptoms are invisible in the archaeological record. Archaeological material is likely therefore to represent the severest of manifestations (Roberts and Connell 2004). All of these modifications have been studied in modern and archaeological populations, with the aim of finding out more about the lives of past peoples (Capasso *et al.* 1999). Each will be described in sections 4.2-4.5. A research summary of each marker type is provided, and the positive and negative aspects of each type discussed.

4.2 Enteseal changes and the expression of activity

4.2.1 Definitions of enteseal change

Enteseal changes were previously referred to as musculoskeletal stress markers (MSM). Recent consensus however has suggested that this term may be mis-leading due to the multi-factorial nature of the skeletal change (Villotte and Knüsel 2013) which as well as activity can include acute trauma and disease (Jurmain and Villotte 2010 (as explored in this section)). As an extremely active area of investigation, during, and just after the completion of this research, a significant amount of research was published on enteseal changes. While an attempt was made to update the information in this section, which was written in 2008, time was not sufficient to add in all new information. Therefore, where very recent studies (2009-2012) have been omitted, it is not because they were ignored, rather it was because they did not exist at the time of writing.

Enteses are areas of bone formation or destruction at the point of a muscle or tendon attachment to bone. Steen and Lane (1998:342) defined MSM (enteseal changes) as ‘the manifestation of muscular hypertrophy which results from an enlargement in the diameter of muscle fibres from increased production of myofibrils, mitochondria, sarcoplasmic reticulum’. Muscle size increase is induced by repetitive activity such as climbing, weight training or persistent running. Increased muscle and ligament size requires a greater area of attachment for the periosteum and the cortex of the bone (Steen and Lane 1998). Bone remodelling takes place at the site of increased muscle activity, stimulated by increased blood flow eventually creating a robusticity mark. However, other factors need to be taken into consideration, and also that different types of enteses exist (Jurmain *et al.* 2012). Enteseal changes are observed both at points of fibrous and fibrocartilaginous attachments (Cardoso and Henderson 2010). Enteses of the diaphysis are mainly fibrous attachments, whereas those found around joints are fibrocartilaginous. Recent research has demonstrated that enteseal changes at fibrocartilaginous markers may be more closely related to activity than those of fibrous and that they have different formation aetiologies (Henderson *et al.* 2013). This is because the appearance fibrous enteses appear to be related to growth, as

well as periods of inactivity, whereas fibrocartilaginous are caused by microtrauma and mechanical stress (Villotte and Knüsel 2013). As such, fibrous and fibrocartilaginous entheses should be analysed separately (Jurmain *et al.* 2012).

As well as distinguishing between fibrous and fibrocartilaginous attachments, two other types of lesion have been identified. Stress lesions are characterised by bone destruction at the site of attachment, whereas increased bone deposition occurs at the site of a robusticity lesion. Robusticity and stress markers are scored separately according to Hawkey and Merbs (1995), whereas researchers such as al-Oumaoui *et al.* (2004) do not distinguish between the two. This means that different results may be obtained from the same study sample depending on the methods and markers chosen.

4.2.1.1 Enteseal changes as indicators of activity

As there is a relationship, albeit a complicated one, between enteseal score, muscle use and activity (Doyling 2010, Godde and Wilson-Taylor 2011, Villotte and Knüsel 2012), it is unsurprising that enteseal changes have been used to access the actions and activities of past populations. Capasso *et al.* (1999) acknowledge that enteseal changes can only be used as an indicator of a range of habitual behaviours. While Godde and Wilson-Taylor (2011) have found a link between enteseal score and activity, enteseal size/score is not solely related to muscle use (Nolte and Wilczak 2013, Villotte and Knüsel 2013). As outlined in section 4.2.2, many factors can effect enteseal expression including sex, age, body size and pathological status. Nevertheless, Robb (1998b) concedes that, although it is not possible to use enteseal change as a direct indicator of activity, statistical study of entheses within a group can inform about past activities and social organisation. Enteseal change studies have generally been used to look for intra- and inter-population patterns (e.g. al-Oumaoui *et al.* 2004, Churchill and Morris 1998, Doyling 2010, Eshed *et al.* 2004, Groves 2005, Lieverse *et al.* 2007, Munson Chapman 1997, Ponce 2010, Steen and Lane 1998) and at more specific activities, which do so in conjunction with documentary, artefactual and ethnographic evidence (Kennedy 1983, Lovell and Dublenko 1999, Molnar 2006, Peterson 1998, Weiss 2004). Methodological papers have also focussed on how enteseal data should be collected (Hawkey and Merbs 1995, Henderson *et al.* 2013, Robb

1998b, Weiss 2003a). For the purpose of this research, each category is discussed separately, but it should be borne in mind that some studies may fall into more than one of the groups.

4.2.1.2 Intra-population differences in the expression of enthesal changes

Generally, all enthesal studies examine intra-population differences to some degree. One common aim is identification of gendered divisions of labour, presumably because sex is one of the most basic and fundamental information recorded in osteology, and is often the starting block of most investigations (Sofaer 2006). Most studies have found variation between men and women (al-Oumaoui *et al.* 2004, Eshed *et al.* 2004, Lieverse *et al.* 2007, Lovell and Dublenko 1999, Molnar 2008, Steen and Lane 1998). Consistently, males have been demonstrated to have greater enthesal scores than females, regardless of the recording method. While this may be a reflection of body size (see section 4.2.2), most studies relate these differences to gendered activities. Eshed *et al.* (2004:311 figure 10) highlight some of the potential different tasks carried out by men and women in the Levant during the Neolithic. Churchill and Morris (1998) identified that female activities varied very little by terrain in Khoisan foragers, but that male tasks were dictated by environmental conditions. In studies where women outscore males (e.g. Hawkey and Merbs 1995, Weiss 2003a), it is highly likely that it is due to activity because men generally tend to have larger muscles than females biologically (Weiss 2003a).

Diachronic population studies are also common. Eshed *et al.* (2004:311) explored the change from hunter-gathering to farming in the Levant during the Neolithic, and demonstrated that a gendered division of labour, but in a different form, was present in both hunter-gatherers and farmers. It was suggested that both sexes had an increased intensity/duration of labour rather than new tasks in farmers. This result was similar to Lieverse *et al.*'s. (2007) research on Cis-Baikal Holocene foragers where there was increased activity intensity, but the authors suggested that there was little temporal variation in activity type. Lack of change may actually reflect that a number of activities can be carried out in the same posture or using the same action.

Cultural influence was assessed in a study by Munson Chapman (1997) who sought to clarify the impact of Spanish contact on the activities of Puebloan Indians. Comparison of pre- and post-contact enthesal scores highlighted an increase in deltoid use in females and the trapezius in males. Both were used as evidence for increased production of maize as was supposedly demanded by the Spanish. Overall, this means that actually demonstrating task variation in the skeletal record is difficult but temporal trends can be observed.

4.2.1.3 Enthesal change and the study of inter-population differences

Enthesal scores have been used in order to explore differences between separate groups. A good example includes Steen and Lane's (1998) study of two Alaskan Eskimo populations. The authors advocate that ethnographic evidence of Golovin Eskimo women masticating hides was born out by enthesal evidence on the skull and mandible. This was backed up by lower skull enthesal scores for the Nunivak women, who were not known ethnographically to chew hides.

Al-Oumaoui *et al.* (2004) explored enthesal score variability in Iberian populations, seeking differences between both lifestyle and environment through comparison of five populations from varying terrains, subsistence types and religion. The populations examined included a lowland farming population, Bronze Age hill farmers, Islamic lowland agricultural farmers, Christian flat agricultural farmers and a monastic herding community. To control for body size, the populations chosen had low sexual dimorphism and similar skeletal size. Although there was no significant asymmetry in any groups, there was far more variation in the entheses of the upper limbs than the lower limbs. In addition, enthesal scores in the legs were less asymmetrical than the arms. The authors suggest this is due to locomotor role of the legs, rather than as a manipulator in the upper limbs. In similarity with other enthesal studies, scores were age correlated, however, this was only significant for some entheses. Overall, males had higher enthesal scores than females. Lowland agricultural populations had the lowest leg enthesal scores, while the two herding communities scored higher. The high level of sexual dimorphism in entheses for the Islamic population is consistent with Islamic gender ideologies. The study highlights that, when

interpreting enthesal data, the influence of environment needs to be taken into account, but only for leg entheses.

4.2.1.4 Enthesal score and the relationship with a specific activity/tool

The relationship between enthesal score and a specific activity or object has been the focus of many researchers' work. This includes everything from kayaking (Molnar 2006) to dog sledding (Lovell and Dublenko 1999). A number of studies, (Kennedy 1983, Peterson 1998 and Weiss 2007), have tried to link enthesal patterns to throwing implements. Kennedy (1983) noted that a Mesolithic Gangetic population from India, who used spears, had similar patterns of ulna hypertrophy to modern individuals engaged in javelin throwing. Peterson (1998) used Natufian entheses and asymmetry evidence to demonstrate the possibility of distinguishing between spear, atlatl and bow use. Natufian males appeared to have undertaken tasks which accentuated the right side more than females. While bow and arrow use could not be excluded based on skeletal evidence, the author suggested that there was still evidence for continual spear and atlatl use over time. Peterson (1998) further inferred that male hunting actions created a sexual division in enthesal scores for the Natufians. The author used faunal material and artefacts as supporting evidence, but also highlighted research on the same Natufian population where males had increased levels of cortical bone in the right arms, which was linked to throwing actions. However, no indication of whether this research included the same individuals used in Peterson's (1998) study is given. Although the evidence seems convincing, it is problematic to link enthesal scores with specific activities and even tool use. The study by Peterson is interesting, but as the author acknowledges, it is not possible to distinguish between spear and atlatl, and bow use cannot be ruled out. A far more interesting feature is the degree of sexual differences in enthesal scores in all the populations studied, as it appears that females were clearly not involved in any throwing activities.

Kayaking/canoeing has frequently been suggested to be the cause of hypertrophy, asymmetry and high upper body enthesal scores, particularly the clavicle and humerus (Cook and Dougherty 2001., Lieverse *et al.* 2007, Lovell and Dublenko 1999, Molnar 2008, Weiss 2003b). In a study of the Hudson Bay fur trading post, Lovell and Dublenko

(1999:253) suggested that the trapezius, deltoid, brachialis and supinator attachments were consistent with paddling or rowing. This was a known activity in the sample, and kayaking was carried out for up to 18 hours a day. Molnar (2006) also attributed hypertrophy of the clavicle at the costoclavicular ligament attachment to kayaking.

While the use of ethnographic evidence is obviously critical for linking enthesal patterns to tools, a consequential problem is matching the enthesal patterns to the evidence. It is entirely possible that other actions or combinations may create the same pattern, but remain hidden due to the ethnographic accounts. This, as Robb (1998b:363) states, is problematic for gender studies where the same pattern of enthesal change can be ascribed to different activities for men and women based on what it is thought they would have been doing (e.g. women working in the household, men in the field).

4.2.1.5 Methodological papers focussing on entheses analysis

In an attempt to assess the best way to analyse entheses, Robb (1998b) evaluated statistical techniques used to reveal population differences. Realising that basic computation of standard deviation, mean and modes had little to offer due to the ordinal nature of enthesal scores, more complicated multivariate tests including principle component analysis and cluster analysis were used. These methods look at entheses sites all over the skeleton rather than individual sites. Through this approach, Robb (1998b) highlighted that there were distinct groupings of individuals from a 19th-century working class site in Italy. This included young people and women with low enthesal scores, a mixed sex group with moderate scores and a group of men together with a single female with high enthesal scores. Robb (1998b) highlighted the importance of looking at activity patterns rather than seeking to identify specific activities.

Weiss, when observing the upper limb (Weiss 2003a) and the lower limb (Weiss 2004), argues that the best way to analyse enthesal patterns is by using an aggregation method whereby the scores were added for each bone for each individual. By using numerous enthesal sites, it was expected that correlations with age, sex, body size and activity might be clarified. Weiss (2003a) highlighted that enthesal scores in the upper limbs were highly

correlated with age, followed by sex, and then by body size. Weiss' (2004) study of the lower limb demonstrated that enthseal scores were highly correlated with age, body size and only then sex. The lower limbs appeared to correlate more strongly to these factors than the upper limbs. As the lower body's main function is locomotion, the higher correlation with age and body size is not surprising, because the legs are constantly bearing body weight. Weiss (2003a) demonstrated that age and body size could be controlled by using correlation analyses. In a study based on known occupation blue- and white-collar workers, Weiss' aggregation method identified lower entheseal scores, but greater asymmetry, in white-collar workers from America (Doyling 2010). Demonstration is thus made for the importance for age, sex and body size controls.

Due to the realisation that changes fibrocartilaginous attachments may have a stronger relationship to activity, Henderson (2009) suggests recording the surface profile of fibrocartilaginous attachments. While differences could be observed between those with and without markers, the method has not yet been used to look at different occupational groups. Furthermore, the relationship between the roughness and morphology of the marker has not been proven to be related to either the strength of the muscle or the intensity or duration of activity. Given the role of trauma and individual variation in enthesis expression, it is unlikely that this method will be used in the near future, or at least until the links between the variables are established. However, Jurmain *et al.* (2012) suggests that as the size of entheses is genetically controlled, analysis will focus on adaptations to entheses as a result of failure to cope with increase muscle mass.

4.2.2 Problems and solutions in entheses studies

Although there are many promising results from population studies of entheses, there are many problems. Other studies, including that by Cardoso and Henderson (2010), have had negative results, where no differences were observable between largely contrasting populations. A number of reasons could be suggested for this. First, a lack of entheseal pattern in some populations, especially in more modern sedentary populations, may be a result of less intensive and more varied lifestyles, and thus are genuine. Researchers

however, tend to see a lack of a pattern as a failure of the methods. This means negative results are potentially not discussed in the most helpful way. Secondly, inter-observer error plays a large role in determining the possibility of inter-site comparisons. Intra- and inter-observer error can also lead to inconsistent scoring. A lack of clarity in scoring methods renders data un-useable by other researchers. Variation in enthesal expression means that the production of standard recording methods has been problematic, and it remains uncertain what is the best way of recording enthesal changes. A recent workshop on enthesal change (Santos *et al.* 2011) highlighted this as a significant problem needing address.

Scoring is also problematic. Some authors (Hawkey and Merbs 1995, Robb 1998b,) suggest a grading scale of 0–3, whereas others (al-Oumaoui *et al.* 2004, Cashmore 2008) suggest that enthesal changes should either be scored as present or absent. This latter method avoids the problem of trying to assess grade on a change that is so variable, but may lack the sensitivity needed to highlight group differences.

4.2.2.1 Relationship between enthesal change and strength, activity and intensity

The exact nature of the relationship between muscles, enthesis morphology and stress levels is not fully understood. Currently, it is not clear what exactly enthesal changes represent in terms of muscle usage and whether development follows a linear progression equivalent to the graded system of Hawkey and Merbs' (1995). This problem has been highlighted by many authors (al-Oumaoui *et al.* 2004, Stirland 1991, Weiss 2003a), who note that many researchers forget that grades 0-3 do not mean that grade 2 is twice as big as grade 1. While on a test of known occupation skeletons from the Coimbra collection, no difference in enthesal scores was found between occupational groups (Cardoso and Henderson 2010), Godde and Wilson-Taylor (2011) have found a correlation between enthesal score and activity in a known population. Significant problems may occur from our definition of 'occupation' (Cardoso and Henderson 2013) and also occupational mobility (Henderson *et al.* 2013).

It is highly likely that there is some genetic component to the development of changes at the sites of entheses; for example, some people are predisposed to forming a lot of bone (Waldron 2009), and it is probable that these people may have elevated enthesal scores. Hormonal variation has been identified as another key factor in development (Cardoso and Henderson 2010:4) but it is not yet fully understood how this occurs. Finally, muscle development between males and females differs, which may have implications for the identification of gendered division of labour.

4.2.2.2 The impact of age on enthesal change

Age has a cumulative effect on the size and score of enthesal changes (Robb 1998b, Stirland 1998, Weiss 1998 and 2004, Wilczak 1998). Weiss (2004) identified that age was the best indicator of enthesal score in a group of British Columbians and prisoners from Quebec (i.e. older individuals had higher scores). Unsurprisingly, this means that when interpreting enthesal data, consideration of the age of individuals and according controls is required. Despite Weiss (1998) making it clear that age controls were critical when seeking clues to population activities, Weiss (2007) noted 10 years later authors were still not taking age into consideration when presenting data on population activities. Age can be controlled for by selecting the younger members of the population under study, and by carrying out correlation testing to determine whether age is a significant factor in the expression of enthesal scores. These can then be statistically controlled.

4.2.2.3 The relationship between enthesal score, sex and body size

Many authors have explored the differences between male and female patterns of enthesal change both within populations (Eshed *et al.* 2004, Lovell and Dublenko 1999, Wilczak 1998) and between populations (al-Oumaoui *et al.* 2004, Churchill and Morris 1998, Munson Chapman 1997, Steen and Lane 1998). The gendered division of labour is often a focus of research, often to establish if it changed at pivotal moments in societies. Many of the studies above have highlighted gender differences, but have been criticised for not considering the impact of sex (Weiss 2007). Sex variation of enthesal scores is largely

related to the body size difference between men and women (Weiss 2007). It has been highlighted that males nearly always have higher enthesal scores than females (Weiss 2007:931), but while some authors use activity differences to explain this, Weiss (2007) argues that when body size is taken into account, these differences disappear. In fact, primate analysis has highlighted that there is a correlation between body size and enthesal scores regardless of locomotor style (Weiss 2004:233). Although this seems discouraging, if females have higher enthesal scores than males, then these are extremely likely to be the result of activity differences. This, however, demonstrates the importance of controlling for sex and body size, and is particularly important in cross-population analyses. Importantly Robb (1998b) has argued that body size cannot be the sole dictator of enthesal scores because we observe asymmetry in enthesal scores and body mass is intrinsically controlled.

4.2.2.4 Enthesal changes and side

General right handedness is a defining characteristic of humans and occurs at a level of nearly 90% in all populations (Cashmore *et al.* 2008:7). The frequency of left handedness ranges from 0% to 27% globally (Cashmore *et al.* 2008:8). Dominance of one side therefore has the potential to create side difference in enthesal scores. Research by Weiss (2003a, 2004 and 2007) has shown enthesal scores to be correlated to side, albeit not as strongly as age. While it may be possible to control sidedness through selecting entheses from one side (as in Robb 1998b), this potentially could obscure enthesal patterns, particularly if group differences are related to laterality. In fact, Doyling (2010) found greater asymmetry in white-collar workers over manual labourers in a modern population. While enthesal asymmetry is usually the result of activity, a differential cause is highlighted by a Neolithic Siberian individual who had pathology which caused severe upper limb asymmetry in enthesal scores (Lieverse *et al.* 2007).

4.2.3 Criteria for the use of entheses in activity reconstruction

Key criteria can be gleaned from the research presented above. First, enthesal changes cannot be used to reconstruct activity on an individual level. Too many activities can be carried out using one motion and individual variation in the expression of enthesal changes is too great.

Second, as highlighted in sections 4.2.2, multiple factors influence the expression of changes at enthesal sites (sex, body size, age and handedness). Weiss (2007) demonstrated that enthesal changes can provide evidence of past activities and actions, but there remains debate as to whether elucidation of patterns of activity is possible from the mixture of other confounding factors affecting enthesal change development. However, studies in section 4.2.1 demonstrate that these factors can be controlled and that the study of entheses can be fruitful in highlighting population differences.

Third, it is important that enthesal scores are considered across a section of the body, whether this is a bone, upper body or lower body. Aggregation techniques are key in identifying when body size is a significant factor in the expression of enthesal change. Importantly, as the lower limbs have been shown to reflect patterns of mobility rather than activity, population differences are more likely to be linked to upper limb enthesal change.

4.3 Non-pathological articular modifications and activity

4.3.1 Definition of non-pathological articular modifications

Articular modifications are changes to joint surfaces and associated connective tissue, which are caused by repetitive activity and the habitual adoption of certain postures such as kneeling, squatting and hyperdorsiflexion of the ankles and toes. Joint alterations include extra facets, extensions to articular surfaces and increased or extra sites of muscle attachment (Barnett 1954, Capasso *et al.* 1999, Molleson 1989, Ubelaker 1979). The following sections outline common articular modifications and the research questions that

have been addressed. The modifications discussed are related to the lower limb as the historical information in chapter 3 has indicated that ritual observation of prayer, which contains a specific set of movements, could result in a number of joint modifications.

4.3.2 The use of articular modifications for inferring activity

The adoption of certain postures can be linked not only to activities, but also to groups that practice them. Accordingly authors have studied articular modifications to explore population differences. In many early studies, the presence of some modifications (namely the squatting facet on the tibia) was used to discern between modern ‘civilised’ and more ‘primitive’ man (Martin 1932, Quarry-Wood 1920). Although today the presence of squatting facets has nothing to do with degrees of being ‘civilised’, research on articular modifications demonstrates that we can observe posture variations caused by social circumstances (in this case absence of chairs). Thus, the study of articular modifications can be a key to exploring social differences and changes. The following sections outline modifications found in the femur, tibia, talus, metatarsals and phalanges.

4.3.3 Identification and location of non-pathological articular modifications

This section explores commonly studied articular modifications by the region in which they appear on the skeleton. It assesses modification causes, and their suitability as an indicator of habitual posture adoption.

4.3.3.1 Articular modifications of the femur

Squatting and kneeling are thought to be the cause of many femoral modifications. Extra facets on the proximal and distal joint surfaces of the femur have been described (Charles 1893, Kostick 1963, Martin 1932, Poirier and Charpy 1911 and Walmsley 1915). The proximal and distal femur is considered separately as they have differing movement functions.

4.3.3.1.1 Articular modifications on the proximal femur

As the hip can be hyperextended during squatting, archaeologists have described numerous squatting-related modifications to the proximal femur. These include Poirier's facet (Charles 1893, Poirier and Charpy 1911), articular border convexity (Charles 1893), the anterior cervical imprint (Kostick 1963) and posterior cervical imprint (Kostick 1963). However, all four have yet to be associated convincingly with squatting. Poirier's facet in particular has been extensively studied (Kostick 1963, Martin 1932 and Trinkaus 1975), and, due to its high frequency in non-squatting populations (Trinkaus 1975), has been ruled out as substantial evidence for squatting. The posterior cervical imprint or Walmsley's facet is found on the posterior of the femoral neck, which is laterally limited by a tubercle bordering the medial margin of the groove for the obturator externus tendon (Capasso *et al.* 1999). The anterior cervical imprint, or Allen's fossa, is described as a facet on the anterior inferior aspect of the medial part of the femoral neck (Kostick 1963:395). Kostick (1963) suggests that the posterior and anterior cervical imprints on the proximal femur are induced by hip extension during squatting. However, as hip extension occurs in locomotion, including running and walking, these facets can not be used as evidence for squatting. As a result of these studies, Kostick (1963) argued that bony modifications of squatting were more evident in the distal femur than the proximal portion. This is because the relationship between the modifications on the proximal femur and squatting are academically insecure.

4.3.3.1.2 Articular modifications to the distal femur

Like the proximal femur, many squatting and kneeling modifications have been described in literature for the distal femur. These have been summarised by Martin (1932), Kostick (1963), Trinkaus (1975) and Capasso *et al.* (1999). An enlargement of the medial femoral condyle (Charles' facet) was first described by Charles in 1893 (Charles 1893). It was thought to be an enlargement of the articular surface created by contact with the tibial condyle in extreme flexion. Charles' facet has since been dismissed as squatting evidence, but is a variation in the origin of the gastrocnemius muscle (Capasso *et al.* 1999, Kostick 1963).

During hyperflexion of the knee, the posterior aspect of the femoral condyles makes contact with the tibial condyles. Prolonged squatting will create flattenings or facets on the lateral aspect of the femoral condyle and, in more extreme cases, this may become an osteochondritic imprint (Capasso *et al.* 1999). Although evidence for their existence in Neanderthals was inconclusive (Trinkhaus 1975), and their aetiology unclear (Kostick 1963), the presence of flattened areas and imprints in known-squatting populations from western Nigeria, combined with a lack of other explanation, makes the adoption of squatting position, or extreme knee flexion, seem the most likely cause (Trinkhaus 1975).

In addition to condyle facets, tibial imprints on the posterior supracondylar femur surface have been described as being a result of knee hyperflexion, created by contact between the posterior femoral diaphysis and the posterior medial tibial condyle border. Kostick (1963) suggests that a tubercle on the medial condyle of the tibia is driven up into the diaphysis of the femur and the bigger the tubercle, the bigger the imprint. This feature was also described in the squatting population from Nigeria (Kostick 1963).

4.3.3.2 Articular modifications to the tibia and talus

As mentioned above, during flexion of the knee, the femoral condyles are forced against the posterior border of the proximal tibia and the patella ligament is pulled taut. The force from these two actions is thought to cause tibial head retroversion or, as described by Boule (2001b:50), a backward inclination of the tibial plateau. Studies of tibial retroversion and squatting have provided contrasting results. While a high level of tibial retroversion was seen in Neanderthals who had squatting-related modifications in the knee, ankle or hip, lower rates were observed in modern Yugoslavians and Egyptians with lateral squatting facets (Trinkhaus 1975). Boule (2001b) suggests that tibial retroversion results from prolonged flexion while in utero, and if this is not continued after birth and through childhood, the retroversion is reversed. Prolonged knee flexion while adopting various positions of kneeling can also cause retroverted tibia (Quarry-Wood 1920). Boule (2001a) suggests that retroversion is not caused by squatting, but instead by kneeling as indicated by the evidence from Quarry-Wood's studies. Further work is required on this form of modification to establish more clearly its aetiology.

Anterior distal tibial squatting facets and squatting facets on the talar neck are some of the most commonly described ARSM features (for example Ari *et al.* 2003, Barnett 1954, Boulle 2001a, Boulle 2001b, Dlamini and Morris 2005, Finnegan 1978, Oygucu *et al.* 1998, Quarry-Wood 1920, Satinoff 1972, Singh 1959, Thomson 1889, Trinkaus 1975 Ullinger *et al.* 2004). Thomson described the facets first in 1889 as a ‘facet upon the anterior margin of the lower articular surface of the tibia and the neck of the astragalus’ (Thomson 1889:619). Failure to distinguish a ‘true squatting facet’ from trochlear extensions led to confusion over the form and the location of the true squatting facet on the talus. As a result, Barnett (1954) attempted to classify these features to differentiate true squatting facets from trochlear extensions. Five different variations were suggested by Barnett (1954:509), which were later used by Singh (1959) to explore the genetic predisposition of the tibial and talal squatting facet:

- 1, A forward elongation of the medial articular trochlear surface of the talus with a corresponding facet on the anterior tibia; it can extend onto the lateral part of the medial malleolus.
- 2, A rectangular surface on the medial surface of the upper surface of the neck of the talus. This is essentially a prolongation of the trochlea on the medial side. It is not a squatting facet as it comes into contact with the trochlear surface of the tibia rather than the anterior margin.
- 3, A medial facet found on the dorsal surface of the neck of the talus which is clearly demarcated from the trochlear surface. Although there is no corresponding facet on the tibia, it has been found to be related to squatting (Barnett 1954), so is termed the medial squatting facet.
- 4, The lateral surface of the trochlea of the talus can also be extended. It is in contact with the trochlear surface of the tibia and is therefore not a true squatting facet.

5, Smooth facet on the dorsal lateral surface of the talus. This facet articulates with a well-marked facet on the anterior portion of the distal tibia. The facet on the talus is usually well demarcated from the trochlear surface. This is the lateral squatting facet and is the one originally described by Thomson (1889) (See figure 4.1).



Figure 4.1 Lateral squatting facets highlighted in red (left tibia, right talus) (author's own photograph)

Only the fifth category can be truly classed as squatting facet. The cause and occurrence of the other four facet categories are not entirely understood, and accordingly, a strong relationship with activity cannot be established. It is the fifth category that is generally used in osteoarchaeological study, however the tibia and talus facets are not always considered together and some authors score presence with only one of the elements present (e.g. Ari *et al.* 2003, Oygucu *et al.* 1998).

Singh (1959) found that European foetuses have more lateral squatting facets than Indian foetuses, yet Indian adults had a far higher prevalence than European adults. This can be attributed to more frequent and habitual squatting in Indian society and greater chair usage in Europeans. This is in line with the observations made by Barnett (1954).

Two different types of lateral squatting facet have been described (Boulle 2001a). It is obvious from earlier work (Singh 1959) that squatting facets are present from birth, but may disappear in adult life if the mechanical demands required to maintain the facet are not

met. If pressure is not maintained on the facet, the capsular ligament will obliterate the facet (Barnett 1954). However, Boulle (2001a) suggests that another type of facet known as ‘pressure facets’, can be induced during life. Body weight placed on the neck of the talus via the anterior tibia, is likely to remodel the talar neck. These facets can be differentiated visually from normal (congenital) facets. A normal facet is that of the kind described by Barnett (1954) and is usually smooth. Pressure facets are slightly raised from the rest of the neck of the talus. They are smooth and well delimited (see page 148). In addition, radiological differences may be observable between the induced pressure facet and the facet present from birth (Boulle 2001a). A true squatting facet is characterised by increased cortical bone on the dorsal surface of the neck of the talus. In contrast, a pressure facet has less cortical thickening, but the edges are demarcated from the dorsal surface of the talus. Both the macroscopic and the radiological differences are hard, but not impossible, to observe.

4.3.3.3 Articular modifications on the metatarsals and phalanges

Ubelaker (1979) has described metatarsal modifications of the dorsal margin of the distal joint surface. Extreme metatarsophalangeal hyperdorsiflexion places body weight onto the distal joint surfaces of the metatarsals and proximal joint surfaces of the proximal phalanges. The distal metatarsal joint surface becomes elongated along its dorsal surface and can form a distinct ridge (see figure 4.2). The first phalanx of the big toe forms bony protuberances on the superior surface, extending distally from the proximal articular surface (Ubelaker 1979:679). In addition to Ubelaker’s (1979:679) observations on the metatarsals and helical proximal phalanx, alterations to the proximal joint surface of the second to fifth proximal phalanges have been noted (Molleson 1989). The superior edge of the proximal joint surface becomes thinner and wedged dorsally. This allows the metatarsophalangeal joint to hyperdorsiflex further as the plane of articulation has become more superiorly inclined (Capasso *et al.* 1999).

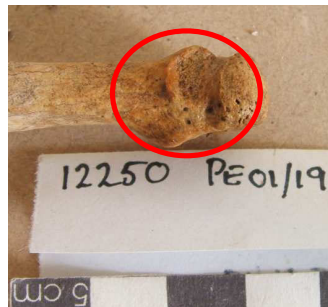


Figure 4.2 Metatarsal extension highlighted in red (authors own photograph)

4.3.3.4 Articular modifications of the patella



Figure 4.3 Vastus notch on the patella (authors own photograph)

Finnegan (1978) described the vastus notch as a small notch in the superolateral border of the patella (figure 4.3). Critical for the observance of the trait is the rounding of the border. The vastus notch is the site of the attachment for the vastus lateralis tendon, and the trait is therefore thought to relate the use of the vastus lateralis muscle. Capasso *et al.* (1999:F106) associate vastus notches with chronic and persistent kneeling.

4.3.4 Articular modifications as an indicator of activity in archaeology

Less research has been undertaken on femoral modifications than tibial and talus squatting facets. This may be due to the difficulty in identifying femoral modifications and the limited amount of research which exists on the subject. Regardless, Kovacic *et al.* (2004) examined Charles' facets, Martin's facets and osteochondritic and tibial imprints in a

Byzantine population thought to have undertaken genuflexion daily as part of religious observance. All four traits were found in over 75% of individuals, with Charles's facet present in 94% of individuals, Martin's facet in 77%, osteochondritic imprints in 79% and tibial imprints in 87.5%. Kovacik *et al.* (2004) compared these results to known squatting Nigerian populations and found higher prevalence of tibial imprints but lower prevalence of Martin's facets. The number of osteochondritic imprints was comparable to Nigerians. Kovacik *et al.* (2004) point out that both populations had a higher prevalence than most other *Homo sapien* groups. The authors advocated that the force of getting up and down during many multiple genuflexions would create changes in the articular cartilage of the knee. The high frequency of Charles and Martin's facets in non-squatting populations makes the choice of these modifications for examination confusing as they are not yet confidently linked with squatting or kneeling.

The presence of tibial and talar squatting facets has been taken as evidence for a number of activities and postures adopted in the past. Ari *et al.* (2003) examined the prevalence of tibial squatting facets in a 13th-century Byzantine sample. Frequency comparison between modern Europeans, Australians and Indians demonstrated that the Byzantine sample had a higher rate than contemporaneous Europeans, but less than the other two samples. The authors argued, through the use of comparative data, that the appearance of squatting facets is subject to different factors in different populations, yet did not speculate as to what these differences might be. They also added that pes valgus deformity may induce squatting facets, but failed to say how this conclusion was derived from the study presented; no data regarding the frequency of the deformity is given. The authors failed to state whether their methods matched those used on the comparative material, and hence the inter-population comparison may be affected.

The analysis of single non-pathological modifications provides little information about specific past activities, as multiple activities can be carried out in a squatting position. Therefore most studies use multiple modifications and additional types of evidence to inform about past lifestyles.

As outlined earlier, Boulle (2001b) examined the presence of lateral squatting facets and tibial retroversion in a diachronic (1st – 20th centuries AD) analysis of French and American archaeological series. A decrease in frequency of the lateral squatting facet over time reinforced the idea that a change in social attitudes and the production of chairs meant that squatting as a posture declined in the Middle Ages to modern times.

Similarly to Boulle (2001b), Dlamini and Morris (2005) examined the prevalence of tibial squatting facets of four South African groups and the relationship to historic information on furniture and ethnicity; Later Stone Age (LSA) foragers, Iron Age (IA) farmers, free black slaves (18th century) and modern South Africans. Only LSA foragers and IA farmers had evidence for a wide adoption of the squatting posture. Only a single free slave had a squatting facet in the modern material. Like Boulle (2001b), the authors suggested that changing use of furniture and house space caused a decrease in the use of the squatting position over time. In addition, cultural and individual preference in posture adoption may influence squatting-facet prevalence in past peoples.

Ubelaker (1979) described bony alterations to the metatarsals, which he believed were caused by prolonged hyperdorsiflexion of the metatarsophalangeal joint adopted while in a kneeling position. The prevalence of metatarsal alterations correlated positively with femoral condyle flattening. No specific activity was proffered as an explanation for the modifications beyond that of a prolonged kneeling for rest or adoption of the posture for work activities.

In one of the only research projects using multiple indicators, Ullinger *et al.* (2004), Ullinger *et al.* (2005) and Kovacik *et al.* (2004) assessed femora, tibiae, tali, metatarsals and phalanges in two groups from medieval Jerusalem to look for evidence of genuflexion and toe hyperdorsiflexion during prayer. The authors found that there was little difference in the prevalence of squatting facets between the monastic (St Stevens) and lay community (Umm el-Jimal), suggesting similar levels of hyperdorsiflexion in both populations. Although the frequency of metatarsal extensions was higher in the monastic group, it failed to reach a level of statistical significance. When other factors, including eburnation,

osteophytic growth and surface porosity were considered, the monastic group appeared to have placed greater strain on their joints, thus providing evidence for more prolonged kneeling in the monks, and possibly prayer (Ullinger *et al.* 2004, 2005). The average age at death however was not fully considered by the authors, as this could not be ascertained for the lay group. It may have played a role in the higher level of osteoarthritis in the monastic group and makes this result a little unsound.

Molleson (1989) also observed the metatarsal extensions in some individuals from Abu Hureyra, Syria but, in addition, recorded wedging of the proximal superior surface of the proximal phalanges two to four, as well as the ankle modifications. The author deduced from the shape and size of the querns that the body was moved backwards and forwards by pushing from hyperdorsiflexed toes. Molleson (1989) believed this to be the cause of the skeletal changes at Abu Hureyra. Other evidence taken from musculoskeletal stress markers included well developed deltoid and radial tuberosity attachments. These were attributed to prolonged use of the biceps muscles occurring through pushing the saddle quern backwards and forwards over the grain.

Lai and Lovell (1992) have also used metatarsal modifications as an indicator of prolonged kneeling. Hyperdorsiflexion of the metatarsophalangeal joint while canoeing up river has been suggested as the cause as it was an ethnographically known occupation for the fur trade post men from which their sample derived.

4.3.5 Criteria for the use of articular modification in activity reconstruction

It is clear that many changes can occur to the articular joint surfaces, some of which are not related to activity. It is therefore critical that the modifications selected to assess population differences are demonstrated to be strongly linked to activity. Only the lower body has been studied in terms of modifications to joint surfaces. This may be due to the fact that a significant amount of mechanical demand is needed to alter the bony outline of joints. Analysis should therefore be restricted to this area of the body. It also seems that a combination of markers provides the best means to highlight activity patterns as single modifications can be created by multiple actions. Observation of prevalence rate changes

seems to be the optimum approach for analysis of modifications and for assessment of temporal changes. Finally, more specific activities can only be observed when historical, ethnographic or strong artefactual evidence is present.

4.4 Osteoarthritis and activity

4.4.1 Definition and aetiology of osteoarthritis

Osteoarthritis (OA) is the inflammation of a synovial joint caused by degeneration or damage to the articular joint cartilage, and a destruction or decrease in the synovial fluid within the joint cavity (Rogers and Waldron 1995). Initially thought to be a result of the ageing process, it is now clear that many other factors, including level of biomechanical demand, anatomy and genetics, play a substantial role in the development of OA (Roberts and Manchester 2005, West 1997). The exact reasons for cartilage deterioration are not fully understood (Ortner 2003). Hunt and Mann (2005:18) detail two different mechanisms relating to the two different clinical classifications. Primary (idiopathic) OA is described as diminishing ability of chondrocytes (cartilage producing cells) to maintain joint cartilage, resulting in the synovium releasing enzymes that break down the cartilage (Hunt and Mann 2005:18). Primary OA occurs later in life and affects over 85% of the American population over 70 years of age (Seeley *et al.* 2000). Secondary OA results from trauma induced inflammation to the cartilage (Ortner 2003). The normal cartilage is degraded by enzymes released from damaged cartilage (West 1997). The secondary form can appear in much younger individuals, usually as a result of other pathological conditions such as joint distortion from fracture or very high-impact, repetitive loading.

Osteoarthritis is the most common form of arthritis reported in clinical and archaeological samples (Roberts and Manchester 2005:136, Rogers 2000:163). Bony changes associated with OA were initially thought to be the result of degeneration of cartilage, but may actually represent skeletal responses to repair and stabilise the joint (Rogers 2000:166). Multiple changes to joint tissues exist in OA, three of which directly involve bone. Ortner (2003:546) described them as follows: 1) breakdown of articular cartilage, which may lead to bone on bone contact causing eburnation; 2) sclerosis of the subcondral compact bone,

underlying trabeculae and cyst formation; 3) cartilage and new bone formation at the joint margins resulting in alteration of the bony contour. Early signs and clinical diagnoses of the disease include joint space narrowing and pain, neither of which are visible archaeologically. This means that prevalence rates calculated from clinical and archaeological settings may not be comparable. However, the more advanced signs visible to the osteoarchaeologist include sclerosis, eburnation and new bone growth.

4.4.2 Causes of osteoarthritis

Although OA can affect any synovial joint, it usually occurs in the weight-bearing joints of the body (Hunt and Mann 2005:18) supporting claims that mechanical stress is the major contributing factor for the development of OA (Larsen 1997). Significantly, the role of increased mechanical demand in development of OA has been demonstrated by the link between obese individuals tending to develop OA in the major weight-bearing joints of the skeleton, particularly the knee and hip (Waldron 2009). Persistent and repetitive use of joints accelerates the breakdown of joint cartilage. This is supported by a large body of research demonstrating that certain groups, particularly those involved in manual labour or physically demanding sports, will develop specific patterns of OA (e.g Baetsen *et al.* 1997, Coggon *et al.* 2000, Croft *et al.* 1992, Jordan *et al.* 1997, Thelin *et al.* 2004). There is strong clinical evidence to suggest that a significant risk of developing knee OA exists in individuals who engage in occupations requiring prolonged squatting and kneeling (Coggon *et al.* 2000). However the link between repetitive activity and OA is not straightforward. For example, the London Spitalfield master weavers had no more hand OA than non-weaving peers (Waldron and Cox 1989). Solomon (2001) suggested that repetitive action may not be the overriding factor, but impact stress is more important in developing OA. This would explain why patterns of OA were seen in builders but not in weavers. Finally, Rothschild (2003) has demonstrated in guinea pigs that living in an artificial environment can also contribute to OA development. In this research it was shown that wild guinea pigs had significantly lower OA prevalence than captive guinea pigs.

The range of movement for some joints has changed as part of hominid evolution. This has made some joints more susceptible OA, as they are not fully adapted to accommodate the

movement, such as the spine, as a result of bipedalism (Roberts and Manchester 2005) and the first metacarpal phalangeal joint, with acquisition of the ability to oppose the thumb (Rogers 2000). Carrying out ergonomically efficient work may inhibit the development of OA, explaining why some long-distance athletes and sportsmen do not appear to develop OA (Stirland 1998).

Genetics both influence an individual's predisposition to the development of OA, and controls the body's response to the disease. Monozygous and dizygous twin studies have indicated that the expression of OA is up to 50% genetic, with the level varying depending on the examined joint. Hip and spinal osteoarthritis have the highest level of heritability (Weiss and Jurmain 2007:439). This was supported by Kier *et al.* (1986), who identified a higher level of sternoclavicular OA in American blacks than whites. Sex differences are also observable in patterns of OA. Males have more cases of hypertrophic new bone growth, where as females generally appear to have a higher prevalence of OA than males later in life (Ortner 2003). This may suggest a hormonal influence in the later development of the disease. Interestingly, and conversely, Steinbock (1976) argues that OA more commonly affects males in archaeological populations. Although the results from twin and familial studies suggest that the use of osteoarthritis as a behavioural indicator may be flawed, it should be remembered that the degree of environmental influence is unknown and may inflate the perceived level of heritability.

The prevalence of osteoarthritis correlates positively with age, yet some joints appear to be affected differently. Jurmain (1980) demonstrated that hip and shoulder osteoarthritis tended to be more age-related than osteoarthritis of the elbow or knee. Positional differences between the shoulder and elbow, and the hip and knee may explain this feature, with the elbow and knee being further from the body, they are under different stress levels. Another explanation proffered by Jurmain (1980) is that the anatomy of the joints has an impact; the hip and shoulder are ball-and-socket joints and are thus more capable of distributing stress over a wider surface area. Other studies have suggested alternative joint involvement patterns, and that these may have varied over time. For example, it is thought that osteoarthritis of the knee is a more modern phenomenon (Waldron and Cox 1989).

Baetsen *et al.* (1997) demonstrated that hip OA was comparatively more prevalent in the medieval period than OA of the knee. Post-medieval samples demonstrate the opposite trend (Ortner 2003:574, Waldron 2012:518). This makes it very difficult to demonstrate a typical pattern of age-related OA and it is possible that one does not exist because age is not the sole dictator of OA.

4.4.3 Osteoarthritis at specific joints

This section explores osteoarthritis at each of the major synovial joints of the human skeleton, paying specific attention to clinical prevalence and causes.

4.4.3.1 Osteoarthritis at the acromioclavicular joints

Acromioclavicular osteoarthritis is largely idiopathic (West 1997) and is commonly observed in the elderly (Waldron 2009). In a clinical study, Heine (1926) found no cases in individuals below 40 years, but 12.3% of individuals over 70 years were affected. Rockwell and Matson (2009) suggest that acromioclavicular OA is under-recognised in modern populations as x-ray and tomography do not always identify the condition. Rockwell and Matson (2009) state that acromioclavicular OA can also be caused by extreme labour and sports, which may be important in past populations where it is observed frequently (Waldron 2009).

4.4.3.2 Osteoarthritis at the glenohumeral joint

Glenohumeral OA is rare in archaeological and modern populations (Ortner 2003, Waldron 2009). As the shoulder is a non-weight bearing joint, it limits the risk of developing OA. The development of the disease is usually secondary (Ortner 2003, West 1997, Aufdeheide and Rodriguez-Martin 1998). As such, trauma and morphology alteration through disease are usually the cause of OA at this joint. Accordingly, in most clinical studies hip and knee OA has higher prevalence than glenohumeral OA. However, in studies on past populations, glenohumeral OA can be more prevalent than in the hip or knee (e.g. Bridges 1991, Klaus *et al.* 2009). The secondary nature of shoulder OA suggests that, in the absence of other conditions, trauma is the likely explanation in these groups.

4.4.3.3 Osteoarthritis at the wrist

Wrist OA is rare in modern populations as it does not bear body weight. It is unsurprising then that Schoen (2000) cited injury as the cause of OA at the wrist. Significant wrist OA develops as a result of trauma. When not a result of fracture, wrist OA has been identified in racket ball players and electricians (Sullivan and Krieger 2001).

4.4.3.4 Osteoarthritis at the hip

The prevalence of hip osteoarthritis varies by population and diachronically. While there is no doubt that scoring-method variation is responsible for some of these differences, inter-population studies undertaken by single researchers have demonstrated inter-population variation (e.g. Thelin *et al.* 2004). As a major weight-bearing joint of the body, it is unsurprising that hip OA develops idiopathically during senescence. However clinical studies have demonstrated that a number of occupations have a higher risk of developing the disease. Thelin and Holmberg (2007) identified construction work, mining, ballet, abattoir working and farming to increase the risk of disease development. Croft *et al.* (1992) also identified increased risk of hip OA in farming communities. Both studies suggested that increased manual load was a significant factor in the development of the disease. In earlier research, Thelin *et al.* (2004) identified an immunological factor in development of hip OA in farming groups. Farmers working closely with animals had a higher risk of the disease than other types of farmers. This may explain higher hip OA in abattoir workers as they also work with animals. This is an important factor when considering early medieval populations, who may have lived and worked in the same buildings as their animals, upon which they heavily relied for economic reasons.

4.4.3.5 Osteoarthritis in the knee

As a major weight-bearing joint of the body, the knee is subject to stress during many activities. For this reason, the knee has one of the highest osteoarthritis rates of any joint in the human body, and is often the first site of involvement in the skeleton (Ortner 2003:547), usually appearing by the third decade of life in modern populations (Hunt and Mann

2005:196). Knee morphology makes it susceptible to OA at three locations, with the level of involvement correlated to the biomechanical stress imposed on each area. The most commonly affected areas are the medial tibio-femoral and patello-femoral joints, in contrast to the lateral tibio-femoral articulation, which tends to be less affected (West 1997). Clinical studies of knee OA have further reinforced the notion that biomechanical factors influence disease rates. It is relatively common in obese women (Weiss and Jurmain 2007), and results from occupations that require prolonged squatting, climbing and kneeling (Coggon *et al.* 2000).

4.4.3.6 Osteoarthritis in the ankle and foot

Ankle osteoarthritis is extremely rare and usually the result of trauma (Aufderheide and Rodriguez-Martin 1998, Rogers 2000). The ankle is surrounded by numerous strong ligaments (Standring 2008), which efficiently maintain the integrity of the joint. As a major weight bearing and locomotive joint, this strong attachment is critical. The most affected foot joint is the first metatarsophalangeal (MTP) joint, potentially related to its importance in the role of weight bearing and function as a lever. Factors that might increase the prevalence of MTP osteoarthritis include long periods of walking over uneven terrain (Lieverse *et al.* 2007) or the use of fashionable footwear (Ortner 2003).

4.4.4 Osteoarthritis studies in archaeology

OA is the most common of all the joint diseases (Rogers 2000). As mechanical stress is a major contributing factor (Larsen 1997), the condition has been used to reconstruct the activities of past peoples in order to investigate past social behaviour. However, scholars disagree over the efficacy of OA in highlighting population differences; some suggest that studying it to yield information about occupation is pointless or stretching limited evidence too far (e.g. Waldron 1994). The highly variable nature of osteoarthritis expression means it may be possible to identify population activities in some groups but not in others. Nevertheless, intra-population studies have been used to examine sex differences (Sofaer Derevenski 2000), status differences (Knüsel *et al.* 1997), occupation (Stirland 1991), rural-urban differences (Jordan *et al.* 1997) and major transitions in human life styles (Larsen 1995).

One of the major issues with the study of osteoarthritis in archaeological populations is its age-related nature. If a large number of older individuals are included in a study, the results may reflect nothing more than the ageing process. This has been controlled by selecting the younger members of the population (e.g. Sofaer Deverenski 2000) and/or assessing by age category (e.g. Jurmain 1980, Knüsel *et al.* 1997, Lieverse *et al.* 2007, Lovell 1994, Rojas-Sepulveda *et al.* 2008).

Klaus *et al.* (2009) sought to explore changing patterns of behaviour with the arrival of the Spanish and the subsequent integration of indigenous peoples from Peru into a new political and economic system. Through observation of appendicular osteoarthritis, Klaus *et al.* (2009:204) observed that while both post-contact men and women had elevated scores of OA, the increase was much more marked in men. Joints which demonstrated an increase in OA prevalence included the shoulder, elbow, wrist and knee. A sharp increase in young individuals suffering with OA was believed to reflect an increase in biomechanical loading, as normal parameters for age-related OA would not yet apply to these individuals.

Inter- and intra-observer variability play a substantial role in the recognition of the disease. Disagreement exists over what changes are attributable to OA, and when they are serious enough to be recorded as disease (e.g. Rogers *et al.* 1981). Only eburnation is unanimously agreed to be unequivocal evidence for OA (Rogers 2000: 166, Rogers and Waldron 1995, Rojas-Sepulveda *et al.* 2008). Additionally, Sofaer Deverenski (2000) warned that some studies focus on one indicator only, which produces a partial picture of the disease. This is extremely problematic considering the debates surrounding what skeletal changes are attributable to the condition. Subsequently, inter-population comparisons become highly problematic and almost impossible. Further issues arise from the lack of standard recording methodology. This was exemplified by Rogers (2000), who noted substantial differences between various English medieval populations, but quickly identified that this could be attributed to differential data collection methods and variable definitions of what was recordable as OA.

To examine whether there was a change in workload during the shift from hunter-gathering to agriculture, and to assess the impact of the shift on human demography, authors have studied OA prevalence (e.g. Larsen 1997, Liewerse *et al.* 2007). This has produced a wide range of results which have challenged the view of the hard existence of the hunter-gatherers (Larsen 1997). Although hunter-gathers tend to have a higher level of OA than agriculturalists, this was not always the case. No significant pattern of OA was attributable to hunter-gathering or agriculturalism individually (Larsen 1997:169), and different OA patterns were observed in the same population types. Larsen (1997) suggests these are the result of terrain difference. In examining the hiatus spanning the transition to agriculture in the Cis-Baikal region in Siberia, Liewerse *et al.* (2007) noted that although levels of activity appeared to remain constant over the hiatus, changing patterns of OA demonstrated that the range of mobility and the activities undertaken might have changed.

A famous study of the relationship between OA and specific occupations was carried out by Merbs (1983) on the Sadlermiut Eskimos, North America. The pattern of OA observed accorded well with ethnographically known activities (Larsen 1997:168). This included kayaking in males and hide chewing in females. Overall, high levels of osteoarthritis reflected the harsh living circumstances in a challenging environment. This research demonstrated the importance of using documentary evidence when interpreting activity patterns from osteoarthritis.

4.4.5 Criteria for the use of osteoarthritis in activity reconstruction

Patterns of OA are useful for activity reconstruction when used on populations that carried out repetitive heavy loading, particularly from a young age. The picture becomes less clear when work is light like weaving, or in non-weight bearing joints, such as the hands.

Various factors need to be controlled as far as possible. Age and sex can be controlled in sample selection, but it is nearly impossible to control for environmental and genetic predisposition in archaeological studies. Many of the studies cited above have used other types of data such as artefactual, historic or ethnographic to support their conclusions. This care in interpretation is crucial in the reconstruction of past activities.

4.5 Metric and geometric bone measurements

This section considers the aetiology of metric variation in bone and then evaluates how data has been used to explore social changes in published research. Analysis of the skull is excluded as it does not comprise part of this research as variation in cranial measurements is primarily related to genetics rather than activity (Mays 2010:96).

4.5.1 Definition/aetiology of morphology changes

Interest in bone morphology was sparked from the great variation in human shape and form visible globally (Ruff 2002). The length and shape of bones are generally dictated by genetics, but final size can be influenced by one, or a combination of external environmental factors (e.g. Larsen 1997, Mays 2010, Pomeroy *et al.* forthcoming, Zakrzewski 2003). Research involving bone measurements has moved from dubious definitions of race and hominid classification (Roberts 2009), to estimation of the impact of loading, differences caused by lifestyle/environment (Maggiano *et al.* 2008, Marchi *et al.* 2006, Mays 1999, Nikita *et al.* 2011, Ruff 1987, Ruff 2001, Sparacello *et al.* 2011, Stock 2006, Stock and Pfeiffer 2001, Weiss 2005, Wescott 2006) and variation in sexual dimorphism (Humphry 1998, Pomeroy and Zakrzewski 2009). These studies have used a mixture of absolute measurements, articular surface morphology and cross-sectional dimensions to explore differences between groups and diachronic change. This section examines the premises behind the use of such measurements in archaeology and their ability to detect social change and activity-pattern difference.

4.5.2 The use of bone measurements to explore activity and social change

4.5.2.1 Absolute measurements (metric)

Metric or absolute measurements can include bone lengths, widths and circumferences. Largely, absolute measurements have been used to explore global and temporal variations in stature (e.g. Roberts and Cox 2003, Shin *et al.* 2012, Tanner *et al.* 1982). Research has indicated that stature has proven to be a good indicator of stress exposure (Larsen 1997, Tanner *et al.* 1982), particularly of stress in childhood and adolescence (Roberts 2009). For

example, Bogin *et al.* (2002) explored differences in achieved adult height between Maya children living in poverty in Guatemala and Maya children that migrated to the USA. The greater adulthood height of the migrated group suggested that stature was a good indicator of a better environment (diet and health). In this case, it was likely to be improvements in living conditions. There has been a secular increase in stature in most populations as improvements to living conditions occur, access to medicine increases and nutritional status improves (Roberts and Cox 2001). Studies have particularly emphasised the importance of adequate nutrition (e.g. Gray and Wolfe 1980).

Other factors are significant in the determination of adult height. As highlighted by Larsen (1997:14), socially advantaged individuals from disparate global regions are different in height e.g. the most socially advantaged people from Holland are far taller than the most socially advantaged people from Japan and suggests some predetermined height. It is, however, uncertain as to how this global variation occurs as Ruff (1994) has demonstrated little correlation between stature and latitude. Body breadth has a better correlation with geographic region (Ruff 1994, 2002) as a result of climatic adaptation. Individuals in cold climates have wider bodies than those in hotter environments. This is related to thermoregulatory principles with individual in colder climates having lower surface area/body mass ratios (Ruff 1991).

The length of individual bones has been taken to explore other changes in activity. Studies have largely focussed on patterns of asymmetry (e.g. Kujanova *et al.* 2008, Mays 2002, Stirland 1993). Two forms of asymmetry exist; endogenous (genetic) and exogenous (environmental) (Auerbach and Raxter 2008:663). Of importance here is the exogenous factor of mechanical activity. Preference of one side over another and the resulting increase in mechanical strain often results in size differences between sides. This is known as directional asymmetry, which can be used to assess activity pattern differences in past populations.

Other research has assessed differences in the relative proportions of the long bones with a view to understanding differences in body shapes. Of particular interest is limb-segment

variation (Auerbach and Sylvester 2011) and brachial and crural indices. The brachial index is the relationship between radial and humeral length, with crural index being the relationship between the tibial and femoral (Schwartz 1995). Trinkaus (1981) identified correlations between temperature and long bone ratios, but Auerbach and Sylvester (2011) suggested that many factors may change indices between groups, and temperature is not the sole dictator of segment ratios. Holliday and Ruff (2001) studied the relative proportion of limb bone lengths between 20 different groups from various geographical locations. Holliday and Ruff (2001) sought to address whether proximal or distal limb bones have greater variability, and whether proximal or distal limb segment lengths are particularly correlated with temperature. The research demonstrated that within groups, distal limb segments (tibia, radius and ulna) varied more than the proximal segments (femur and humerus). Between sexes, the lower limb segments varied equally, but in males the tibia showed the greatest variation. They were unable to definitely state whether there were significant intergroup differences due to low samples sizes.

Indices created from whole measurements have also been used to assess limb bone robusticity as a measure of strength. This has been criticised because it does not take into account the internal structure of bone, which is pivotal in the distribution of stress. However, Ruff *et al.* (1984) suggested that a relationship does exist between the external dimensions of bone and the distribution of bone within. This means that it is possible to examine differences in stresses imposed on bone through external morphology. Good examples include studies focusing on changes to the femoral shaft shape with the transition to agriculture (Capasso *et al.* 1999, Larsen 1997). Loss of mobility results in rounder cross sections (Larsen 1997). As such, external dimensions have been used as a measure of strength (e.g. Bridges *et al.* 2000, Wanner *et al.* 2007, Westcott 2006) to examine changes in activity, which can then be related to differences in lifestyle between groups, sexes and other social divisions.

4.5.2.2 Geometric analysis

Biomechanics have become important in the analysis of bone morphology and the reconstruction of activities in past populations. Recently bone morphology studies have

shifted towards using more complex imaging and engineering techniques. Cross-sectional morphology has been analysed using principles from beam model analysis (Larsen 1997, Mays 2010, Ruff 2008). Bones are essentially tubes. The strength of a tube in axial compression or tension is proportional to the area of the tube wall (Larsen 1997, Mays 2010). In the case of bones, this relates to the thickness of the cortical bone. Axial compression and tension forces are rarely imposed on human bone due to the nature of human movement and the irregularity of bone shape. Torsional (twisting) and bending forces are more likely to be experienced in human movement (Mays 2010, Ruff 2008). In such cases, it is not just the thickness of bone which is important in dictating strength, but also the position of bone in relation to its long axis. The strength of bone under torsion or bending is known as a second moment of area (Mays 1999, Ruff 2008) and is usually measured in the medio-lateral or the anterior posterior plane. Differences in the second moment of area can therefore be related to differences in loading on bone. This type of analysis has been used extensively to explore differences between populations in archaeological research (e.g. Maggiano *et al.* 2008, Marchi *et al.* 2006, Mays 1999, 2002, Nikita *et al.* 2011, Ogilvie and Hilton 2011, Rhodes and Knüsel 2005, Sparacello *et al.* 2011, Stock 2006, Stock and Pfeiffer 2001, Weiss 2003b, 2005 and 2009).

Analysis of cross-sectional morphology through CT scanning, radiographs and sectioning is thought to produce the best estimates of bone distribution and strength in various planes. Unfortunately these methods are expensive and time consuming as they require the use of complex and expensive imaging equipment. Thin sectioning is destructive and is no longer necessary when such imaging techniques are available. With the advancement of imaging techniques in the last 30 years, Ruff *et al.* (1984) demonstrated a correlation between the external dimensions of bone and geometric values, including bone strength. This means that where it is not possible to image bones, it is still possible to obtain important information on stresses imposed on bones (and potentially activity) through external dimensions. Furthermore, substantial comparative data exists for populations globally. Analysis of variation in cross-sectional measurements can therefore highlight differences in the stresses placed on bone and the direction of such stress.

4.5.2.3 Articular surface morphology and activity

The relationship between articular surface morphology and activity is not as well understood as cross-sectional morphology. Articular surfaces have been demonstrated to be both responsive (e.g Plochocki 2004) and unresponsive to activity (e.g Lieberman *et al.* 2001), leading to conflicting pictures as to the usefulness on joint surface morphology for activity reconstruction.

Many researchers have stated that articular morphology is stable and far more genetically controlled than that of cross sectional shapes (e.g Auerbach and Ruff 2004, Larsen 1999, Ruff 2002). While this may be the case in adults, it is not certain how much plasticity there may be in childhood. Many researchers have cited Lieberman *et al*'s. (2001) work on the non-plasticity of articular joint surfaces. In this experiment, Lieberman *et al.* (2001) exercised sheep of various ages daily, and then measured articular dimension after death. They suggested that the diaphyses in the running group were larger than their non-running counterparts, but joint surfaces remained constant between groups. There are a number of reasons why this experiment should not be used exclusively to dismiss the possibility of plasticity in juvenile articular surface morphology. First, the sample size was extremely small (n=44) and hence statistical testing was problematic (Lieberman *et al.* 2001: Table 1 Page 268). Secondly, one of the results was extremely close to statistical significance but was not commented on by the authors (Lieberman *et al.* 2001:271 Table 2). Thirdly, sheep limbs are largely involved in simple anterior posterior movement in gait. Rotation at the knee and elbow are limited. Humans can move their limbs in ways not examined in this experiment. Fourthly, the animals were not subjected to significant loading, running speed was low and on a flat surface. Finally, this work has not been replicated.

Clinical research has suggested that articular surfaces are responsive to mechanical loading. Hellier and Jeffery (2006) demonstrated that the talar articular surfaces were sensitive to changes in body weight in the juvenile growth period. As an increase in body weight would be equal to an increase in mechanical demand, it demonstrates plasticity due to activity. Research has also demonstrated, through the use of handedness as an example, that articular surfaces may be altered during the growth phase of life, prior to the fusion of

epiphyses onto diaphyses, because of the observance of larger right side articular surfaces (Plochocki 2004). This change is thought to be related to the metabolism of chondrocytes responsible for endochondral bone growth in children. Increased mechanical demand accelerates chondrocyte metabolism and hence increases bone growth. Frost (1999) has argued that chondral remodelling theory is extremely important for the size, shape and smoothness of joint surfaces in adult life. This is because, as Hamrick (1999:206) states ‘chondrocyte proliferation and differentiation in growing articular cartilage requires cell-cell and cell-extracellular matrix interactions induced by mechanical stimuli’. This may be supported by changes to articular surfaces in children with pathological conditions where articular surfaces appear reduced or unusual in morphology (e.g. Knüsel 2000).

Accordingly, articular size and morphology may be informative about activities undertaken prior to bone fusion. It seems, however, that apart from the development of osteoarthritis and marginal lipping, joint morphology after bone fusion is probably stable.

4.5.3 Bone morphology as an indicator of social change in archaeology

This section explores how bone measurements have been used in archaeology to explore past societies. Three general themes exist, including the analysis of sexual dimorphism, asymmetry and robusticity.

4.5.3.1 Sexual dimorphism as an indicator of social organisation

The degree of sexual dimorphism is thought to relate to a number of possible factors including; male sensitivity to environment, differences in marriage patterns, genetics, allometry and activity (Pomeroy *et al.* forthcoming). Variation in the degree of sexual dimorphism therefore has the potential to inform about differences both in and between populations, particularly when one or more of the influencing aspects can be controlled. A high degree of sexual dimorphism has been identified in a number of different social circumstances, including in polygamous groups (Alexander *et al.* 1979, Gray and Wolfe 1980), highly mobile groups, groups with a high age at reproduction (Smith 1999), differences in gendered activities (Carlson *et al.* 2006) and good environmental conditions (Gray and Wolfe 1980).

Sexual dimorphism is usually explored as a ratio which takes into account general variation in stature between populations. Smith (1999) examined methods for determining the degree of sexual dimorphism and argued that, despite criticism of this rather simplistic methodology, ratios are an important and valid method of demonstrating the proportional difference between males and females.

Sexual dimorphism in long-bone estimates, particularly stature estimates (derived from long bone measurements) has been substantially studied in archaeology and bioanthropology. This is most apparent in the field of forensics where researchers have exploited the presence of sexual dimorphism in populations to create standards for estimating sex from long bone lengths and articular surface size (e.g. Asala 2002, Black 1978, Introna *et al.* 1997, King *et al.* 1998). On average, the difference in stature between males and females is 4.5-9.5% depending on the group (Gaulin and Boster 1992). This variation is thought by many authors (e.g. Eveleth and Tanner 1990, Ortner 1998, Zakrzewski 2003) to be the result of greater male sensitivity to environmental factors. Females are thought to be more buffered against the effects of malnutrition and disease. As such, the closer the average male and female stature is, the more stressed the population could be said to be under. Gray and Wolfe (1980) found that diet is critical in the expression of sexual dimorphism. In particular, protein consumption may play a key role in male attainment of genetically determined stature. For example, Larsen (1997) indicated that the adoption of maize, a food low in dietary protein, could have led to a reduction in stature in the New World. Gray and Wolfe (1980) did caution that in some low sexually dimorphic populations, protein consumption is high. It is clear that diet cannot solely be responsible for dimorphism variation, and, as the authors argue, other factors involving diet (e.g. different diets by sex) and separate factors are important. This notion is supported by Pomeroy *et al.* (forthcoming), who in a study based upon range of medieval populations, indicated that multiple factors may come into play including marriage patterns, differential investment in male and female children, local environmental circumstances and genetics.

Carlson *et al.* (2006) tested the hypothesis that greater mobility results in greater sexual dimorphism. Australian hunter-gatherers and foragers were compared as Aboriginal groups

offer an opportunity to explore traditional hunter-gatherer and forager lifestyles. There was greater expression of sexual dimorphism in the upper limbs than in the lower limbs in hunter-gatherers, but little expression of sexual dimorphism in foragers, who had the greatest mobility. This suggests that populations with greater mobility may not always be characterised by high dimorphism. In Carlson *et al.*'s. (2006) case, low dimorphism might be the result of comparably high mobility of females, which made them as robust as males. Such female mobility is not always observed in forager groups. This also demonstrates that sexual dimorphism is influenced by activity.

All archaeological studies are unable to determine exactly the cause of sexual dimorphism, which demonstrates that sexual dimorphism is the expression of many different factors. As Gray and Wolfe (1980:455) conclude, this gap in current research needs addressing with more systematic comparative analysis before the impact of biological and cultural factors on sexual dimorphism can be realised. Regardless, it is possible to identify differences between populations and relate these to social changes/differences.

4.5.3.2 Directional asymmetry as an indicator of activity

The favouring of one side over the other can result in directional asymmetry in bone morphology (Mays 2002). Most of the world's population is right handed (McManus 1999, Steele 2000), and in general studies of upper limb-bone morphology, the right side will be larger than the left (e.g. Cashmore 2008, Kujanova *et al.* 2008, Larsen 1997, Mays 2002, Stirland 1993). This is due to the increased mechanical stimuli on the favoured side, resulting in larger skeletal dimensions. However, the amount of directional asymmetry varies between populations and can be related to the degree of preference for one side over another.

Archaeologists have assessed directional asymmetry through the analysis of absolute measurements and cross-sectional properties. Many skeletal elements have been examined, but most focus on the long bones of the upper limb, and usually the humerus (Stirland 1993, Trinkaus *et al.* 1994, Weiss 2003b), but the clavicle (Auerbach and Raxter 2008, Mays *et al.* 1999) and hand bones have also been considered (Cashmore 2008, Cashmore

and Zakrzewski 2009, Mays 2002). Lower limb bones are generally not considered due to the locomotor role of the legs.

Researchers have sought to identify whether patterns of asymmetry differ between groups with differing subsistence strategy types, usually between foragers and farmers. Ogilvie and Hilton (2011) found that Pre-Hispanic American Southwest female farmers had low asymmetry when compared to contemporaneous foraging females and males. The authors suggested that symmetry was a result of heavy loading in farming females during symmetric activities known from ethnographic and historic sources. Nikita *et al.* (2011) also found low asymmetry in the agricultural Garamantian population from the Sahara; this was also speculated to be the result of symmetrical activities. Larsen (1997) suggests that, with the transition to agriculture in the American Southwest, loss of asymmetry was more significant for females than males, implying that the transition to agriculture more significantly affected women than men.

It appears that agricultural lifestyles usually result in low asymmetry; whether it is possible to say this is a generalisation of agricultural populations is uncertain. This trend was also observed in enthesal scores (section 4.2.2.4). Weiss (2009) assessed whether lateral differences in humeral cross-sections between males and females of two hunter-gather populations of Californian and British Columbian Amerinds were related to subsistence strategies. The x-ray data showed that males in both groups were more asymmetric than females, but more so in the Californian population where males threw spears. Both populations, despite being non-agricultural, had low levels of asymmetry. From this Weiss (2009) suggested that sexual dimorphism differences appeared to be related more to intra-population variation in activity rather than general subsistence strategy type.

As well as assessing differences in subsistence strategies, some researchers have sought to identify dissimilarities caused directly by occupation, or other lifestyle variations (e.g. urban versus rural). Mays (2002) assessed metacarpal asymmetry in second moments of area (torsional strength) in a group of differing occupations, including master weavers, where external measurements did not produce any notable variation. Cashmore and

Zakrzewski (2009) found that absolute metacarpal measurements were able to demonstrate a strong expression of handedness in the early medieval Spanish Écija population when compared to other medieval sites. It was not clear why the laterality had occurred. Differences in the pattern of asymmetry between groups of weapon-injured and non-injured individuals from Medieval York were examined by Rhodes and Knüsel (2005). They suggested that differences both in the degree of humeral asymmetry and morphology over time may reflect advances in the type of weaponry used by men.

In a similar fashion, Mays (2007) compared cross-sectional properties of two populations from Medieval York, rural Wharram Percy and urban Fishergate. The results demonstrated a greater expression of asymmetry in the urban population, who may have been undertaking less physically active roles (associated with more specialist trades) than their rural farming peers. In particular, rural females appeared to have undertaken more loaded activities than urban females, and urban males undertook more asymmetrical work than rural males. Mays (2007) was able to support this idea with the use of historic documentation on the jobs allocated to males and females in the medieval period, with a lack of strict gender division noted in the countryside.

Stirland (1993) scrutinized the metric dimensions of the humerus in medieval individuals from the crew of the Mary Rose, and made a comparison between individuals from a lay urban cemetery in Norwich. Greater asymmetry in the Norwich men was noted, suggesting more equal arm use in the Mary Rose sample. In addition, analysis of proximal humerus measurements demonstrated that the Mary Rose men had significantly larger shoulders than the Norwich men. Hard physical labour seems to result in more symmetric patterns of body and bone dimensions.

4.5.3.4 Bone robusticity and analysis of activity patterns

A number of studies (e.g. Carlson *et al.* 2006, Ruff 1987) have demonstrated that, with the transition from foraging to farming, there was a reduction in femur robusticity; changes in mobility have been cited as a cause. External measurements have been used to explore this theory further. For example, Wescott (2006), in a broad study of mobile and sedentary

prehistoric and historic North American populations demonstrated that femur shape and robusticity was not solely related to mobility, but other factors were also important including activity.

Stock and Pfeiffer (2001) examined differences in long-bone robusticity by comparing two foraging populations (one marine and one terrestrial). Greater bone robusticity was observed in the upper arms for the canoeing Andaman Islanders. Greater lower limb robusticity was observed in the later terrestrial Stone Age population from Africa. As Stock and Pfeiffer's (2001) study controlled for body size by using two closely matched populations, it was demonstrated that subsistence strategies did impact on bone morphology. In contrast to other research (Stock 2006), this study also suggested that the proximal element may be more responsive to loading.

Chapter summary

This chapter has demonstrated that the dynamic nature of bone means that it is possible to assess differences in activity between populations. This relationship has been successfully used to explore changes in activity patterns in many different geographic and temporal social groups. However, there are clearly many methodological issues that need to be taken into consideration before collecting, analysing and interpreting data. Such issues include the relationship between specific skeletal changes and activity, and how these are impacted by other factors including age, sex, body size, skeletal region, environmental effects and genetics. In addition, inter-observer error has proved to be a considerable factor. Accordingly, these factors need to be taken into consideration whenever the analysis of activity is undertaken. Although it is not possible to completely control for all of these factors, significant methodological and statistical approaches can limit their effects enough to allow meaningful interpretation.

Chapter 5: Materials

This chapter provides the context of the study samples and delineates their suitability for this research. To assess the emergence of Islamic identity through the analysis of the body and ARSM, it was crucial that well preserved, dated pre-Islamic and Islamic skeletal material were used to detect social change. The archaeological background and previous work on the material are outlined as both have the potential to impact on the results of ARSMs.

5.1 El Salon, Plaza de España, Écija

The city of Écija is located in the province of Sevilla in modern Andalucía, Spain and is situated approximately 50km southwest of Córdoba and 160km northwest from Granada (Figure 5.1).

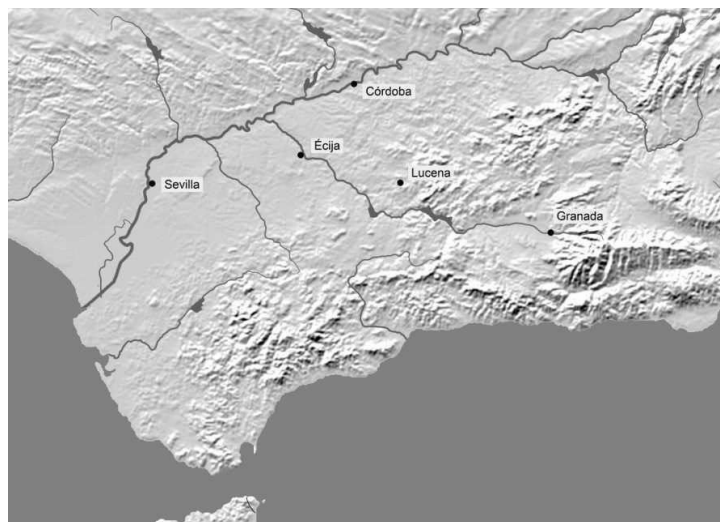


Figure 5.1 Location of Écija (author's own map)

5.1.1 Historical background of Écija

Substantial evidence indicates that human inhabitation of Écija dates back to at least the Roman period, when it was known as Astigi (Garcia Baena 2006). Écija is mentioned frequently in historic texts as a productive cereal and olive (olive oil) region during the Roman and Islamic periods (Melville and Ubaydli 1992). After the Romans, Écija was inhabited by Visigoths (Garcia-Dils de la Vega *et al.* 2005) who, after the conversion of King Reccared in AD 587 (Boone 2009, Collins 1995:53), were a Catholic people. Islam arrived early in Écija (Hitti 2002,

Kennedy 2007). Crossing over from Gibraltar, a critical battle was fought by the Berbers and Arabs just outside Écija in AD 711. (For more details on the invasion see section 3.3.1). It is thought that Écija was initially settled by Arabs but was renowned for having a large converted Ibero-muslim population (Garcia Baena 2006), something thought to be a factor instigating unrest in the town during the early 10th century (Melville and Ubaydli 1992, Safran 2001).

Located in the Guadalquivir valley situated between Sevilla and Córdoba, Écija has always been an important trading city since the Roman period (Bridgman 2007). The Islamic period was no exception, with Almohad (12th- and 13th-century) ceramic evidence suggesting that Écija was involved in at least medium distance trade, with ceramic ware being imported into the region, rather than being produced locally (Bridgman 2007). This likely relates to the importance of the region strategically on the Christian/Islamic frontier during this time, which impacted on Écija's economy. Studies focussing on the size of the town suggest that Écija was of medium size, with around 14000-16000 inhabitants in the 12th century (Garcia Baena 2006). It has been suggested that, although Écija was technically urban, it was very rural in character, being made up of many close villages (Garcia Baena 2006).

5.1.2 Archaeological background of Écija

The *makbara* (cemetery) in the Plaza de España was excavated between 1997 and 2002 (Romo Sales n.d.) (see figures 5.2 and 5.3). The remains of over 4500 Islamic individuals including males, females and children of all ages were excavated from 7 phases of activity spanning the 8th to 12th centuries. These remains are currently curated in the municipal museum of Écija. The majority of burials came from the Umayyad period of the site (8th-10th centuries AD). The earliest phases (3–7) were damaged by the continuing use of the site, and subsequently have fewer skeletons available for analysis (Romo Sales n.d.).



Figure 5.2 Aerial photograph of early excavations at Plaza de España (Photograph Garcia-Dils de la Vega)



Figure 5.3 Aerial photograph (looking west) of the later stages of excavation at the Plaza de España (Photograph Garcia-Dils de la Vega)

Analysis of burial rites highlights a number of important trends that need to be borne in mind for the later interpretation of results. The *makbara* is located next to a Visigothic cemetery, on top of the ruined Roman town, Astigi. The positioning of the earliest graves (phase 7) was dictated by the remaining structures.

Individuals were interred in old graves, or in disused structures. Increasing burial organisation appears in the 3rd phase of the *makbara*. The northwest sector however, becomes organised from as early as the 5th phase. Phase 2, which was clearly separated from the final phase (phase 1) by a 30-40cm layer, has the greatest burial organisation, with less intercutting of graves and distinct rows of burials. The *makbara* becomes increasingly crowded with time. In the later phases, burials are superimposed on each other. The soil layers between phases become thinner, and there are an increasing numbers of ossuaries and secondary deposits (Romo Sales n.d). This is an interesting phenomenon as Islamic law states that bodies should not be disturbed or put in multiple graves (Insoll 1999).

Burials were identified as Islamic for many reasons. First and importantly, it is prohibited for non-Muslims to be included within a *makbara* (Insoll 1999). Second, individuals were buried facing Mecca, a generally closely adhered rite also observable at Granada (Torres Palomo and Acien Almansa 1995), Seville (Pecero Espin *et al.* 1999) and Tel-el Hesi, Israel (Eakins 1993). Pre-Islamic individuals from the adjacent Visigothic cemetery in Écija were clearly identifiable through being buried supine, with ceramic grave goods (Romo Sales n.d.)

Islamic law states that every person becomes equal in death (Halevi 2007). As a result, grave goods are not usually part of the burial ritual. While there was some evidence for jewellery (Romo Sales n.d.), very few other grave goods were recovered. In keeping with the simplicity and equality of burial, bodies appear to have been wrapped in shrouds as coffins are not normally permitted in Islam (see section 2.3.3 for more detail on Islamic burial). With the exception of a handful of monument graves, most were simple earth-cut graves, as was the case at Triana, Sevilla (Pecero Espin *et al.* 1999). While there was some variation in the use of tiles, mud bricks and stone, this can be permitted in Islam if there are concerns over grave disturbance (Halevi 2007).

The date of the construction of the major mosque in Écija is not known; however, writings from Cordoba suggest that during the reign of Muhammad I, in the mid 9th century, the mosque was already old and undergoing restoration (Garcia Baena

2006). This mosque is less than 1 km away from the burials at the Plaza de España. This is important in terms of recognisable Islamic identity in the region.

Osteologically, Écija is an important site as it is the largest Islamic cemetery to be excavated in Europe, if not the world (n=4500). As use spanned the Islamic period in Écija, the cemetery offers an opportunity to undertake a diachronic population-level analysis. Other osteological investigations have been undertaken on the Écija collection and have relevance to this research. The first of these was undertaken by Pomeroy and Zakrzewski (2009) who assessed sexual dimorphism in long-bone lengths and indices and compared the results to other medieval and archaeological populations. Écija presented high sexual dimorphism compared to a contemporaneous English medieval sample and other agricultural populations. The difference could not be attributed to any specific factor. Écijan male and female lower long-bone indices also differed. The authors suggested this to be the result of comparative greater mobility in Écijan males. Importantly, it demonstrates a gender division in mobility in the Écijan sample, something that is not examined further in the present research. The final difference was an asymmetry identified in female radial head diameters. The authors were not able to speculate on why this had occurred.

Cashmore (2008) compared Écijan long-bone measurements and MSM (entheseal) scores to a number of other samples including gorillas, chimpanzees, and Greenwich Naval hospital (England). The Écijan population had the highest degree of laterality and presented with right-side dominance for measurements of the hands and humeri. Furthermore, Écija was the only sample to have a statistically-significant MSM (entheseal) asymmetry also favouring the right side. This suggests that right hand dominance is more clearly expressed in the Écija sample.

5.1.3 Taphonomic alterations at Écija.

Over 70% of the individuals were well preserved, meaning that 70% or more of the cortical bone surfaces were available for analysis. However, during excavation, bones were exposed to intense heat (above 40°C) and light conditions.

Accordingly, some skeletal material became sun bleached and fragmented. This was particularly notable for the skeletal elements of the left side, as burial on the right side offered protection to the right skeletal elements (Inskip *et al.* forthcoming). Elements with high spongy bone content were particularly damaged. Despite this, the skeletal remains were well preserved and it was possible to reconstruct many fragmented bones.

The only other significant taphonomic process was that of root damage. Acids secreted by roots demineralised cortical bone surfaces (Lyman 1994). Material that was heavily root damaged was excluded from analysis as this may prevent observation of ARSM. No evidence of animal gnawing existed, probably due to the rapid burial of individuals after death.

5.2 The Pre-Islamic cemetery at Cortijo de Coracho, Lucena.

Cortijo de Coracho (from here referred to as Coracho) is situated just outside the borders of the modern-day Lucena city, in the province of Córdoba, Andalucía, Spain (see figure 5.4). Lucena is approximately 50km east southeast of Écija, 60km south of Córdoba and 105km west of Granada (see figure 5.1).

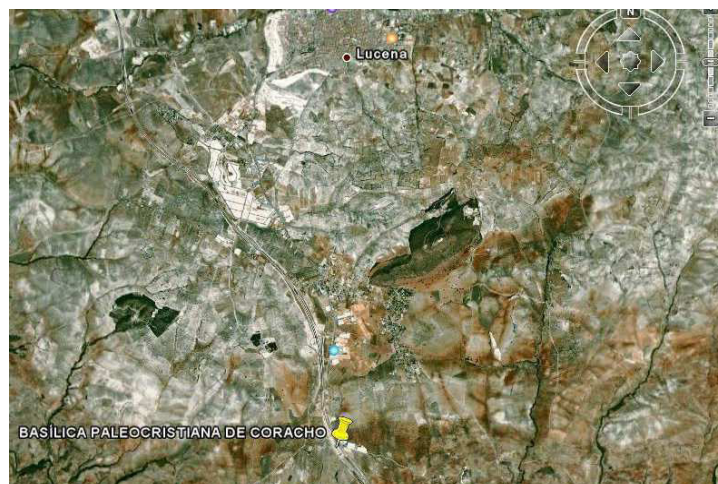


Figure 5.4 Location of the site of Coracho (Dieguez-Ramirez 2011:30).

5.2.1 Historic background of Coracho

During the Visigothic period Coracho was in the territory of Córdoba. Little historical text pertaining directly to Coracho exists. However, more is known about nearby Córdoba, from which history at Coracho may be inferred. King Agila lost control of Córdoba and parts of south Iberia during a civil war. In AD 551 one of the protagonists appealed to Justinian and the Byzantines for assistance (Collins 1995, Diéguez Ramírez 2011). This briefly resulted in the establishment of Byzantine rule in southeastern Iberia. Córdoba was regained just 21 years later but it is unknown whether Coracho was regained at the same time. It is suggested that Coracho may have remained independent of Visigothic control until the AD 572 (Diéguez Ramírez 2011). While the human skeletal remains are from the Visigothic period (5th-7th century), it should be noted that the burials may contain the remains of Byzantines, Visigoths and native Ibero-Romans; all of these were Christians, and therefore make up a discrete religious group with which the Islamic individuals can be compared. So when referring to Visigothic, the individuals come from the Visigothic time period.

5.2.2 Archaeological background at Coracho

During the construction of the Córdoba to Málaga autoroute, a Basilica and burials were excavated (Diéguez Ramírez 2011). The Basilica dates from the Roman period but has Byzantine and Visigothic extensions. Dating evidence (coins and ceramics) and clear stratigraphy infers that all the burials are Visigothic in time period (5th-7th century) (Diéguez Ramírez 2011). The skeletal remains are currently curated at the Museo Arqueológico y Etnológico, Ayuntamiento de Lucena, Lucena.

Few grave goods were excavated at Coracho, potentially inferring a Roman Christian influence in the cemetery. Funerary rites however were typical of the Visigothic period, with individuals buried supine, some with ceramic vessels, coins and oil lamps (Diéguez Ramírez 2011). In the sites later phases, many graves were reused, as is common for the period and the region (Berenguer 1998). Coracho is one of the largest excavated Visigothic/early Medieval cemeteries in the region. The cemetery may be related to a small urban centre (possibly

suggested by the high number of burials) which commonly existed in Andalucía in the post-Roman period (Dieguez Ramírez 2011). The skeletal remains are probably those of settlers and farmers who may have worked the land for the wealthy elite (Dieguez Ramírez 2011).

294 individuals were excavated from 276 tombs (Diéguez Ramírez 2011:42), 74 of which contained multiple burials. The remains of men, women and children were discovered. Diéguez Ramírez's (2011:187) study of the demography of Coracho identified that 35% of individuals were immature, 24% were young adults (21-40 years), 15.9% were mature adults (41-60 years) and 1.8% were senile adults (61 years+). The remaining 23% were of unknown age. Of the 144 sexable adults, 75 were male and 69 were female. As the excavation was a rescue excavation, many more burials may remain *in situ* in areas not excavated. As such, this sample represents part of the population. As a newly excavated site, little osteological analysis has been undertaken on the remains beyond the research of Diéguez Ramírez (2011).

5.2.3 Taphonomic alterations at Coracho

An interesting feature of this necropolis was that many of the funerary structures were reused, and it should be possible to identify relationships between burials. Commingling of burials, however, does cause problems if the mixed individuals are similar in age, sex and body size, as it is difficult to definitively separate out bones into discrete individuals (Inskip 2008).

Preservation of the material was variable. Some skeletons were well preserved, whereas others were poor and unusable. Fragmentation of long bones was a particular problem, inhibiting collection of metric data. Feet and spines were also poorly represented. However, the large sample size makes this cemetery a valid resource as commingled remains could be avoided through selection of individuals from single occupancy graves or where individuals were distinctly different in size.

5.3 Individual selection criteria for inclusion in this project.

The diachronic nature of this research means that each Islamic skeleton required information regarding the temporal phase of the cemetery from which it originated. Each burial had to be discrete or the individuals had to be easily separated to prevent ARSM data becoming mismatched with sex and age data. Ossuary material was excluded.

5.3.1 Skeletal completeness, preservation and fragmentation

All skeletons were aged and sexed (see section 6.1 and 6.2). To accurately examine changes and differences in activity patterns it was critical to assess the impact age and sex had on the markers. Each skeleton required the presence of a pelvis and skull for sexing and ageing. Furthermore, to assess for the impact of body size on ARSM, long-bone lengths were required. As humeral size was used as a proxy for body size (see section 6.3.1) intact humeri were required.

As the ARSM examined require macroscopic evaluation, it was critical that the preservation of the material was good, meaning that over 75% of the cortical bone surfaces were available to analyse. If large quantities of cortical bone were lost, then the skeleton was removed from study. Fragmentation was only a problem when sections of bone were absent or too fragmented for meaningful reconstruction.

5.3.2 Pathological material

Pathologies can alter the structure of skeletal elements through the addition or destruction of bone, which might subsequently alter the contour of bones and joints. Accordingly, any skeleton demonstrating severe pathological changes, including infectious disease, congenital disorders and trauma, was excluded from analyses. Furthermore, skeletons with metabolic disease were discounted from the study as metabolic diseases often result in poorly formed bone, which can result in malformation of bones and joints.

Chapter 6: Methods

As this study aims to explore the emergence and development of Iberian Islamic identity as a product of the interaction between religious ideology and other social factors, as displayed through the physical body, a comparative method was required to explore trends in activity before and during the Islamic period. This chapter therefore outlines the methods used to collect data on activity (ARSM) and the processes of analysis undertaken to answer the research questions outlined in chapter 1. As this research also focuses on Islamic gender identity, it was important that sex was estimated in the skeletal material. In addition, as age influences the activity modifications used in this research, estimation of age was required to assess its impact, and to subsequently control for it. Accordingly, sexing and ageing methods are outlined and discussed in section 6.1 and 6.2 prior to methods for recording and analysing ARSM in section 6.3.

6.1 Sexing human skeletal remains

The difference between the male and female bodies is known as sexual dimorphism. Sexing human skeletal remains relies on the analysis of sexually dimorphic traits (Buikstra and Ubelaker 1994). Skull and pelvic characteristics are given particular weight as the most sexually dimorphic regions (Hunter *et al.* 1997, White and Folkens 2000). In fact, analysis of sex from the skull and pelvis combined has produced 90%, and up to 100%, accuracy in tests on skeletons of known sex (e.g. Đurić *et al.* 2005).

As the degree of sexual dimorphism expressed by an individual varies between traits, a suite of indicators were analysed following Schwartz (1995). Sex estimation was based on the average result of all traits examined. Metric studies were not used due to the lack of comparative known sex material from Spain.

Sex was scored on a scale of 1–5 initially, in accordance with the standards of Buikstra and Ubelaker (1994). This was 1=definite female, 2=probably female, 3=unknown, 4=probably male, 5=definite male. In order to create sample sizes that were statistically viable, three categories were used, female, unknown and male. ‘Female’ included categories 1 and 2. ‘Unknown sex’ was score 3, and ‘male’ was scores 4 and 5. Individuals of unknown sex were excluded from this analysis. In terms of assigning

individual sex, when sex estimates from the pelvis and skull conflicted, preference was given to the pelvic scores as this is the most dimorphic region of the skeleton (Buikstra and Ubelaker 1994, Mays 2010).

6.1.1 Estimating sex from the pelvis

Human females usually give birth to one large infant with a large head. As such, a large pelvic outlet is required, which is thought to be the driving factor behind the development of sexually dimorphic os coxae in *Homo sapiens* (Hager 1996). Analysis of the os coxae thus provides the most reliable indicators of sex (Buikstra and Ubelaker 1994:16).

Examination of the subpubic region by Sutherland and Suchey (1991) on known sex individuals provides 96–100% accuracy when using the Phenice (1969) method. Other indicators shown to be reliable accessory indicators include the sciatic notch (Hager 1996), the subpubic angle and the shape of the obturator foramen (Bass 2005). These sex indicators are more reliable as they are related to the morphology of the pelvis as opposed to the preauricular sulcus, which has been demonstrated to relate to pelvis size (Cox and Mays 2000:119). While assessment of the pubis according to the Phenice (1969) method, and sciatic notch following Hager (1996) have been shown to be variable by population (Cox and Mays 2000:117), they are far less so than other indicators, such as metric analyses. Therefore these traits were used here. The methods used are outlined in table 6.1.

Table 6.1 Sexually dimorphic features examined from the os coxae

Pelvic feature	Method and source
Subpubic concavity	Phenice 1969
Ventral arc	Phenice 1969
Inferior pubic ramus	Phenice 1969
Greater sciatic notch	Buikstra and Ubelaker 1994
Obturator foramen	Bass 2005
Subpubic angle	Buikstra and Ubelaker 1994

6.1.2 Estimating sex from the skull

Males tend to have larger, more robust skulls than females due to hormonal differences (Mays 1998) which initiate an increase muscle mass and a longer growth period (Cox and Mays 2000:117). Within a population, the skull can be sexed to within 80–90% accuracy (White and Folkens 2000:362). Table 6.2 highlights the characteristics chosen to estimate sex from the skull, selected as they undergo increased bone development in males (Buikstra and Ubelaker 1994). Furthermore, they preserve well in fragmented remains.

Table 6.2 Sexually dimorphic regions of the skull used for sexing

Skull feature	Method
Supraorbital margins	Buikstra and Ubelaker 1994
Nuchal crest	Buikstra and Ubelaker 1994
Mastoid process	Buikstra and Ubelaker 1994
Supraorbital ridge/glabella	Buikstra and Ubelaker 1994
Mental eminence	Buikstra and Ubelaker 1994
Temporal lines	White and Folkens 2000:363

As the degree of robusticity and level of dimorphism for the traits in table 6.2 is population dependent (Brickley and McKinley 2004), to be population specific, the cut-off limits for male and female were redrawn based on the variation in the Ēcija population rather than being directly compared to standard diagrams provided in Buikstra and Ubelaker (1994). This was carried out by Sonia Zakrzewski (*Pers. comm.*). This allowed the method to be standardised to the population and prevented either over- or under-estimation of sexual dimorphism.

6.2 Ageing human skeletal remains

As an individual ages and attains all major developmental stages (e.g. dental eruption and long-bone fusion), scholars examine degenerative morphological changes, including dental wear and changing bone structure, to estimate age (Mays 1998). Individual factors such as diet, activity and health play an important role in the expression of age. Consequently, great age variation is observed, and the older an individual is, the wider the age estimates become. Research has indicated that it is not

possible to macroscopically accurately estimate age in osteological material to less than a 15-year age range because of this individual variation (Cox 2000).

Age ranges were utilised because enthesal changes and osteoarthritis expression is impacted by age. Before specific ageing methods were applied, it was important that developmentally incomplete individuals were excluded as skeletal morphology changes during growth. Individuals were identified as being immature if the long bones (humerus, ulna, radius, femur, tibia, fibula) were unfused, suggesting that significant growth was still to take place. If doubt remained, an analysis of the sternal clavicle was made, as this fuses in the early twenties (Scheuer and Black 2000). Cox's (2000) suggestion of 15-year age ranges was used for this project. Individuals were placed in an age group based on the average age determined from all methods used. Accordingly, the following age categories were produced:

Young adult (21–35 years)

Middle adult (36–50 years)

Old adult (51 years +)

Due to the impact of age on the expression of enthesal scores and OA, only individuals in the young and middle category were used in the analysis of activity. Old individuals were however included in the analysis of enthesal scores, in order to assess the impact of age, so that it might be controlled (see section 6.4.1.2).

Due to financial constraints, it was not possible to undertake a microscopic analysis of age, hence only macroscopic morphological methods were applied. A multi-factorial approach was taken since it was shown by Bedford *et al.* (1993) and Martrille *et al.* (2007) on individuals of known age at death, that it provides a more accurate age estimate.

6.2.1 Estimating age from the pubic symphysis

The pubic symphysis is the joint between the pubic bones of the os coxae and undergoes age-related change in the human skeleton (Todd 1920). These changes have been demonstrated by Bedford *et al.* (1993) to be accurate in ageing young adults. Although

there is no pubic symphysis method which ages precisely, it can be used to provide an accurate wide age estimate. A number of methods have been produced to assess age from the pubic symphysis (see Schwartz 1995:199-201), but the majority of research uses the Todd system or the Suchey-Brooks method. The method that has proven more reliable to use by many osteologists (e.g. Mays 2010, Roberts 2009) is the Suchey-Brooks method (Brooks and Suchey 1990; Katz and Suchey 1986). This is because, despite the fact that Suchey-Brooks has wider age estimates than the Todd system, it is shown to be more accurate in studies including those undertaken on known age-at-death individuals by Gillet (1991) and those listed in Cox and Mays (2000). Importantly, the Suchey-Brooks method has separate standards for men and women, who are both used in this study. Accordingly, the Suchey-Brooks method was employed.

6.2.2 Estimating age from the auricular surface

The auricular surface is the non-mobile joint between the sacrum and ilium. Like the pubic symphysis, the auricular surface has been demonstrated to senesce progressively (Mays 2010). While age-related changes were first noted by Sashin (1930), the first significant method was produced by Lovejoy *et al.* (1985). Unlike the pubic symphysis, the auricular surface has been demonstrated to discriminate particularly well between middle age and old adults (Bedford *et al.* 1993). This makes the auricular surface complementary to the pubic symphysis method, important in this research as older adults needed to be excluded. A further benefit was that, unlike the pubic symphysis, the auricular surface survives well in fragmentary remains (Cox and Mays 2000). While the age estimates produced by auricular surface analysis are wide, and have been subject to revision (e.g. Buckberry and Chamberlain 2002), the estimates produced were sufficient for the three age groups proposed for this project.

6.2.3 Estimating age from the dentition

When all bones are fused and teeth are erupted, dental wear age estimates still provide one of the most accurate methods for ageing adult skeletal material (Mays 1998). The dental method used here was developed by Miles (1962), as enough children and sub-adult individuals were available to calibrate the method. Dental ages for the population were obtained from previous research on the material (Zakrzewski *pers comm.*).

6.2.4 Other methods of age estimation

Due to the preservation of the remains, it was not possible to employ two sets of commonly used ageing methods. The first was the cranial suture-closure methods. As Islamic law requires every individual to be buried on the right side facing Mecca (Insoll 1999), the left side of the body was more fragmentary than the right, particularly the cranium (Inskip *et al.* forthcoming). As many skulls were broken or forced open in the Écija and Coracho material, it was decided not possible to use cranium suture closure ageing methods. The Meindl and Lovejoy (1985) method also requires the cranium to be complete, which was not often the case for either the individuals from Écija or Coracho.

The second method analyses the age-related degeneration of sternal rib ends (Iskan *et al.* 2005). Changes to the rim and pit depth are progressive with age. However, this system relies on using the fourth rib. As archaeological remains are normally fragmentary and incomplete, it can be difficult to identify the fourth rib with certainty. Accordingly, the rib method was not used. The methods used are presented in table 6.3.

Table 6.3 Methods of ageing employed in this study

Age indicator	Method
Long bone fusion	Relevant pages in Scheuer and Black 2000
Pubic symphysis	Brookes and Suchey 1990, Katz and Suchey 1986
Auricular surface	Lovejoy <i>et al.</i> 1981
Dental ageing	Brothwell 1981, Miles 1962

6.3 Analysis of ARSM as an indicator of changing religious identity in Écija and Coracho

This section presents the process of analysis and the ARSM-specific methodologies. Although, mathematically, the types of data differed between ARSM, and required individual statistical analysis, the comparative mode of analysis was the same between ARSM types. Accordingly, the general comparisons made using ARSM are outlined prior to the presentation of ARSM-specific methodologies. Detailed information regarding the choice of methods is provided for enthesal analysis, non-pathological

articular modifications, osteoarthritis and metric analysis. Following this, the individual statistical analyses required for each type of ARSM are outlined.

6.3.1 Comparative analysis of ARSM

In order to satisfy the research questions outlined in Chapter 1, eight different data comparisons were required. The following paragraphs outline the comparisons made, and their purpose in regards to answering the research question.

1. Analysis of sex difference in ARSM: Islamic gender division

To examine whether Islam was a strong structuring principle for gender in Islamic Iberia, an analysis of gender division was required. As there is a strong link between sex and gender in Islam, sex was used as a proxy for assigning gender, in this, and all the comparisons outlined below. If Islamic gender ideology strongly influenced activity, a sex differences would be visible in the Islamic ARSM data. Accordingly ARSM data was split by sex and statistically compared to look for male/female differences.

2. Analysis of temporal difference in ARSM: Changing social organisation

As this research aimed to investigate if changing socio-political circumstances impacted on the interpretation of religious ideology and therefore the expression of Islamic identity, ARSM were analysed diachronically by splitting the ARSM data by Islamic phase (early and late) and comparing the results. Individuals were assigned as being early if they derived from the first 5 layers of occupation (phases 7-3), they were designated as late if they originated from phases 1 or 2. It is not yet possible to give definite dates to these layers at present, but they are chronologically ordered.

3. Analysis of temporal differences in female ARSM: Changes in female activity and identity

This assessment sought to address whether female Islamic identity changed over time by assessing for changes in female activity patterns. As such, early and late Islamic female ARSM data was statistically compared.

4. Analysis of temporal differences in male ARSM: Changes in male activity and identity

This question sought to address whether male Islamic identity changed over time by assessing for changes in male activity patterns. As such, early and late Islamic male ARSM data was compared.

5. Analysis of the temporal variation in sex differences in Islamic ARSM:
Temporal changes in gender division

To further assess the malleability of Islamic identity, a temporal analysis of gender division was undertaken. The sex differences in ARSM in the early phase and late phase Islamic individuals were established. The variation in sex differences between phases was then ascertained to explore if the degree or nature of gender division changed over time.

6. Analysis of sex difference in ARSM: Visigothic gender division

As gender division exists in most populations, the Visigothic material from Coracho was used as a control sample to ascertain whether Islamic ideology impacted on activity patterns in Iberia by establishing the pre-Islamic gender division. As such, ARSM were compared between Visigothic males and females to establish the degree of sex difference in ARSM in the pre-Islamic Córdoba region.

7. Analysis of interfaith variation in female ARSM: Changes to female activity and identity with the emergence of Islam

In order to determine whether the emergence of Islam impacted on the activity, and specifically the identities of women, a comparison of female Islamic (pooled early and late data) and pre-Islamic ARSM was required. Data from early and late Islamic women were pooled to make the Islamic data set.

8. Analysis of interfaith variation in male ARSM: Changes to male activity and identity with the emergence of Islam

In order to determine whether the emergence of Islam impacted on the activity, and specifically the identities of men, a comparison of male Islamic (pooled early and late data) and pre-Islamic ARSM was required. Data from early and late Islamic men were pooled to make the Islamic data set.

Statistical significance of any differences in ARSM was always set at $P \leq 0.05$, in accordance with most scientific research. However, it is worth noting that Fisher (1956) argues that values slightly above $P=0.05$ should not be entirely dismissed. The setting of $P=0.05$ is an arbitrary cut-off point that acts almost as a control to maintain good practice in statistical analysis, rather than having an explicit mathematical function. All statistical testing was carried out in SPSS 19 for Windows.

6.4 Individual methods for activity-related skeletal modifications

Four different types of modifications were analysed because they have the potential to inform about slightly different aspects of activity. The following section describes the methods used to record ARSM, commencing with enthesal analysis, non-pathological articular modifications, osteoarthritis and finally bone geometry methods. To prevent bias when collecting data, all ARSM were scored blind as to the individual's age and sex. This was achieved by scoring ARSM prior to scoring age and sex. The four ARSM types were selected as they have been successful in demonstrating group differences (see chapter 4).

6.4.1 The analysis of enthesal changes

In section 4.2.1 it was highlighted that it is possible to assess changes in activity overtime, and between groups, through the analysis of enthesal scores. Enteses were selected to assess whether patterns of muscle use varied between comparison groups outlined in section 6.3.1. It should be noted that the selection and recording of enteses for this research commenced in 2008, prior to a significant body of research on the analysis of enthesal changes which has subsequently been published. Of particular importance has been development of knowledge surrounding the importance of distinguishing between fibrocartilaginous and fibrous enteses in analysis (Villotte and Knüsel 2013), and also inter-observer error problems and the oversimplified method of comparative mean analysis using the Hawkey and Merb's (1995) method (Jurmain *et al.* 2012). Accordingly, these issues were not ignored; rather the information did not exist at the time of research. While means were sometimes compared between populations, significant interpretation was based on the patterns of scores rather than a direct comparison of scores. In terms of inter-observer error, as all data was collected by the author it was not a significant problem in this research.

As explained in section 4.2.1.3, the lower body is primarily involved in locomotion. The upper limb in modern humans is used in fine manipulation and is free from locomotive function. As this study aimed to explore differences in activity rather than locomotion, analysis of upper limb entheses offered the best opportunity to seek differences in activity-patterns, particularly those that require manipulation.

6.4.1.1 Enteseal data collection

Prior to 2008, two significant methods existed for the collection of enteseal data; Hawkey and Merbs's (1995) graded system, and al-Oumaoui *et al.*'s. (2004) present/absent method. It could be argued that the present/absent method does not provide a good enough distinction between enteseal expressions, making it problematic to elucidate group differences. As temporal changes may be slight, it was decided that the 0 - 3 grade scale of Hawkey and Merbs's (1995) was more appropriate. An additional factor was that it is more difficult to observe trends related to age and body size using the present/absent technique. For these reasons, and the fact that good written descriptions and images exist, enteses were recorded following Hawkey and Merbs (1995) as outlined in table 6.4. This method distinguishes between robusticity (caused by repetitive action) and stress lesions (those caused by trauma). Although Hawkey and Merb's (1995) method has come under recent criticism for problems on inter-observer error (Davis *et al.* 2013), as the data collected here was all taken by the author, this limits the problem.

As enteses can potentially display robusticity and stress lesions, each was scored for both types. Stress lesions were measured using co-ordinate callipers to measure depth. Figure 6.3A provides an example of pectoralis major robusticity grades, while figure 6.3B shows the biceps brachii stress grades. Table 6.4 provides the criteria for grade selection.

As muscles work in groups, 21 different enteses were scored on the left and right side. All selected enteses were easy to identify and have been used by other authors in similar studies. Some enteses, including the infraspinatus and supraspinatus on the proximal humerus, were not included due to the fragility of the proximal humeral head. Table 6.5 lists enteses and the motions produced by the related muscle. Figures 6.4–

6.6 depict the location of each enthesis. Red outlines signify areas of attachment. Blue represents ligament attachments.

Table 6.4. Grading criteria for entheseal robusticity and stress lesions according to Hawkey and Merbs (1995:328).

Enthseal Score	Visible appearance
Stress	
Grade 0	no expression
Grade 1	'faint' shallow pitting observable, lytic appearance. Less than 1mm deep
Grade 2	'moderate' pitting is now between 1 and 3 mm deep
Grade 3	'strong' pitting is over 3mm deep.
Robusticity	
Grade 0	no expression
Grade 1	'faint' exostosis extends less than 2mm from cortical bone surface
Grade 2	'moderate' distinct shape. Extends over 2mm but less than 5mm from cortical surface
Grade 3	'strong' pronounced mass extending over 5mm from the cortical bone surface

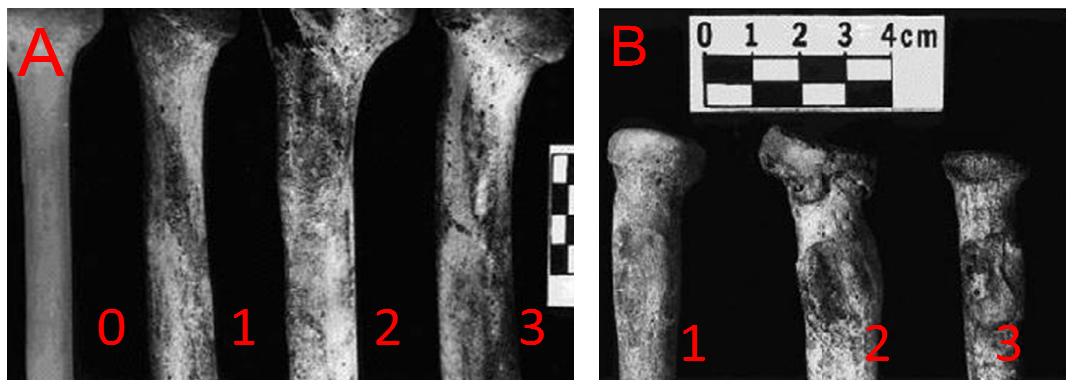


Figure 6.3 A) Hawkey and Merbs's robusticity grade 0 – 3 for the pectoralis major. B) Stress grades 1 - 3 bicep brachii on the radius (adapted from Hawkey and Merbs (1995:328)).

Table 6.5. Muscle attachment location and bone with associated action

Bone and enthesis	Action	Enthesis location
Humerus		
Deltoid	Flexes and extends shoulder. Abducts and medially and laterally rotates arm.	Deltoid tuberosity.
Teres major	Extends shoulder, adducts and rotates arm.	Medial to the intertubercular groove on proximal humerus.
Latissimus dorsi	Adducts and medially rotates arm, extends shoulder.	Proximal end of the intertubercular groove.
Pectoralis major	Flexes shoulder, adducts and medially rotates arm. Extends shoulder from flexed position.	Lateral to the intertubercular groove.
Brachioradialis extensor carpi radialis longus	Flexes elbow.	Distal lateral shaft.
Common extensor	Various muscles involved in extension of the hand and wrist.	Lateral epicondyle.
Radius		
Biceps brachii	Flexes shoulder and supinates radial head.	Radial tuberosity.
Pronator teres	Pronates forearm.	Lateral side of the midshaft.
Supinator brevis	Supinates forearm.	Lateral surface of proximal midshaft.
Flexor pollicis longus	Flexes thumb.	Inferior to the radial tuberosity and superior to the interosseous crest.
Quadratus	Pronates forearm.	Distal anterior section of the shaft.
Ulna		
Triceps brachii	Extends shoulder, adducts and medially rotates arm.	Most superior part of the olecranon.
Flexor digitorum superficialis (Supinator crest)	Supinates forearm.	Lateral shaft, inferior to the radial facet. Supinator crest.
Pronator quadratus (origin)	Pronates forearm.	Medial surface of the distal ulna shaft.
Brachialis	Flexes elbow, supinates forearm.	Inferior to the semilunar notch and medial to the supinator crest.
Clavicle		
Subclavius	Fixes clavicle and elevates first rib.	Inferior surface of the clavicle midshaft.
Costoclavicular ligament	Fixes sternal end of clavicle prevents excess superior, anterior and posterior movement of clavicle.	Inferior surface of the sternal clavicle end.
Deltoid	Elevation of the arm, shoulder rotation.	Posterior superior surface of the lateral clavicle.
Trapezium	Shoulder elevation and depression.	Anterior superior surface of the lateral clavicle.

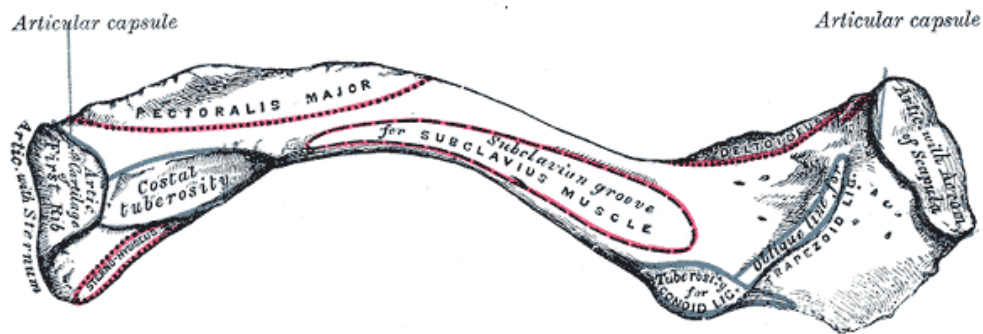


Figure 6.4 Locations of muscle attachments on the clavicle (adapted from Standring 2008)

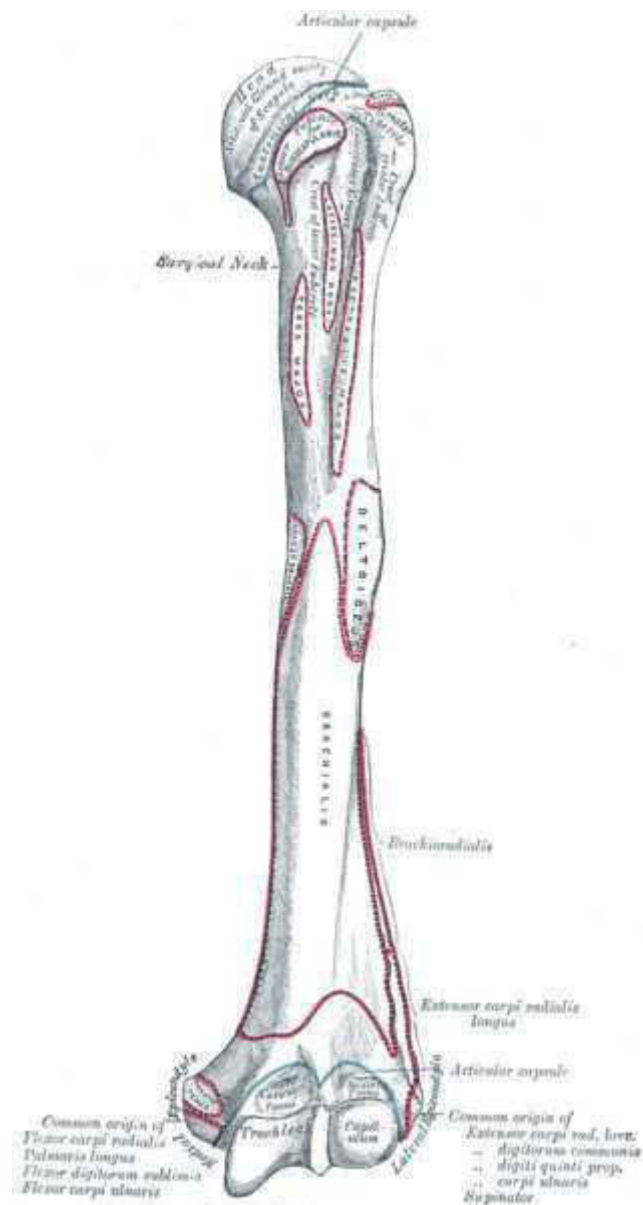


Figure 6.5 Location of muscle attachments of the humerus (adapted from Standring 2008)

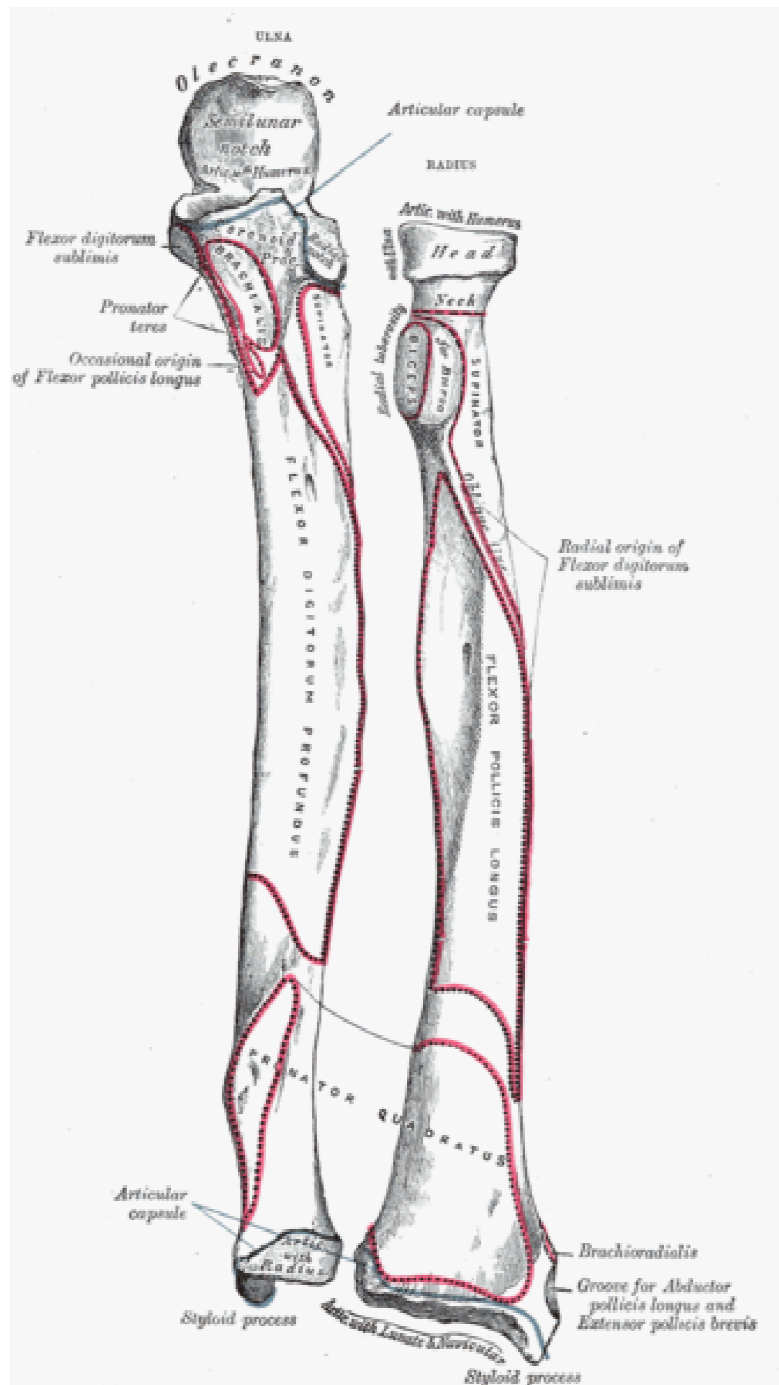


Figure 6.6 Location of muscle attachments of the radius and ulna (adapted from Standring 2008)

6.4.1.2 Statistical analysis of enthesal data

The complex nature of enthesal changes required a number of controls. Enthesal scores correlate with a number of other physical factors, including body size and age (see section 4.2.2). Therefore prior to any inference of activity-related changes, it was critical to consider the influence of each of these factors, and, where appropriate, control

for them. A Spearman's correlation test was used to test for correlations between aggregate upper limb musculoskeletal stress marker score (ULMM) and body size, age and sex. The term musculoskeletal stress marker score is used here rather than enthesal score to remain consistent with the original methodology by Weiss (2003a).

Weiss (2003a, 2004, and 2007) suggests that to gauge the impact of age and body size on enthesal scores, an aggregate scoring analysis is required. This can be carried out using Hawkey and Merb's (1995) method as demonstrated by Weiss (2003a) and Godde and Wilson-Taylor (2012). The ULMM was then ranked (highest ranked individuals have higher enthesal scores). To then examine the relationship between ULMM score and each factor (age, sex and body size), a Spearman's correlation test was carried out.

The ULMM score was created for each individual by adding all entheses scores (6 humerus + 5 radius + 4 ulna + 4 clavicle) for robusticity and stress scores for the eight (4 left, 4 right) upper limb bones. In very few cases were ULMM scores complete. Following Weiss (2007), missing scores were calculated from the observable scores. Ideally, the enthesal score for the corresponding side was substituted. If scores for a particular entheses was absent from both sides, then an average score (derived from all the individuals entheses scores) was computed and substituted. For example, if there are 22 of 24 possible observations on the humeri which have an average of 1.5 per marker, then 2×1.5 were added to create the total observable score. As Weiss (2007:934) advises, this limits the impact of missing data by providing an average of what was observable and thereby controlled the chance of a significant effect on the final result. Less than 15% of the data was created in this way, an amount comparable to that in studies by Weiss (2003a, 2004).

To assess whether ULMM score was related to body size, a body-size proxy was created which was tested for correlations with the ULMM rank. This was important as perceived sex differences can disappear once body size is considered. Humeral measurements were used as a proxy for body size as proximal limb segments are less likely to be morphology altered by environmental factors (Stock 2001). Also, 31 absolutely complete humeri were preserved in the Écija sample. Weiss (2004) has demonstrated success using the humerus with aggregation methods. Weiss (2007) created standardised scores obtained from three humeral dimensions (maximum length,

vertical head diameter and distal epiphysis breadth) to create a proxy for body size. Z scores for humeral dimensions were calculated and added to produce an aggregated humeral size Z score.

Once the relationship between body size and ULMM score was known, Spearman's correlation tests were carried out to determine whether individual entheses correlated with body size, and were therefore not suitable for this study. As enthesal changes are intrinsically controlled for body weight, if a particular enthesis had a positive correlation with humeral size on the left and right sides it was excluded from the analysis.

To test for correlations between age and ULMM scores, numerical age categories were required. As age was scored in three categories (young, middle and old), for the sake of statistical testing, these were changed into numerical categories. Young individuals were scored as 1, middle aged individuals were scored as 2, and the old individuals were scored as 3. Therefore if age correlated with ULMM rank or individual entheses, a positive correlation was observed. Individuals that were thought to be over 51 years were not further included in the project (see section 6.2).

Once the relationship between age and body size with ULMM and enthesal scores was known, testing was carried out to determine whether individual enthesal scores and use-patterns differences existed between the comparison groups outlined in section 6.3.1. To test whether correlations existed between muscle scores and sex, Islamic time phase and faith groups, disaggregated enthesal scores had to be tested against each factor. To permit a correlation analysis for each independent factor (sex, Islamic-phase and faith group) and enthesal score, the independent factor required numeric categories. Females were scored as 1 and males as 2. When a correlation was negative, female scores were larger than males, if positive, males outscored females. For the Islamic phase groups, early individuals were scored as 2 and late individuals as 1. A negative correlation insinuates an increase in muscle score over time, and a positive, a decrease in score over time. Visigothic individuals were scored as 1 and Islamic as 2. A positive correlation insinuates an increase in muscle score in the Islamic period, and a negative correlation, a decrease in score in the Islamic period. These numeric values had no meaning other than for the sake of statistical comparison.

Where enthesal scores correlated with sex and/or phase, but also correlated with age and body size, age and body size were controlled using a partial Spearman's correlation test.

To discern whether enthesal asymmetry differed between sexes, and in the case of the Islamic individuals, over time, the difference between left and right enthesal scores was computed and compared. The difference between left and right scores was denoted with 'd' and was calculated by subtracting the left enthesal score from the right. Differing patterns of asymmetry were examined using a Kruskal-Wallis test (a non-parametric version of the repeated measures test) because much of the enthesal data was not normally distributed and could not be transformed suitably.

6.4.2 Non-pathological articular modifications

In order to assess whether Islam impacted on posture adoption, an analysis of non-pathological articular modifications was undertaken. Differences in kneeling and squatting behaviour were analysed between sexes, Islamic phases and faith groups. This section outlines the methods for data collection and the statistical manipulation of data.

6.4.2.1 Methods for non-pathological articular modification collection

Non-pathological articular modifications indicate changes in activity patterns by means of highlighting alterations to posture adoption. In addition, the possibility that Islamic individuals undertook ritual prayer may have created Islamic/Visigothic differences in articular modifications. As weight-bearing joints are more likely to have articular modifications (Trinkaus 1975), the lower body was examined rather than the upper body.

A high prevalence of tibial and talus squatting facets was identified during a pilot study of the Écija material, possibly as a result of kneeling during prayer or daily activities with ankle hyperdorsiflexion (Inskip 2009). During prayer (*salat*), an individual moves through a set of postures which could potentially alter joint surfaces (see section 2.2.2.1). Observers kneel with the toes hyperdorsiflexed and the ankle hyperdorsiflexed (see figure 6.7) to keep the heel vertical. If *salat* was being undertaken by all members of the community, then a higher prevalence of kneeling and squatting modifications

could be expected in the Écija group than in the Visigothic group. Accordingly, to assess for modifications induced by kneeling or squatting activity, the knee, ankle and the metatarsophalangeal joints were examined. As Trinkaus (1975) suggests that the hip does not bear weight during kneeling, it was not included in these analyses. The following subsections highlight and clarify the modifications chosen for study.

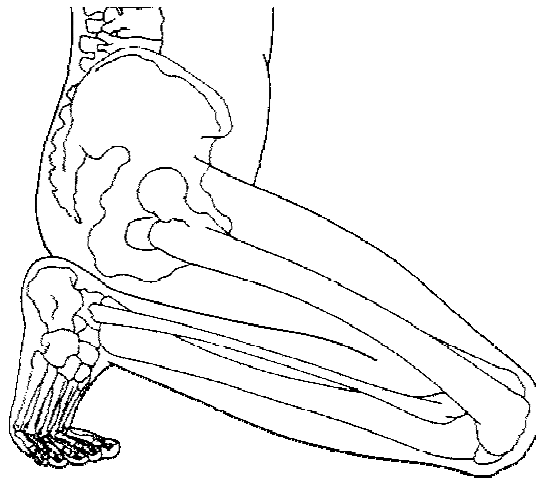


Figure 6.7 Lower leg position during kneeling phase of *salat* (adapted from Ubelaker 1979:683)

Knee modifications: osteochondritic imprints, tibial imprints and vastus notches.

In order to identify knee flexion, three modifications were examined; osteochondritic marks on the femoral condyles, tibial imprints on the supracondylar surface and vastus notches. These were selected based on research outlined in section 4.3.

Osteochondritic marks are imprints or flattening on the superior-inferior femoral condyles (Capasso *et al.* 1999, Kostick 1963, Trinkaus 1975) and were recorded as absent or present on the medial and lateral condyles of both femora. To distinguish if the extent of the modifications differed between comparison groups, if present, they were scored as i (imprint), n (new bone growth) or f (facet) if present. See figure 6.8 for an example of osteochondritic imprint.



Figure 6.8 Imprint on the femoral condyle (author's own photograph).

Related modifications are tibial imprints on the supracondylar surface of the femur. The tibial plateau is forced into the supracondylar surface of the femur when the knee is hyperflexed. Tibial imprints, following Capasso *et al.* (1999), were identified on the medial and lateral supracondylar surfaces of both femora (figure 6.9). If present, they were scored as either i (imprint), n (new bone growth) or e (extension) to the condylar surface.

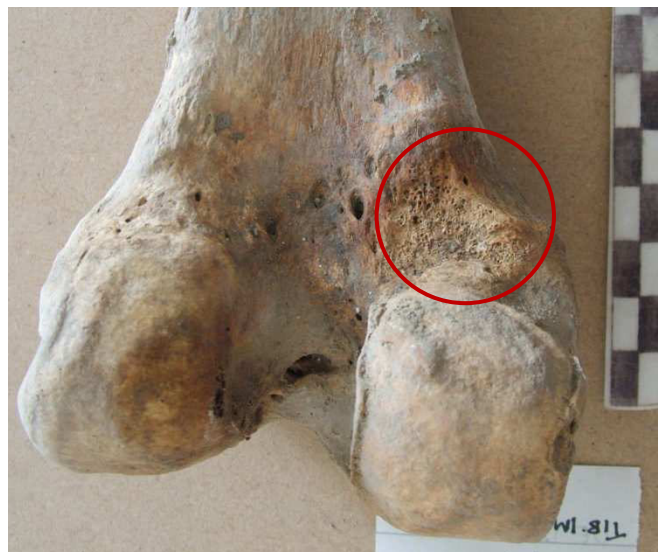


Figure 6.9 Tibial imprint on the medial condyle (author's own photograph).

Vastus notches

Vastus notches are thought to be caused by tension of the vastus lateralis tendon during persistent kneeling (Finnegan 1978) (Figure 6.10). Vastus notches were scored following Finnegan (1978). The notch borders had to be smooth. If the notch was small and the border was only just compromised, it was scored as 1 (small). If the notch was larger, then it was scored as 2 (large). This permitted the observation of whether there

was any size difference in the notch between groups which indicated whether kneeling behaviour differed by group.



Figure 6.10 grades of vastus notch, A) absent (note sharp edge, B) 1= small C) 2 = large (author's own photograph)

Ankle hyperdorsiflexion modifications: squatting facets on the tibia and talus

For the identification of ankle hyperdorsiflexion, three squatting facets were examined: the medial tibial, the lateral tibial and the talus squatting facets. All are thought to be associated with habitual squatting (Trinkaus 1975).

The medial tibial squatting facet was described by Finnegan (1978) but has not really been described further by other authors. It was therefore scored as present or absent. The facet is present when 'the inferior articular surface is extended into the medial fossa' (Finnegan 1978:25).

The lateral tibial squatting facet, while noted by Barnett (1954), was better described by Finnegan (1978:25) as being where the 'inferior articular surface extends into the lateral fossa of the transverse depression'. It has been general practice to score the facet as either present or absent (e.g. Brothwell 1981, Mays 2007). However Satinoff (1972) noted that variation existed in the facet size and argued that lateral tibial squatting facets should be scored differently as this variation may indicate posture differences. While it is not possible to highlight the exact cause, intergroup facet size variation could indicate a change in adoption of posture type or duration and therefore merits studying. Accordingly, the facets were scored on a scale of 0–3, based on size (table 6.6). See figure 6.11 for a visual representation of these facets.

Table 6.6 Written descriptions for the identification of tibial squatting facets

Tibial squatting Facet type	Visible description
Absent	No facet observable
1	A small indent made in the lateral anterior contour of the distal tibia
2	A large clearly demarcated facet on the lateral anterior contour of the fossa.
3	A large facet that impinges on the distal shaft of the tibia.



Figure 6.11 Tibial Facet types. A) facet type 1. B) facet type 2. C and D) facet type 3. (author's own photographs)

Talus squatting facets have been subject to greater attention than tibial squatting facets. Although Barnett (1954) described five talar facets, only one was associated with prolonged contact between the tibia and talus (the lateral talus squatting facet (see figure 6.12)). Importantly, the lateral squatting facet has been demonstrated by modern clinical studies to be related to ankle hyperdorsiflexion (Singh 1959). As the only clear definition of the talar facet, Barnett's (1954) description was used here, with facet identification requiring it to be clearly demarcated from the trochlear surface.

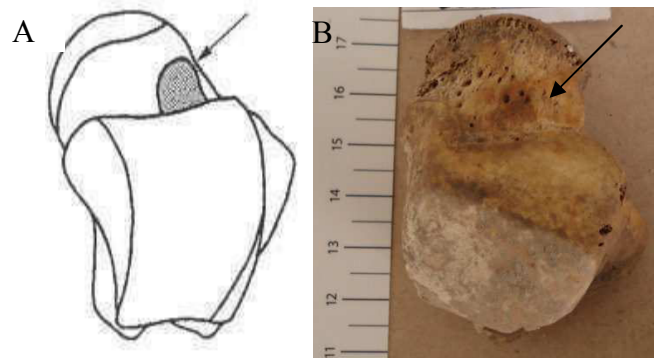


Figure 6.12 A) Position of the lateral talar squatting facet (adapted from Barnett 1954:510) B) Facet on skeletal material from Écija (author's own photograph)

Research by Boule (2001a) has indicated that the talar squatting facet can appear in two forms; normal (congenital) or due to pressure (induced during life) (see figure 6.13). If Islamic prayer was undertaken from the earliest periods of Islamic rule, the presence and type of facet may permit identification of increasing conversion in the early phases of Islamic occupation in Spain. Therefore the nature of facet was recorded following Boule (2001a) as absent, pressure or congenital. Table 6.7 provides descriptions of pressure and congenital facets as used in this research. Also see figure 6.13 for x-ray images of a congenital and a pressure facet, and 6.14 for dry bone images.

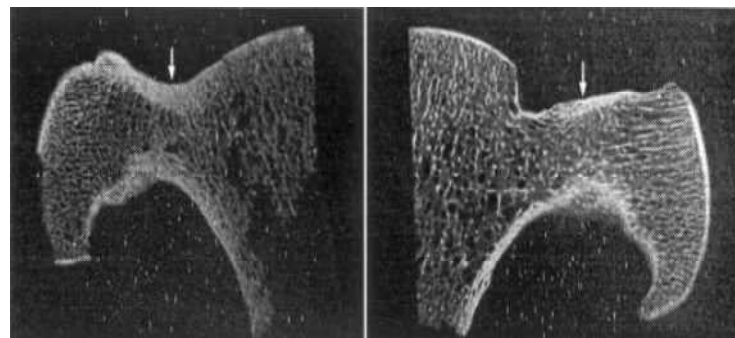


Figure 6.13 X-ray of lateral squatting facets. Right normal, left pressure facet (Boule 2001a:347)

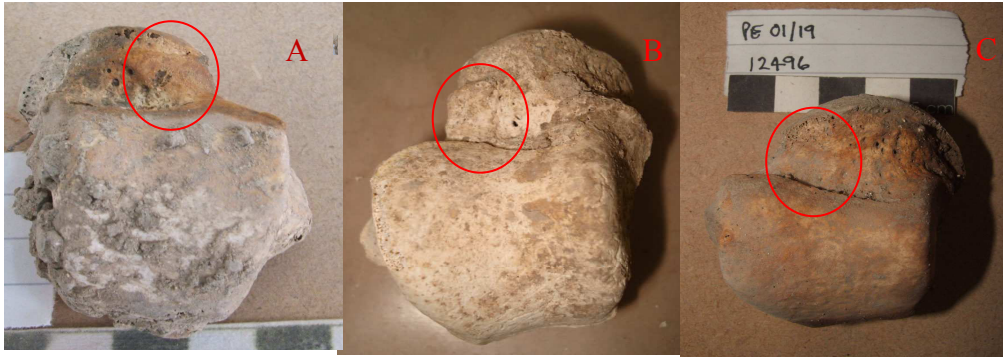


Figure 6.14 A) congenital facet B) dry bone pressure facet. C) Absence of facet. (author's own photograph)

Table 6.7 Descriptive criteria for pressure and congenital facets.

Talar Squatting facet	Visual description
Congenital	A smooth clearly demarcated facet (figure 6.14a)
Pressure	A rough raised facet which may have exostosis (figure 6.14b)
Absent	No modification present on talar neck (figure 6.14c)

Metatarsal hyperdorsiflexion: Metatarsal facet extensions and phalangeal wedging.

To identify metatarsal hyperdorsiflexion, two modifications were examined: metatarsal facet extensions and phalangeal wedging. Facet extensions on all distal dorsal surfaces of the metatarsals have been related to prolonged hyperdorsiflexion of the toes at the metatarsophalangeal joint (Capasso *et al.* 1999:142). During prayer, an individual is required to position the heel superiorly, meaning that the toes are hyperdorsiflexed (see figure 6.15). Following the only published method that exists for recording this modification, facet extensions were identified using descriptions in Ubelaker (1979) and scored as absent or present. To be present, the articular facet extends beyond the original border of the distal joint surface and onto the superior aspect of the metatarsal shaft. See figure 6.16 for an example of articular extension.

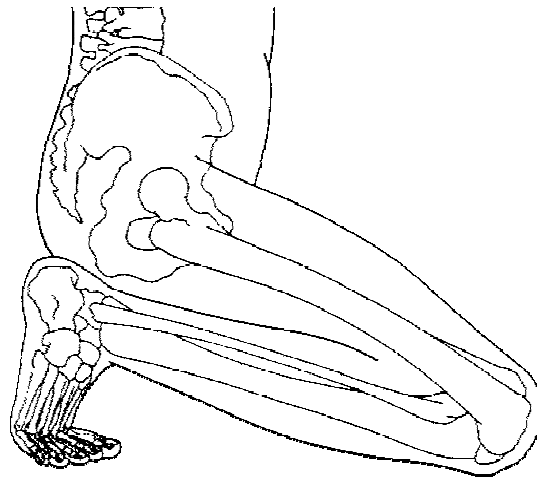


Figure 6.15 hyperdorsiflexion of the ankle and metatarsophalangeal joints (adapted from Ubelaker 1979:683)



Figure 6.16 Extension to the articular border of metatarsal 3 (author's own photograph)

Pressure placed on the superior surface of the first proximal phalanx during hyperdorsiflexion of the first metatarsophalangeal joint creates a bony protuberance raised 2mm from the bone surface on the superior portion of proximal phalanx. This was recorded following the only method available (Ubelaker 1979). Proximal phalanges 2 to 5 also undergo morphological change to the proximal joint surface. To accommodate for persistent hyperdorsiflexion of the metatarsophalangeal joints, the proximal joint surface becomes wedged dorsally, allowing an upward inclination of the toes. This was identified following Molleson (1989) and was visible as superior rounding on the edge of the proximal phalanges. Like extensions to the metatarsals, phalangeal wedging was scored as absent or present (see figure 6.17 for an image of a phalanx with dorsal wedging). Where phalanges were not bagged separately, they were sided using White *et al.* (2011).



Figure 6.17 An example of phalangeal wedging (author's own photograph)

6.4.2.2 Statistical analysis of non-pathological articular modifications

Before the comparisons outlined in 6.3.1 could be made, it was necessary to make the data comparable between groups. A calculation of modification prevalence was undertaken by adding the total number of joints with articular modification and dividing the sum by the total number of observed joints x 100. As the data was non-parametric (not normally distributed) and categorical, the statistical significance of any differences between two categories was assessed using a Fisher's exact test. Where multiple categories existed, a chi-squared test was applied. In tests with multiple modifications, some observations were removed from the chi-squared test when observed values were '0', as these violate the rules of the test and create unreliable P values.

6.4.3 Osteoarthritis

6.4.3.1 Osteoarthritis data collection

The studies examined in section 4.4.4 demonstrate how diachronic variation and inter-population changes can be identified from OA data. Patterns of OA were therefore recorded in the samples from Écija and Coracho to explore the changes in the distribution of repetitive loaded activities in the population. Generally most studies outlined in section 4.4.4 analyse joints in their entirety rather than by joint surface. While analysis of joints indicate whether repetitive actions or motions have been undertaken for a certain part of the body, analysis of joint surfaces has the benefit of having a greater resolution, permitting a more detailed and, as argued by Jurmain and Kilgore (1995), a more statistically robust study. For example, osteoarthritis of the radial head and ulna radial notch may signify extensive pronation supination activities, whereas osteoarthritis on the semilunar notch and trochlear surfaces may indicate greater levels of arm extension and flexion. The joints and joint surfaces examined are listed in table 6.8.

Table 6.8 Joints and bones examined for OA in the study of the Écija and Coracho samples

Region	Peripheral Joint	Joint surface
Upper body	Temporomandibular	Temporal
		Mandible
	Acromioclavicular	Acromion
		Acromial end of clavicle
	Shoulder	Glenoid
		Humeral head
	Elbow	Distal humerus
		Proximal ulna
		Proximal radius
	Wrist	Distal Ulna
		Distal Radius
Lower body	Hip	Acetabulum
		Proximal Femur
	Knee	Distal Femur
		Proximal Tibia
		Patella
	Ankle	Distal Tibia
		Distal Fibula
		Talus
	Metatarsophalangeal	Distal metatarsal
		Proximal phalange

Multiple methods exist for scoring osteoarthritis in dry bone (Buikstra and Ubelaker 1994, Jurmain 1980, Rogers and Waldron 1995, Rojas-Sepulveda *et al.* 2008, Waldron 2009). The methods agree on the types of changes attributable to the disease (sclerosis, eburnation, pitting and new bone growth on and around the joint surface), but differences of opinion arise from the combination of changes required for the disease to be scored as present (Jurmain and Kilgrove 1995). Only eburnation is a definite indicator of the disease as it is caused by erosion of synovial cartilage and bone on bone contact (Jurmain 1999, Larsen 1997, Waldron 2009). However, research has suggested that relying solely on eburnation would drastically underestimate the prevalence of the disease (Mays 2010). Therefore an additional criterion was required for the diagnosis of OA. Rogers and Waldron (1995) suggest that in the absence of eburnation, two or more features of the disease need to be present on a single joint surface. In contrast, a multifaceted study by Rojas-Sepulveda *et al.* (2008) argued that the best method appeared to be scoring positive for OA with any modification except isolated pitting. However, methods that use a single indicator are at high risk of over-estimating the prevalence of the disease. Rogers and Waldron (1995) also caution against the use of marginal new bone growth as a sole indicator of osteoarthritis as this can be associated with ageing. Therefore, to prevent over estimation of osteoarthritis, two or more indicators, or eburnation were required to be present following Rogers and Waldron (1995) and Waldron (2009). Table 6.9 describes the criteria for each of the features scored in osteoarthritis.

Table 6.9 Description of features of scored in osteoarthritis

Osteoarthritis feature	Description
Eburnation	Polishing and ivory-like appearance which may have grooving on the joint surface.
Pitting	Porosity or holes on the joint surface
Sclerosis	Densification of the joint surface without polishing
New bone growth	New bone growth on the joint surface
Lipping around joint margin	New bone growth around the joint margin

As osteoarthritis is a progressive disease that may show skeletal changes before any clinical symptoms (Jurmain 1980, Waldron 2009), problems arise in defining the degree of severity required for the disease to be scored as present. Joint involvement is variable, ranging from a single pit to an entire eburnated joint surface. Jurmain (1980)

scores on a degree of severity (slight, moderate and severe) whereas Roger and Waldron (1995) suggest that 10% of the joint surface should be involved before a positive diagnosis of OA can be made. Identification using a single minor change over-estimates the prevalence of OA; however, the amount of joint surface required to be affected should not be so large that nearly all possible cases are excluded. Accordingly a positive diagnosis was made when changes covered at least 10% of the joint surface, as this provided a clear mode of differentiation. Furthermore, the low prevalence of osteoarthritis in early and late Islamic phases would have rendered statistical analysis impossible if using a scale of severity. Figure 6.18 demonstrates examples of where pitting, new bone growth and eburnation were scored as present

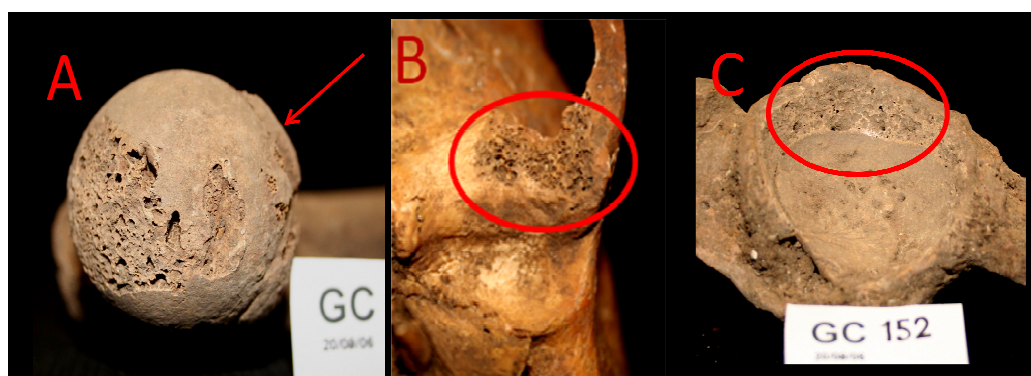


Figure 6.18 A) Femoral head with pitting, sclerosis and new bone growth around the joint margin. B) TMJ with extensive pitting and sclerosis. C) Acetabulum with pitting and eburnation (author's own photographs)

6.4.3.2 Statistical analysis of osteoarthritis data

Due to reasons set out in section 6.2, individuals who were considered to be 50 years+ were removed from all data sets. Before the comparisons set out in section 6.3.1 could be made it was necessary to make the data comparable between groups. Calculations of true prevalence rate is the standard method for comparing osteoarthritis between groups as this takes into account that not all skeletons may be complete. This was carried out using the following formula:

$$(\text{Total joints affected} / \text{Total number of observable joints}) \times 100 = \text{True prevalence rate \%}$$

The same calculation was used to ascertain overall prevalence of osteoarthritis for joint surfaces. In order to establish the skeletal pattern of osteoarthritis involvement, the

prevalence of osteoarthritis for each individual joint and joint surface was calculated and compared.

The prevalence of osteoarthritis was low in the Écija population. In order to permit statistical comparison, data from both sides was pooled together. To determine whether the prevalence of osteoarthritis at a joint or joint surface differed between the comparison groups outlined in 6.3.1, Fisher's exact tests were used. Chi-squared tests were used to determine whether the overall pattern of joint involvement was significantly different between men and women as well as early and late phase individuals. Some joints had to be removed from the test as the expected value was 0, violating the rules of a chi-squared test.

6.4.4 Analysis of bone geometry

As outlined in section 4.5.2 bone size and shape have the ability to inform about changes in social organisation and activity patterns. Accordingly, long bone measurements were taken to explore whether the emergence of Islam impacted on the existing social structure through an analysis of changing bone size. This was achieved by looking at both long-bone lengths and cross-sectional indices (bone loading). While it would have been preferable to use imaging or x-ray, absolute measurements and indices still provide a useful mode of analysis as they have been shown to produce useful indicators of change.

Specifically, the analysis of absolute measurements was important for three reasons. The analysis of sexual dimorphism and temporal dimorphism can highlight whether there were differences in activity between men and women, and between temporal comparison groups set out in section 6.3.1. It can also demonstrate general changes in social organisation. Understanding the sex difference and temporal variation in absolute measurements was also crucial for identifying where differences in body size may have impacted on enthesal results.

Indices acted as a measure of robusticity and identified whether loading on the clavicle, humerus, ulna and radius differed between groups or over time. Absolute measurements were analysed according to the comparison groups outlined in section 6.3.1, prior to

indices. Due to fragmentation in the Visigothic sample, indices were only analysed for the Islamic comparisons. Analysis of stature did not make up part of this research as this was already investigated by Pomeroy and Zakrzewski (2009).

6.4.4.1 Measurements data collection

Absolute measurements

Measurements were taken from specific fixed anatomical landmarks to ensure comparability between individuals. Standard measurements outlined in Buikstra and Ubelaker (1994) were followed. These measurements are based on the work by Moore-Jansen *et al.* (1994) using skeletal landmarks identified by Martin and Seller (1957). The measurements are frequently used in osteoarchaeology, permitting comparison with other samples. Specific measurements used in this research are presented in Table 6.10. Left and right elements were measured where possible. Broken long bones were only measured if fragmented into 2 parts, if the break was clean, and could be held together securely and measured with the assistance of a second party.

Bone lengths were measured using an osteometric board. Diameters were taken using electronic sliding callipers. A tape measure was used to take circumferences. Means and standard deviations were calculated for each measurement. All measurements were taken in mm to the nearest 2.d.p. Measurements were taken twice to ensure accuracy.

A particularly good indicator of social change is fluctuations in the degree of sexual dimorphism. A number of mathematical methods exist for the calculation of sexual dimorphism, including ratios and regression analysis (see Smith 1999). While regression analysis has been used in biological studies, it has been shown to be no more beneficial than ratios (Smith 1999:453). Accordingly, sexual dimorphism (DI) was calculated by dividing the male mean by the female mean, as proposed by Smith (1999), following Lovich and Gibbons (1992). The result indicates the male measurement as a proportion of the female mean.

Table 6.10. Definitions and sources for measurements used in this research

Measurement	Abbreviation	Source
Clavicle		
Superior inferior diameter of sternal clavicle	DsistC	Derived
Anterior posterior diameter of the sternal clavicle	DapstC	Derived
Superior inferior diameter of the acromial end of the clavicle	DsiacC	Derived
Anterior posterior diameter of the acromial end of the clavicle	DapacC	Derived
Maximum clavicle length	XLC	Buikstra and Ubelaker (1994)
Circumference of clavicle midshaft	CmC	Buikstra and Ubelaker (1994)
Superior inferior diameter at clavicle midshaft	DsimC	Buikstra and Ubelaker (1994)
Anterior posterior diameter at clavicle midshaft	DapmC	Buikstra and Ubelaker (1994)
Humerus		
Maximum length of the humerus	XLH	Buikstra and Ubelaker (1994)
Physiological length of the humerus	LphH	Martin and Seller (1957)
Minimum circumference of humeral shaft	YCH	Martin and Seller (1957)
Circumference of humeral head	CHH	Martin and Seller (1957)
Maximum diameter of the humeral midshaft	XDmH	Buikstra and Ubelaker (1994)
Minimum diameter of the humeral midshaft	YDmH	Buikstra and Ubelaker (1994)
Sagittal diameter of the humeral head	XDshH	Martin and Seller (1957)
Transverse diameter of humeral head	XDthH	Buikstra and Ubelaker (1994)
Width of the humeral proximal epiphysis	WPH	Martin and Seller (1957)
Width of the humeral distal epiphysis	WDH	Buikstra and Ubelaker (1994)
Radius		
Maximum length of the radius	XLR	Buikstra and Ubelaker (1994)
Transverse diameter at radial midshaft	DtmR	Buikstra and Ubelaker (1994)
Anterior posterior diameter at radial midshaft	DapmR	Buikstra and Ubelaker (1994)
Transverse diameter of radial head	DthR	Martin and Seller (1957)
Maximum diameter of radial head	DXhR	
Width of distal radial epiphysis	XWdR	Martin and Seller (1957)
Ulna		
Maximum length of the radius	XLU	Buikstra and Ubelaker (1994)
Anterior posterior diameter at ulna midshaft	DapmU	Buikstra and Ubelaker (1994)
Transverse diameter at ulna midshaft	DtmU	Buikstra and Ubelaker (1994)

Patterns of long bone asymmetry calculated from absolute measurements have been used to explore differences in activity between populations (see section 4.5.3.2). For example, urban populations have been demonstrated to have more asymmetry than rural populations (Mays 2010). The difference between left and right measurements was calculated in SPSS.

Indices calculated from absolute measurements

Table 6.11 Indices calculated from raw measurements

Index	Description	Abbreviation	Source
Clavicle sternal end	<u>superior-inferior diameter of sternal end</u> anterior-posterior diameter of sternal end	Sternal SIAP	Derived
Clavicle acromial end	<u>superior-inferior diameter of acromial end</u> anterior-posterior diameter of acromial end	Acromial SIAP	Derived
Clavicle midshaft	<u>superior-inferior diameter midshaft</u> anterior-posterior diameter of midshaft	-	Pomeroy and Zakrzewski (2009)
Humeral midshaft	<u>minimum diameter of humeral midshaft</u> maximum diameter of humeral midshaft	-	Bridges <i>et al.</i> (2000)
Radial midshaft	<u>minimum diameter of radial midshaft</u> maximum diameter of radial midshaft	-	Wanner <i>et al.</i> (2007)
Ulna midshaft	<u>minimum diameter of ulna midshaft</u> maximum diameter of ulna midshaft	-	Pomeroy and Zakrzewski (2009)

Cross-sections were analysed in order to compare whether loading on upper limbs varied between groups. Cross-section data was obtained by creating indices from the absolute measurements. Indices were calculated using the formulae outlined in Table 6.11. The indices were selected as they reflect bending strength and therefore the degree of force imposed on the bone. As no indices have been created for the sternal and acromial ends of the clavicle, superior-inferior dimensions were divided by anterior posterior measurement as is practiced for other long bone indices.

6.4.4.2 Statistical analysis of measurement data

Prior to comparative analysis, it was important that data was tested for normality to ensure the integrity of any significant results identified. Where data was normally distributed, measurements and indices were compared using a GLA test. Where data log transformed, it was retested and the P value marked with a *. If the data was not normally distributed, a Mann-Whitney U test (a non-parametric equivalent) was used to test for statistical significance and the resulting P value is marked ⁺.

The degree and significance of asymmetry between left and right sides was tested using a repeated measure test (RPM). Where data did not transform to a normal distribution, a Kruskal-Wallis test was used on the difference between left and right estimates and the

P value is marked [^]. A comparison of the pattern of asymmetry between males and females was also calculated using a RPM test or Kruskal-Wallis test.

Chapter 7: Results

7.1.1 Presentation of results

This chapter outlines the results of the comparison of ARSM data both in, and between the Islamic and pre-Islamic groups. Sections 7.2-7.5 explore each type of modification separately, commencing with enthesal changes, non-pathological articular modifications, OA and bone metrics. Each section is presented following the comparisons set out in 6.3.1.

7.1.2 Total number of individuals

Table 7.1 shows the number of individuals examined from each phase of the Écija cemetery and from the Coracho cemetery. Due to the small number of individuals in the earliest phases of the cemetery, the Islamic phases were amalgamated to form two groups, the late phases (1 and 2) and the early phases (3-7). This allowed temporal changes to be observed more clearly and permitted statistical analysis.

Table 7.1 Total number of skeletons used in this research

Cemetery Phase	Number of Skeletons	Temporal group	Number of skeletons
1	43	Late	101
2	58		
3	26	Early	83
4	31		
5	10		
6	3		
7	13		
Coracho	114	Visigothic	114
Total	318		318

7.1.3 Age and sex

As age and sex can influence the development of ARSM, it was important to highlight where imbalances in the proportion of age and sex categories could impact on the results of comparisons between groups. Fisher's exact tests indicated that there were no significant differences in the numbers of males and females in any of the groups tested. Where a sex or age imbalance was noted, statistical tests were controlled to take into account this imbalance, therefore negating the impact of age or sex imbalance on the result. Table 7.2 presents the numbers of males and females in each group assessed.

Table 7.2 Age and sex distribution for Écija and Coracho samples

Age and sex	Early Écija	Late Écija	Visigothic Coracho
Young female	14	25	34
Middle female	10	14	21
Old female	22	16	3
Young male	18	24	14
Middle male	5	4	37
Old male	4	4	3
Total	73	87	114

7.2 Analysis of entheal changes

This section explores whether differences in muscle use and patterns exist between comparison groups set out in section 6.3.1. As entheal scores can be influenced by age and body size, the results of Spearman's correlation analysis between aggregated and disaggregated entheal scores, age, body size and sex are presented to highlight where controls were needed to prevent bias in results. Following this, intra-faith analysis of entheal data is presented.

7.2.1 Results of correlation tests between entheal score, body size and age

Entheses for 228 individuals were analysed: 145 Islamic and 83 Visigothic. Aggregate ULMM were analysed prior to disaggregated entheal scores, as it was important to assess whether there were general correlations between ULMM score and body size, age and sex before individual entheses were assessed.

7.2.1.1 Aggregate muscle marker correlations with age and body size

38 Islamic individuals had complete entheal scores and measurable humeri. Table 7.2.1.1 presents Spearman's correlation scores and significance values for ULMM with body (humeral) size, age, sex and phase. Results indicated that ULMM correlated with age ($P=0.021$ $n=38$). Humeral size correlated strongly with sex ($P\leq 0.001$ $n=38$) but did not correlate with ULMM. Age and phase were correlated ($P=0.018$ $n=35$).

Table 7.2.1.1 Correlation between ULMM score and age, sex, phase and body size for humeral size sample.

Humeral size sample n=38										
Factor	ULMM		Humeral size		Age		Sex		Phase	
	Score	P	Score	P	Score	P	Score	P	Score	P
ULMM	-	1.000	0.265	0.107	0.377	0.021	-0.18	0.280	0.068	0.684
Humeral size			-	1.000	0.174	0.296	-0.812	≤0.001	-0.175	0.295
Age					-	1.000	-0.068	0.684	0.315	0.018
Sex							-	1.000	0.171	0.303
Phase									-	1.000

Key: ULMM=aggregate upper limb entheses score, P=P value,

Table 7.2.1.2 Spearman's correlations between ULMM score and age, sex and phase for total sample.

Total sample n=71								
Factor	ULMM	ULMM P	Age	Age P	Sex	Sex P	Phase	Phase P
ULMM	-	1.000	0.373	0.001	0.277	0.019	0.053	0.663
Age			-	1.000	0.149	0.216	-0.063	0.604
Sex					-	1.000	0.018	0.878
Phase							-	1.000

Key: ULMM=Aggregate upper limb entheses score.

Due to humeral size not correlating with ULMM, data from another 71 Islamic individuals without measurable humeri were analysed. Subsequent Spearman's correlation tests indicated that age was still highly correlated with ULMM ($P \leq 0.001$ $n=71$) but sex also correlated with ULMM ($P=0.019$ $n=71$). Phase did not correlate with ULMM score (see table 7.2.1.2). Importantly, the statistically significant result between age and phase was lost in the total sample ($P=0.604$ $n=71$) indicating that phases are not biased towards containing a particular age group.

Table 7.2.1.3 Partial Spearman correlations between ULMM and sex and phase controlled for age.

Pooled data $n=71$ with age controls						
Factor	ULMM	ULMM P	Sex	Sex P	Phase	Phase P
ULMM	-	1.000	0.245	0.041	0.086	0.481
Sex			-	1.000	0.046	0.707
Phase					-	1.000

Key: ULMM=Aggregate upper limb enthesal score, P=P value

A partial Spearman's correlation test was undertaken to observe whether sex correlated with ULMM after controlling for age. It demonstrated that sex still correlated statistically with ULMM ($P=0.041$ $n=71$) suggesting that sex was a good predictor of enthesal score and may suggest a gender division in muscle use (see table 7.2.1.3). In particular, males had greater enthesal scores than females when controlling for age and body size. As humeral size did not correlate with ULMM, an analysis of disaggregated entheses was carried out to explore differences in enthesal scores and patterns between sexes which could demonstrate activity differences.

7.2.1.2 Disaggregated enthesal scores correlations with age and body size

The following section explores individual enthesal scores and their correlation with age and body size prior to assessing for sex differences. Table 7.2.1.4 presents the relationship between enthesal score and humeral size for those individuals with measurable humeri.

Table 7.2.1.4 Correlation of humeral size and enthesis score.

Marker	Left			Right		
	C coefficient	P	N	C coefficient	P	N
Trapezius	-0.434	0.049	21	-0.262	0.251	21
Deltoid	-0.243	0.288	21	0.190	0.409	21
Subclavius	-0.117	0.585	24	0.602	0.005	20
Costoclavicular ligament	-0.022	0.920	24	0.036	0.879	20
Deltoid	0.309	0.097	30	0.292	0.084	36
Teres Major	0.261	0.180	28	0.254	0.135	36
Latissimus Dorsi	0.197	0.326	27	0.432	0.010	35
Pectoralis Major	0.008	0.968	30	0.331	0.048	36
Brachioradialis extensor	-0.147	0.464	27	0.457	0.005	36
Common extensor	-0.087	0.678	25	0.003	0.987	35
Biceps brachii	0.631	≤0.001	35	0.384	0.030	32
Flexor pollicis longus	-0.022	0.904	32	-0.356	0.053	30
Pronator teres	0.345	0.042	35	0.105	0.563	33
Supinator brevis	-0.203	0.242	35	-0.189	0.318	30
Quadratus	0.147	0.446	29	0.083	0.700	24
Supinator crest	-0.102	0.567	34	-0.025	0.885	35
Pronator quadratus	-0.172	0.402	26	-0.052	0.773	33
Brachioradialis	0.131	0.461	34	-0.175	0.315	35
Triceps brachii	0.054	0.801	24	-0.15	0.464	26

Key: C=correlation, N=number, P=P value.

Table 7.2.1.4 demonstrated that 8 enthesis scores correlated with humeral size; (left trapezius, right subclavius, right latissimus dorsi, right pectoralis major, right brachioradialis extensor, left pronator teres and both biceps brachii). These statistically significant outcomes were recalled during further examination of results. The only marker to correlate with body size on both sides was the biceps brachii and it was difficult to use this marker in the analysis of activity patterns.

7.2.2 Analysis of Islamic entheses scores

7.2.2.1 Analysis of sex differences in disaggregated entheses scores in Islamic group: analysis of Islamic gender division

67 Islamic females and 78 Islamic males were available for enthseal analysis by sex. Due to the quantity of data analysed, only statistically significant values are presented in the text. Correlation values are also presented in the relevant table. Table 7.2.1.5 presents the results of the disaggregated enthseal analysis and their correlations with age. Sex was assessed using a partial correlation which controlled for age.

After controlling for age and body size, 12 enthseal scores still correlated with sex (see table 7.2.1.5). While males generally had greater enthseal scores than females, 5 entheses scored greater in women than men as indicated by the negative correlation (see table 7.2.1.5). Table 7.2.1.6 displays the mean scores for each enthesis by sex and side.

Table 7.2.1.5 Individual enthesis correlation with age and sex (controlled for age), P value and number of observations. Significant values are bold.

Enthesis	Left					Right				
	Age	P	Sex	P	N	Age	P	Sex	P	N
Trapezius	-0.057	0.605	-0.229	0.036	85	0.142	0.21	-0.245	0.031	76
Deltoid	0.047	0.671	-0.161	0.146	84	-0.014	0.905	-0.029	0.801	76
Subclavius	-0.09	0.412	0.107	0.331	86	0.076	0.519	0.077	0.516	72
Costoclavicular ligament	-0.039	0.72	0.306	0.004	86	0.249	0.039	0.358	0.003	72
Deltoid	0.355	0.001	0.208	0.060	75	0.342	0.001	0.235	0.009	120
Teres Major	0.223	0.053	0.248	0.032	73	0.203	0.030	0.063	0.507	115
Latissimus Dorsi	0.361	0.003	0.07	0.585	61	0.247	0.020	0.094	0.384	89
Pectoralis Major	0.129	0.253	0.14	0.220	77	0.126	0.117	0.344	0.001	116
Brachioradialis extensor	0.215	0.072	-0.002	0.986	68	0.151	0.098	0.215	0.215	121
Common extensor	0.346	0.005	0.086	0.505	60	0.493	0.001	0.005	0.961	116
Biceps brachii	0.27	0.007	0.302	0.003	98	0.204	0.020	0.456	0.001	130
Flexor pollicis longus	0.185	0.069	-0.12	0.235	98	0.194	0.031	0.062	0.495	124
Pronator teres	0.283	0.004	0.174	0.080	100	0.087	0.315	0.201	0.021	134
Supinator brevis	0.254	0.011	-0.125	0.216	97	0.009	0.920	-0.142	0.109	129
Quadratus	0.287	0.011	-0.115	0.317	78	0.100	0.323	0.017	0.87	87
Supinator crest	0.092	0.345	0.261	0.007	107	0.075	0.409	0.189	0.037	123
Pronator quadratus	-0.156	0.175	-0.356	0.002	77	-0.032	0.730	-0.196	0.036	115
Brachialis	0.097	0.332	-0.074	0.459	108	-0.011	0.904	0.041	0.651	126
Triceps brachii	0.318	0.003	0.047	0.673	102	0.211	0.040	0.012	0.905	96

Key: P= p value, N=number of individuals.

Table 7.2.1.6 Disaggregated enthesis scores by sex and side.

Enthesis	Female							Male							Significance of difference in d between L and R
	Left			right			d	Left			Right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	44	2.09	0.60	40	2.10	0.67	0.01	41	1.78	0.94	40	1.85	0.92	0.07	0.127
DEL C	45	2.93	1.14	39	2.87	1.11	0.06	39	2.64	1.16	41	2.85	1.09	0.21	0.896
SUB	44	1.57	0.55	37	1.62	0.55	0.05	42	1.67	0.75	39	1.57	0.62	0.10	0.219
CCL	44	2.27	1.21	35	2.94	1.28	0.67	42	3.07	1.42	35	3.97	1.34	0.90	0.977
DEL H	38	1.97	0.82	59	1.92	0.68	0.05	40	2.30	0.79	62	2.33	0.82	0.03	0.334
TM	38	2.34	1.15	53	2.51	0.82	0.27	38	2.83	1.10	62	2.66	1.10	0.19	0.047
LD	31	0.87	0.85	41	0.90	0.63	0.03	33	0.91	0.58	48	1.06	0.76	0.15	0.796
PM	40	2.63	0.95	53	2.68	0.94	0.05	40	3.08	1.40	63	3.46	1.26	0.38	0.100
BE	36	1.94	0.63	56	1.89	0.56	0.05	35	1.94	0.54	65	2.02	0.63	0.08	0.564
CET	33	1.79	0.65	54	1.85	0.71	0.06	30	1.90	0.61	62	1.94	0.67	0.04	0.551
BB	54	2.31	0.87	62	2.23	0.71	0.08	44	3.11	1.26	68	3.15	1.15	0.04	0.324
FPL	58	1.90	0.67	52	1.87	0.63	0.03	66	1.85	0.61	46	1.74	0.61	0.11	0.849
PT	62	1.42	0.62	54	1.57	0.77	0.05	72	1.72	0.76	49	1.84	0.83	0.12	0.216
SB	58	1.41	0.75	53	1.21	0.66	0.20	71	1.20	0.62	47	1.09	0.62	0.11	0.189
Q	43	1.28	0.93	46	1.46	0.86	0.22	56	1.34	0.79	32	1.31	0.78	0.03	0.474
SC	53	1.72	0.53	60	1.90	0.57	0.18	54	1.98	0.53	64	2.14	0.66	0.16	0.567
PQ	53	2.23	0.58	55	1.98	0.59	0.25	54	1.71	0.73	61	1.74	0.75	0.03	0.616
BR	53	3.62	0.99	60	3.40	0.94	0.22	54	3.52	1.07	67	3.50	0.96	0.02	0.797
TB	43	1.53	0.51	42	1.86	0.81	0.33	42	1.69	0.64	54	1.81	0.55	0.12	0.240

Key: n=number, $\bar{x}$ =mean, SD=standard deviation, P=p value, d=absolute difference between left and right side, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii.

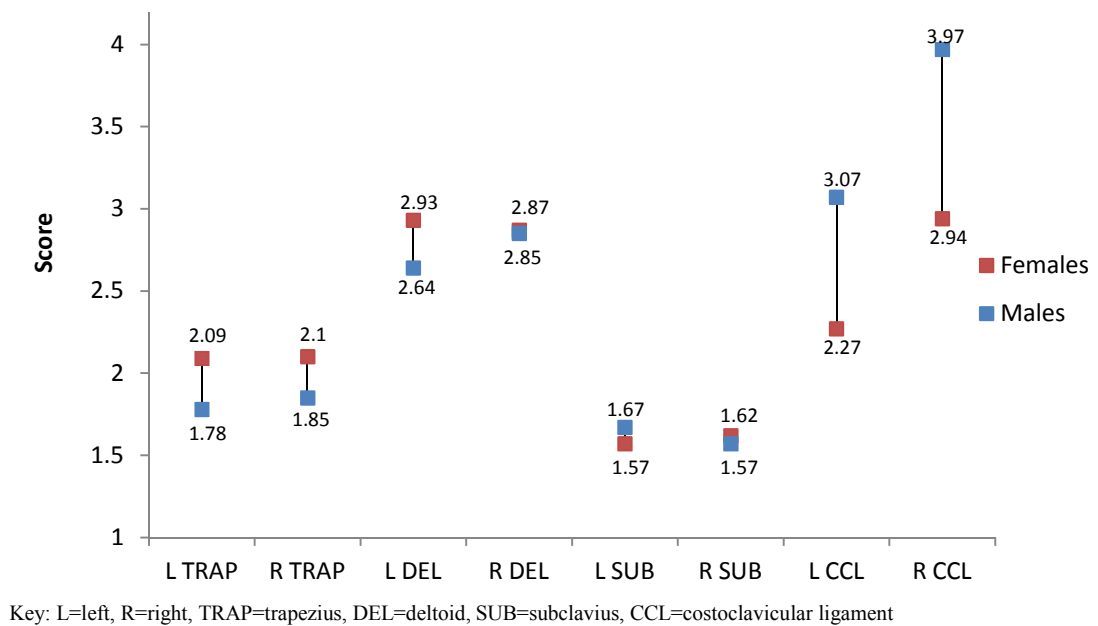
Clavicle

Figure 7.2.1.1 Comparison of mean clavicle entheseal scores between males and females

Left trapezius scores correlated with humeral size whereas right did not (left $P=0.049$ $n=21$). A negative correlation between humeral size and trapezius score existed, suggesting smaller humeri had higher trapezius scores and a large trapezius attachment was associated with females (see table 7.2.1.4). Females scored greater than males at both trapezius attachments (left $P=0.036$ $n=85$, right $P=0.031$ $n=75$). In males, the trapezius asymmetry was small with the right scoring 0.07 more than the left. In females, no difference existed between sides. Overall the asymmetry experienced by each sex was not statistically different.

No correlation between humeral size and deltoid score existed. A weak correlation with sex existed for left deltoid score, but not for the right deltoid score. In males the difference in score between left and right deltoids was $d=0.21$. In females, asymmetry was lower, but the difference in d between the sexes was statistically insignificant.

The right subclavius score correlated strongly with humeral size ($P=0.005$ $n=38$). However, there was no correlation between sex and subclavius scores. Males had a greater difference between left and right subclavius scores than females (male $d=0.1$, females $d=0.05$), but the difference was not significant.

Costoclavicular ligament scores did not correlate with humeral size. Costoclavicular ligament score did however correlate with sex. Males had statistically significantly larger costoclavicular ligament scores on both sides than females (left $P=0.004$ $n=86$, right $P=0.003$ $n=72$). Males also had greater asymmetry than females at the costoclavicular ligament (males $d=0.90$ females $=0.67$), but the difference was not statistically significant.

Humerus

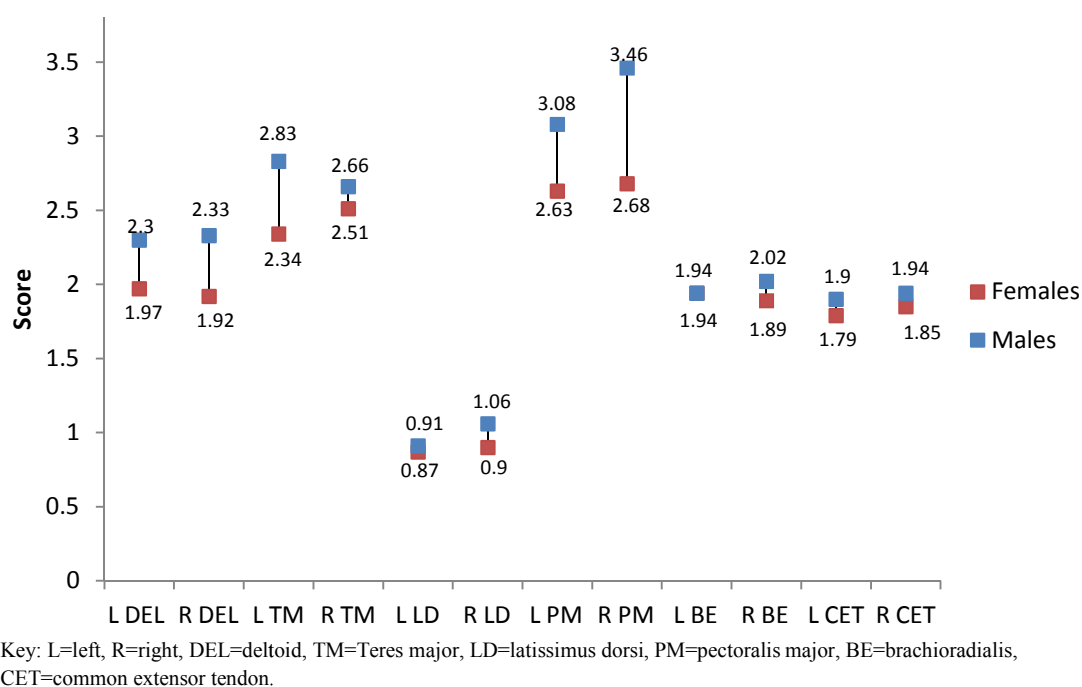


Figure 7.2.1.2 Comparison of mean humeral enthseal scores between males and females

Of note was a weak correlation between humeral size and deltoid score (left $P=0.097$, $n=30$ right $P=0.084$ $n=36$). However, right humeral deltoid scores were more strongly statistically positively correlated with sex, with the left close to significance (left $P=0.06$ $n=75$, right $P=0.009$ $n=120$), suggesting that males have larger deltoid scores on both sides than females. No asymmetry existed for either sex at the deltoid (female $d=0.05$ males $d=0.03$).

Teres major scores (left and right) did not correlate with humeral size, although the left teres major score had a stronger relationship with sex and correlated significantly ($P=0.032$ $n=73$), whereas the right did not. Females had greater difference in scores between sides than males (female $d=0.27$; males $d=0.19$). The difference in asymmetry

between sexes was statistically significant ($P=0.047$ $n=191$) demonstrating that females had greater asymmetry than males for the teres major attachments.

The left latissimus dorsi score did not correlate with humeral size, but a correlation between the right latissimus dorsi score and humeral size did exist ($P=0.010$ $n=35$). Regardless, latissimus dorsi scores did not correlate with sex. Males presented with greater asymmetry at the latissimus dorsi attachments than females (males $d=0.15$ females $d=0.03$), but the asymmetry difference was not significant, suggesting similarity in asymmetry between sexes.

A correlation was identified between right pectoralis major score and humeral size ($P=0.048$ $n=36$). However right pectoralis major scores correlated more strongly with sex and were larger in males ($P=0.001$ $n=116$). The left pectoralis major score failed to correlate with sex, even though males had greater scores than females. Males had greater pectoralis major score asymmetry than females (male $d=0.38$, females $d=0.05$). The difference in asymmetry between the sexes was not significant ($P=0.100$ $n=196$) but was noteworthy.

Humeral size was strongly correlated with only the right brachioradialis extensor score ($P=0.005$ $n=36$). No correlation with sex was identified for the brachioradialis extensors, which were similar in size between sexes. Statistically, asymmetry differed little between the sexes (females $d=0.05$; males $d=0.08$).

No correlation between humeral size and common extensor scores existed. Although, common extensor scores were larger in males, they were not statistically correlated with sex. Statistically, little difference existed in the asymmetry experienced by males and females (females $d=0.06$; males $d=0.04$).

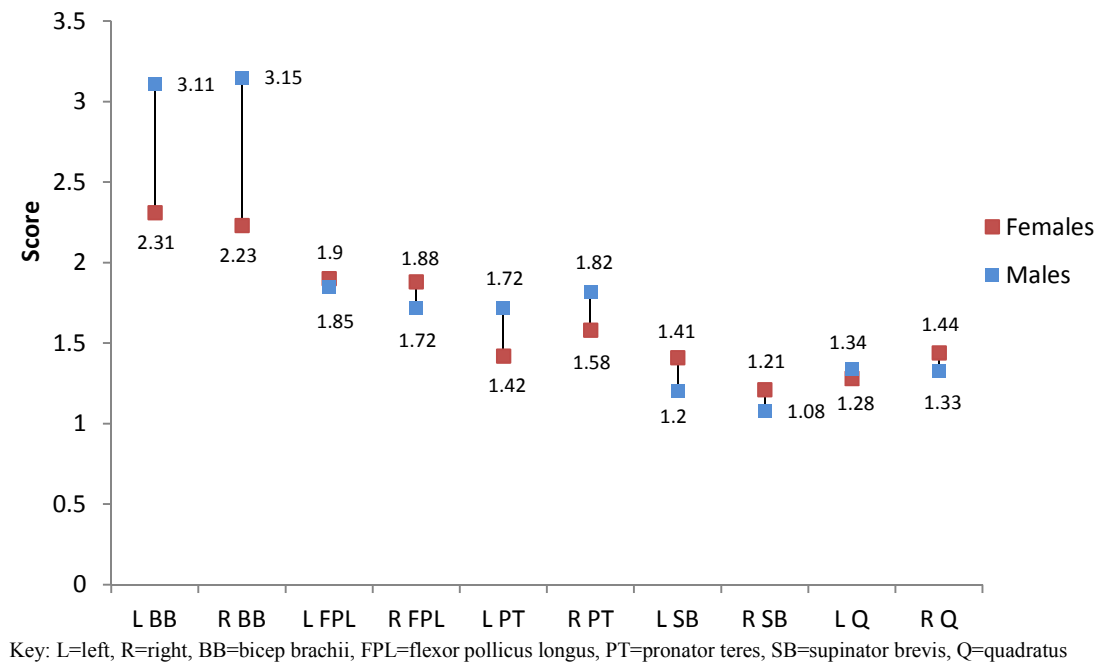
Radius

Figure 7.2.1.3 Comparison of mean radial enthesal scores between males and females

There was a strong correlation between humeral size and both biceps brachii scores (left $P \leq 0.001$ $n=35$, right $P=0.03$ $n=32$) and as such, males substantially outscore females at this marker (see figure 7.2.1.3). Due to the strong correlation of both the left and right biceps brachii score with humeral size, it was difficult to comment on biceps brachii score sex differences. Statistically, there was little difference in asymmetry between sexes (female $d=0.08$; males $d=0.04$) as might be expected when the marker correlates strongly with body size.

The left flexor pollicis longus score did not correlate with humeral size, but right flexor pollicis longus scores were weakly correlated with humeral size ($P=0.052$ $n=30$). Regardless, neither flexor pollicis longus scores correlated with sex. Males had greater asymmetry at the flexor pollicis longus attachments than females (male $d=0.11$: females $d=0.03$) but the difference was not statistically significant.

The left pronator teres score correlated statistically with humeral size ($P=0.042$ $n=35$), however, the right pronator teres score did not. The right pronator teres did correlate with sex and scored higher in males ($P=0.021$ $n=134$). Although asymmetry was greater in males (males $d=0.12$ females $d=0.05$) the difference was not significant.

Supinator brevis scores did not correlate with humeral size. Of note were higher supinator brevis scores in females (see figure 7.2.1.3), and a weak negative correlation with sex was demonstrated for the right supinator brevis scores (right $P=0.107$ $n=129$). Females were more asymmetric than males for supinator brevis scores (females $d=0.20$, males $d=0.11$) but the difference was not statistically significant.

Quadratus scores were not correlated with humeral size. While left quadratus scores were greater in males, neither side correlated with sex statistically. Greater asymmetry was seen in female quadratus scores (females $d=0.22$ males $d=0.03$) but, statistically, asymmetry was similar between the sexes.

Ulna

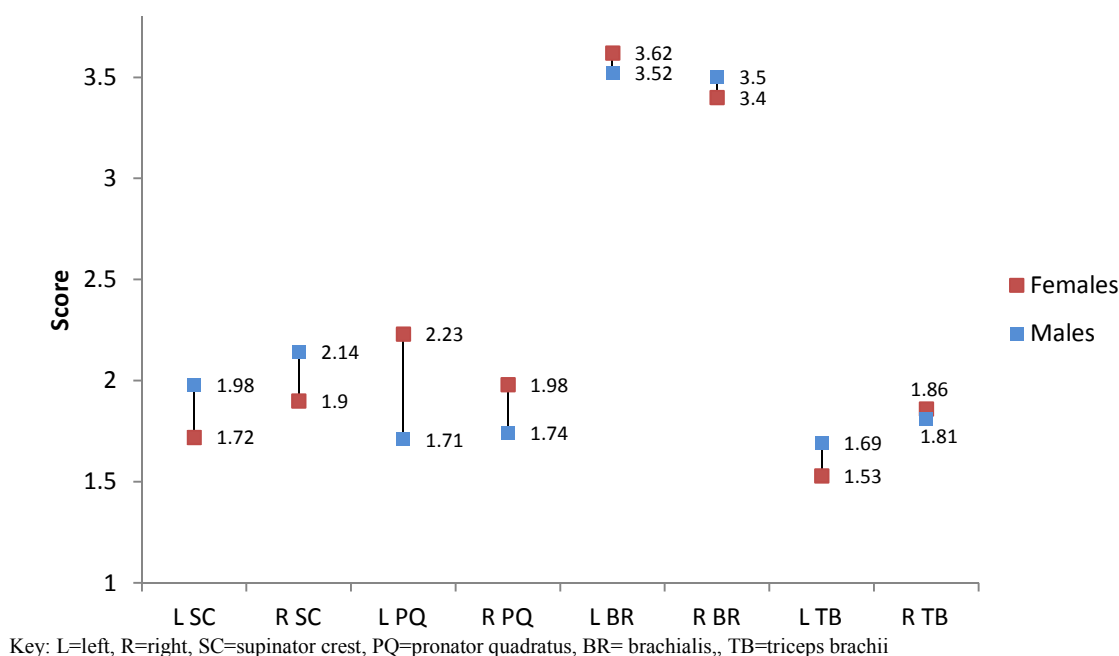


Figure 7.2.1.4 Comparison of mean ulna enteseal scores between males and females

A Spearman's correlation test did not reveal any correlation between ulna entheses scores and humeral size (see table 7.2.1.5 for P values).

The supinator crest scores correlated statistically with sex, being greater in males (left $P=0.007$ $n=107$, right $P=0.037$ $n=123$). Little difference in supinator crest score asymmetry existed between sexes (females $d=0.18$, males $d=0.16$)

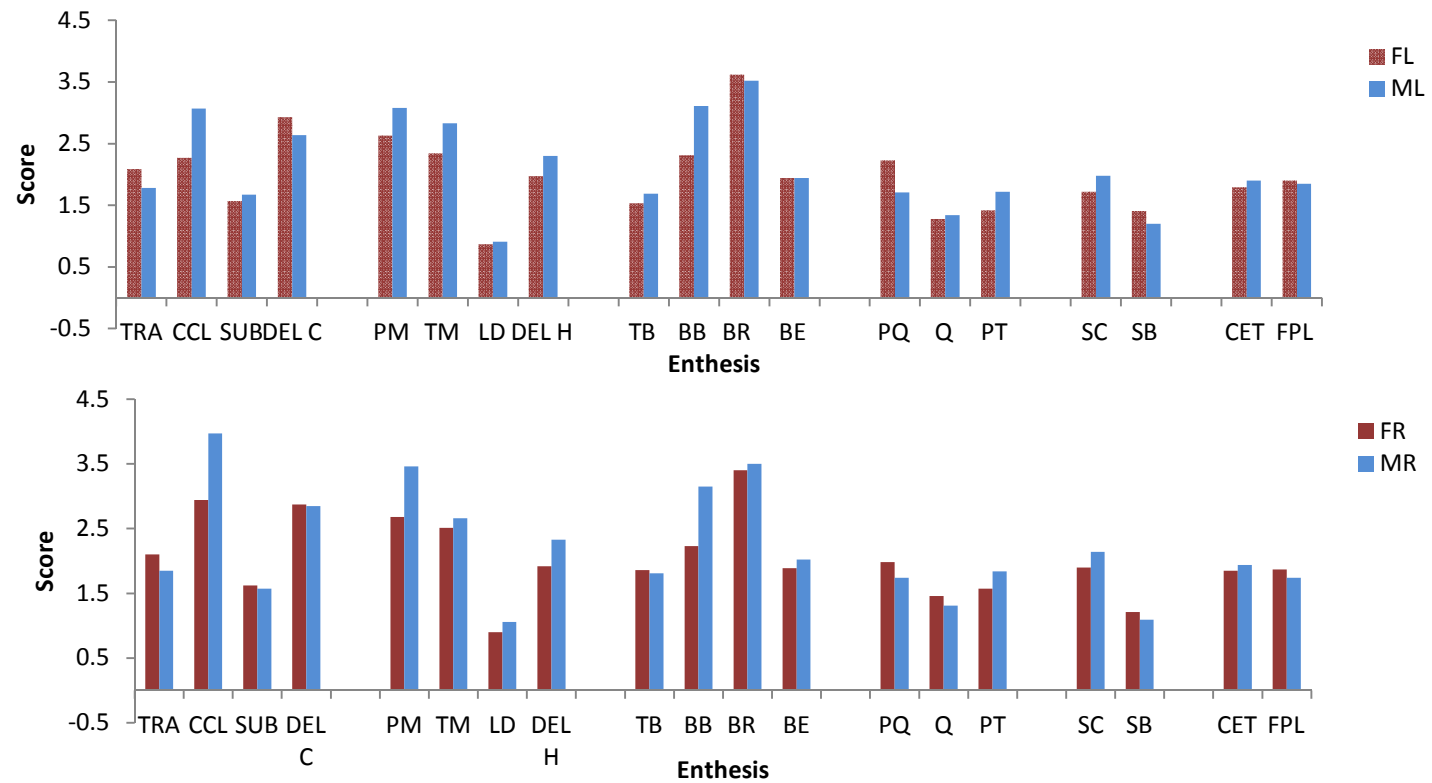
Pronator quadratus scores were significantly correlated with sex. The negative correlation indicates higher scores in females (left $P=0.002$ $n=77$, right $P=0.036$ $n=112$)

(see figure 7.2.1.4). Female pronator quadratus scores were more asymmetric than male scores (females $d=0.25$ males $d=0.03$), but the difference was not significant.

The left brachialis score was greater in females than males, but the opposite trend was observed for the right brachialis, however these differences were not significant.

Females had greater brachialis score asymmetry than males (female $d=0.22$, males $d=0.02$), however the difference was not significant.

Triceps brachii scores were indifferent between sexes. Although it was realised that females had greater tricep brachii score asymmetry than males (females $d=0.33$, males $d=0.12$), the difference was not significant.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. FL=female left, ML male left, FR= female right, MR = male right.

Figure 7.2.1.4.1 Enthesal scores presented by major muscle groups for Islamic males and females

Figure 7.2.1.4.1 demonstrated that some differences were visible in the muscle groups used between men and women. There was less variation in the scores of female muscle groups than in male muscle groups. On the left side, females appear to have undertaken more scapular elevation whereas in males, medio-lateral arm movement appeared to be a significant movement. On the right side, similar trends were noted.

Summary

Of note in this section were two entheses where females outscored males; the trapezius and the ulna pronator quadratus. Four other enteseal scores were elevated in females and were worthy of note; the flexor pollicis longus (radii) and the supinator brevis (radii), the deltoid attachment (clavicle) and the left brachialis (ulna). Entheses which were substantially larger in males than females and that did not statistically correlate with humeral size were the costoclavicular ligament, right pronator teres, left and right humeral deltoids and the teres major attachments.

7.2.2.2 Temporal differences in disaggregated enteseal scores between early and late Islamic individuals: analysis of changing social organisation

Sixty six early and 77 late individuals had observable entheses for the analysis of temporal change. There was no correlation between phase and humeral size (see table 7.2.1.2). Table 7.2.1.7 demonstrates where statistically significant correlations between enteseal score and phase were identified. Table 7.2.1.8 demonstrates the significance of any asymmetry for each enthesis analysed.

Table 7.2.1.7 Correlations between mean enthesal score with age and phase.

Enthesis	Left					Right				
	Age	P	Phase	P	N	Age	P	Phase	P	N
TRA	-0.057	0.605	-0.04	0.717	85	0.142	0.210	0.004	0.973	79
DEL C	0.047	0.671	-0.202	0.066	84	-0.014	0.905	-0.045	0.689	79
SUB	-0.09	0.412	-0.16	0.142	86	0.076	0.519	-0.201	0.082	75
CCL	-0.039	0.720	-0.063	0.566	86	0.249	0.039	0.024	0.842	69
DEL H	0.355	0.001	0.022	0.847	80	0.342	0.001	-0.123	0.178	122
TM	0.223	0.053	-0.128	0.269	80	0.203	0.030	-0.063	0.503	115
LD	0.361	0.003	0.361	0.887	64	0.247	0.020	0.108	0.315	89
PM	0.129	0.253	0.129	0.555	80	0.126	0.117	0.014	0.880	116
BE	0.215	0.072	0.215	0.727	80	0.151	0.098	0.196	0.031	121
CET	0.346	0.005	0.346	0.090	63	0.493	0.001	0.002	0.980	116
BB	0.27	0.007	-0.034	0.740	98	0.204	0.020	-0.02	0.825	130
FPL	0.185	0.069	-0.018	0.864	98	0.194	0.031	-0.068	0.453	124
PT	0.283	0.004	0.031	0.757	108	0.087	0.315	0.038	0.664	134
SB	0.254	0.011	0.17	0.091	100	0.009	0.920	-0.017	0.845	129
Q	0.287	0.011	-0.104	0.366	78	0.100	0.323	-0.241	0.016	99
SC	0.092	0.345	0.137	0.160	107	0.075	0.409	-0.005	0.959	123
PQ	-0.156	0.175	0.013	0.913	77	-0.032	0.730	0.016	0.862	115
BR	0.097	0.332	0.096	0.339	108	-0.011	0.904	-0.13	0.145	126
TB	0.318	0.003	0.061	0.580	85	0.211	0.040	0.082	0.427	95

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis, TB=triceps brachii.

Table 7.2.1.8 Disaggregated enthesal scores by phase and side. Left and right asymmetry (d) and statistical significance value

Enthesis	Left							Right							P value
	Early			Late			d	Early			Late			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	34	1.88	0.73	34	1.97	0.76	0.11	51	1.98	0.84	46	1.98	0.86	0.00	0.128
DEL C	31	2.48	1.24	35	2.80	1.08	0.48	53	2.98	1.07	45	2.91	1.10	0.07	0.086
SUB	34	1.50	0.83	34	1.50	0.62	0.19	51	1.69	0.51	42	1.76	0.53	0.26	0.318
CCL	38	2.55	1.33	29	3.48	1.24	0.93	47	2.72	1.41	41	3.44	1.52	0.72	0.075
DEL H	33	2.18	0.92	58	2.03	0.79	0.00	44	2.11	0.75	63	2.22	0.77	0.00	0.140
TM	31	2.52	1.21	57	2.68	1.02	0.16	44	2.57	1.15	57	2.49	0.95	0.08	0.608
LD	26	0.85	0.61	39	1.05	0.56	0.30	37	0.91	0.80	49	0.94	0.80	0.03	0.744
PM	33	2.91	1.21	57	3.05	0.99	0.14	46	2.80	1.24	58	3.16	1.36	0.36	0.121
BE	30	1.90	0.55	57	2.04	0.60	0.14	40	1.98	0.62	63	1.87	0.58	0.11	0.070
CET	29	1.93	0.59	54	1.89	0.72	0.04	33	1.73	0.63	61	1.90	0.68	0.17	0.559
BB	42	2.64	1.10	62	2.66	1.04	0.02	55	2.71	1.17	67	2.75	1.11	0.04	0.504
FPL	38	1.79	0.66	56	1.82	0.66	0.03	59	1.81	0.60	67	1.91	0.62	0.10	0.228
PT	42	1.74	0.86	63	1.60	0.61	0.14	60	1.67	0.77	70	1.57	0.79	0.10	0.521
SB	42	1.29	0.71	63	1.27	0.75	0.02	57	1.05	0.58	65	1.31	0.64	0.26	0.419
Q	32	1.28	0.85	46	1.07	0.90	0.21	45	1.47	0.82	52	1.52	0.75	0.05	0.106
SC	47	1.91	0.55	57	1.98	0.48	0.07	58	1.79	0.55	66	2.05	0.73	0.26	0.176
PQ	34	1.94	0.74	50	1.86	0.76	0.08	42	1.98	0.68	65	1.85	0.64	0.13	0.318
BR	44	3.73	0.95	59	3.34	0.99	0.39	56	3.45	1.09	67	3.55	0.91	0.1	0.097
TB	37	1.68	0.58	46	1.93	0.74	0.25	47	1.57	0.58	49	1.76	0.60	0.19	0.992

Key: n=number, P=p value, d=absolute difference between left and right sides, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii.

According to a Spearman's correlation test, only two enthesal scores correlated with phase after controlling for sex and age. A further four enthesal scores were close to correlating with phase.

Clavicle

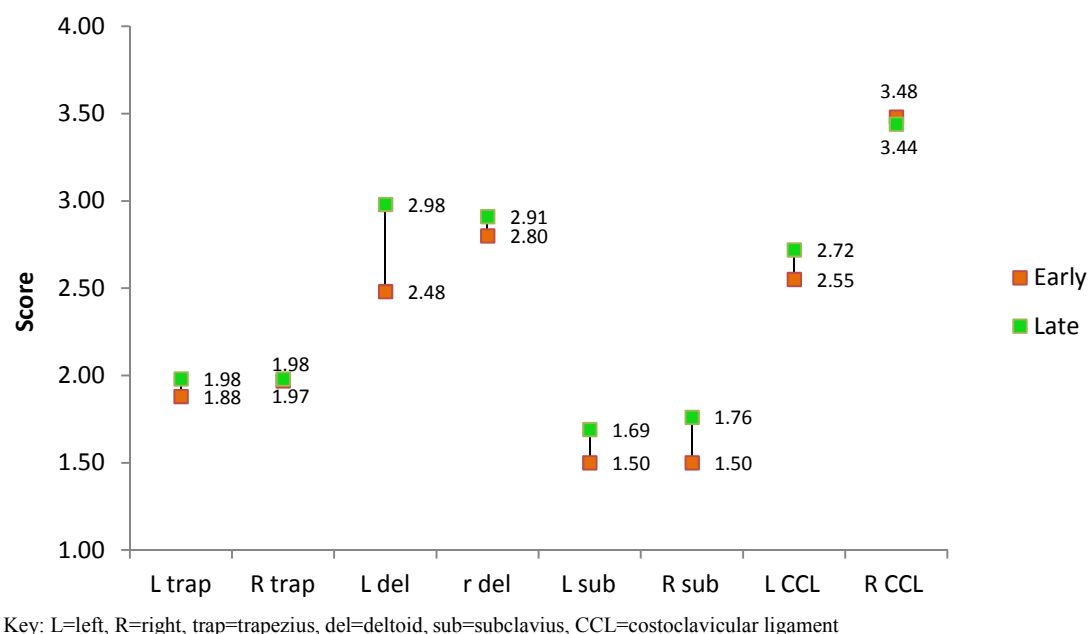


Figure 7.2.1.5 Comparison of mean clavicle enthesal scores between phases

Little difference was observed in trapezius scores between phases (figure 7.2.1.5). The trapezius scores were not asymmetric in either phase, although greater asymmetry was seen in the early phase (early $d=0.11$, late $d=0.00$). The difference in asymmetry was not significant.

The left deltoid score had a strong correlation with phase ($P=0.066$ $n=84$), with greater scores in the late phase, but the right deltoid score did not correlate with phase. The degree of deltoid score asymmetry was small in the late phase and more pronounced in the early phase (early $d=0.48$, late $d=0.07$). This difference was just outside significance ($P=0.086$ $n=115$), suggesting some asymmetry in the early phase, but not the late.

The right subclavius score correlated positively with phase but was outside significance ($P=0.082$ $n=75$). There was no relationship between the left subclavius score and phase. The subclavius scores had greater asymmetry in the late phase (early $d=0.19$ late $d=0.26$). The asymmetry difference was not significant.

No correlation between phase and costoclavicular ligament scores existed, despite the left costoclavicular ligament scoring higher in the late phase. In both phases, the right costoclavicular ligament scored greater than the left attachment. The early phase had the greatest degree of asymmetry (early $d=0.93$, late $d=0.72$). Although not statistically significant ($P=0.075$ $n=102$), the data implies a trend for greater costoclavicular ligament asymmetry in the early phase.

Humerus

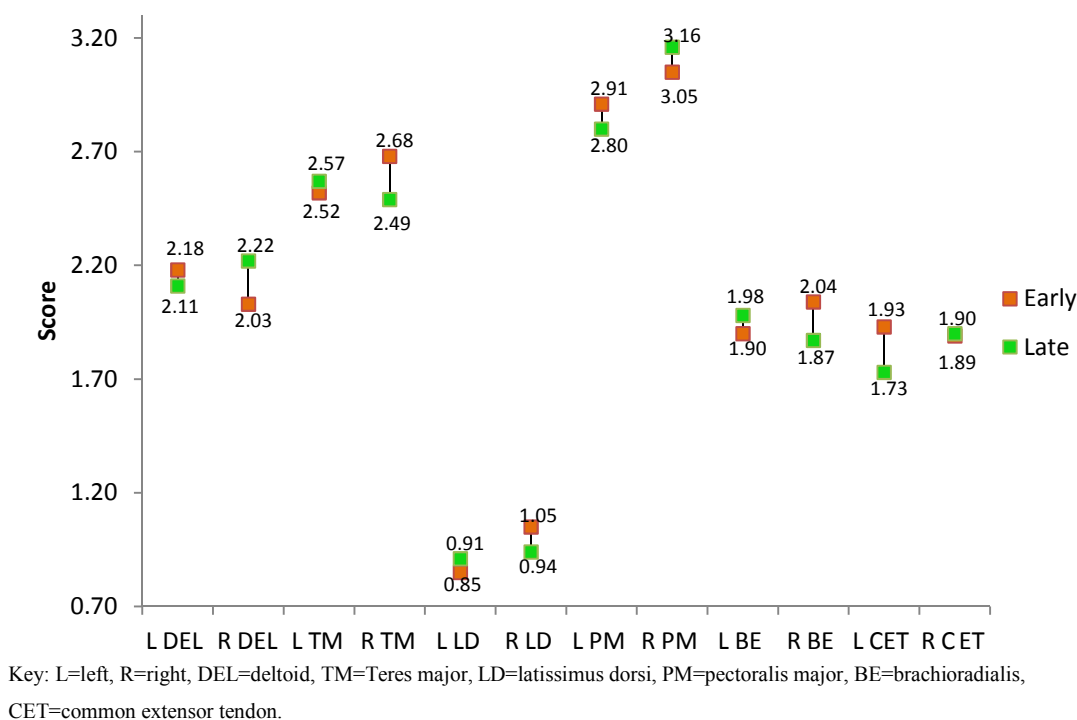


Figure 7.2.1.6 Comparison of mean humeral enthesal scores between phases

The deltoid scores had no correlation with phase despite the later deltoids having a higher score. Statistically, the deltoids had no asymmetry difference between phases (early $d=0.15$, late $d=0.11$).

Teres major scores were not correlated with phase. While in the early phase the left teres major scored greater, the right teres major scored higher in the late phase. Teres major scores were slightly more asymmetric in the early phase (early $d=0.16$, late $d=0.08$), but the difference in asymmetry was not statistically significant.

The latissimus dorsi scores did not differ between phases. Early phase latissimus dorsi markers had greater asymmetry than the late phase equivalent (early $d=0.3$, late $d=0.03$). Statistically, the difference was not significant.

The left pectoralis major score was greater in the early phase, whereas the right pectoralis major score was larger in the late phase. Regardless, neither the left or right score correlated with phase. Late phase individuals had greater pectoralis major asymmetry than early phase individuals (early $d=0.14$, late $d=0.36$). The difference in asymmetry was outside significance.

The late right brachioradialis extensor scored greater than the early phase equivalent, resulting in a positive correlation with phase ($P=0.031$ $n=121$). This pattern was also observed for the left side but was not significant. Little difference in asymmetry existed between phases for brachioradialis extensor scores (early $d=0.14$, late $d=0.11$).

Finally, the left common extensor tendon score decreased in the late phase indicating a trend for larger left common extensor tendon scores in the early phase ($P=0.09$ $n=63$). There was no difference in the score of the right common extensor tendon attachment over time. The common extensor tendon statistically had the same degree of asymmetry in both phases (early $d=0.04$, late $d=0.17$).

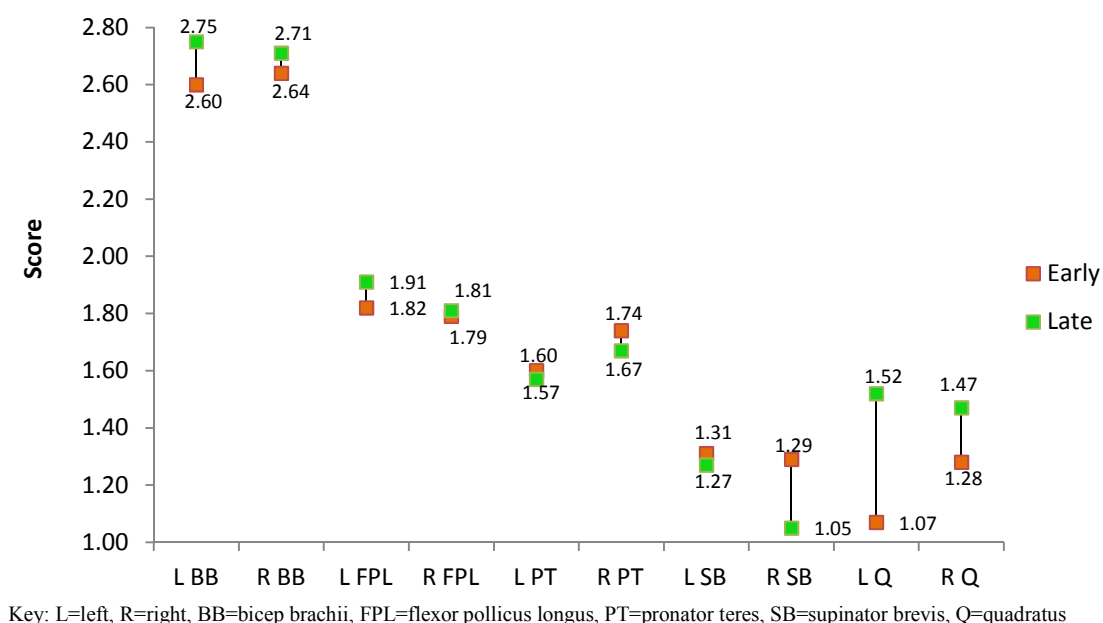
Radius

Figure 7.2.1.7 Comparison of mean radial enthesal scores between phases

Left and right biceps brachii scores increased in the late phase, however the difference was not statistically significant. This was expected as biceps brachii scores had a strong correlation with humeral size, and there was no correlation between humeral size and phase (table 7.2.1.2). Little asymmetry difference was observed between phases for the biceps brachii scores (early $d=0.02$, late $d=0.04$).

Left and right flexor pollicis longus scores increased in the late phase, but did not correlate with phase. The late flexor pollicis longus scores had greater asymmetry than the early phase scores (early $d=0.03$, late $d=0.10$), but the difference in asymmetry was small, and not significant.

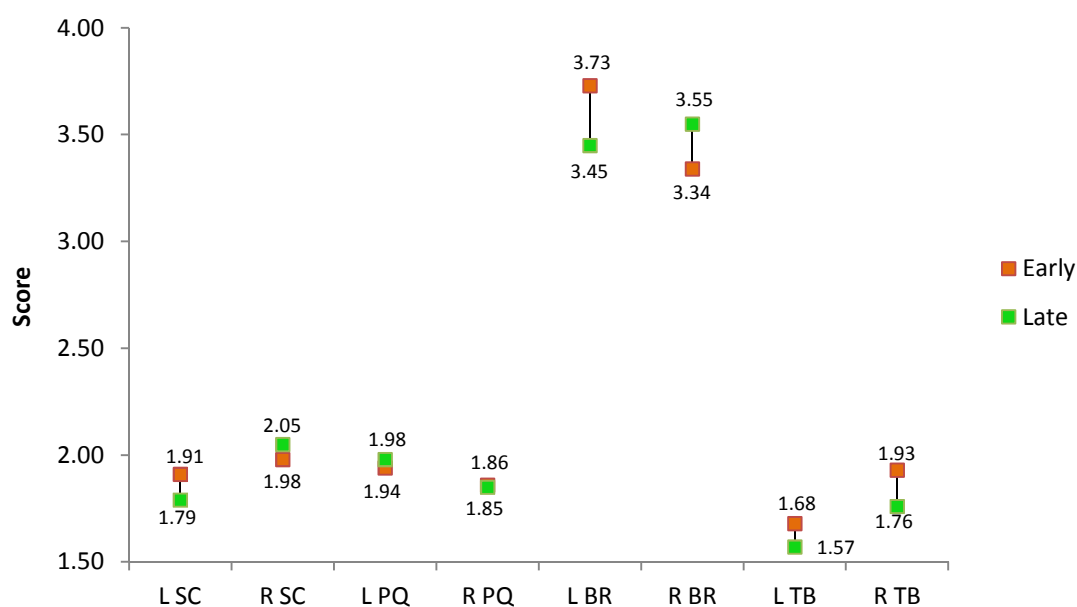
The pronator teres scores were higher in the early phase, but the difference was small and not significant. The early pronator teres scores were slightly more asymmetric than the late pronator teres scores (early $d=0.14$, late $d=0.10$). Statistically, however, no difference in asymmetry existed between phases.

The early left supinator brevis scored greater than late equivalent and demonstrated a weak correlation with phase, suggesting a temporal decrease in supinator brevis scores ($P=0.091$ $n=100$). The right supinator brevis score increased over time but not statistically. Greater asymmetry in supinator brevis scores existed in the late phase

(early $d=0.02$, late $d=0.26$), yet the asymmetry differences between phases was not statistically significant.

The left and right quadratus scores were greater in the late phase, however only the right score statistically correlated with phase ($P=0.016$ $n=99$), indicating an increase in right quadratus scores over time. The early phase quadratus scores differed by 0.21 in favour of the left side. Greater asymmetry was displayed in the late phase ($d=0.26$ in favour of the right side). The difference in asymmetry between phases was not significant but demonstrated a trend for greater asymmetry in the late phase ($P=0.106$ $n=114$).

Ulna



Key: L=left, R=right, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii

Figure 7.2.1.8 Comparison of mean ulna enthesal scores between phases

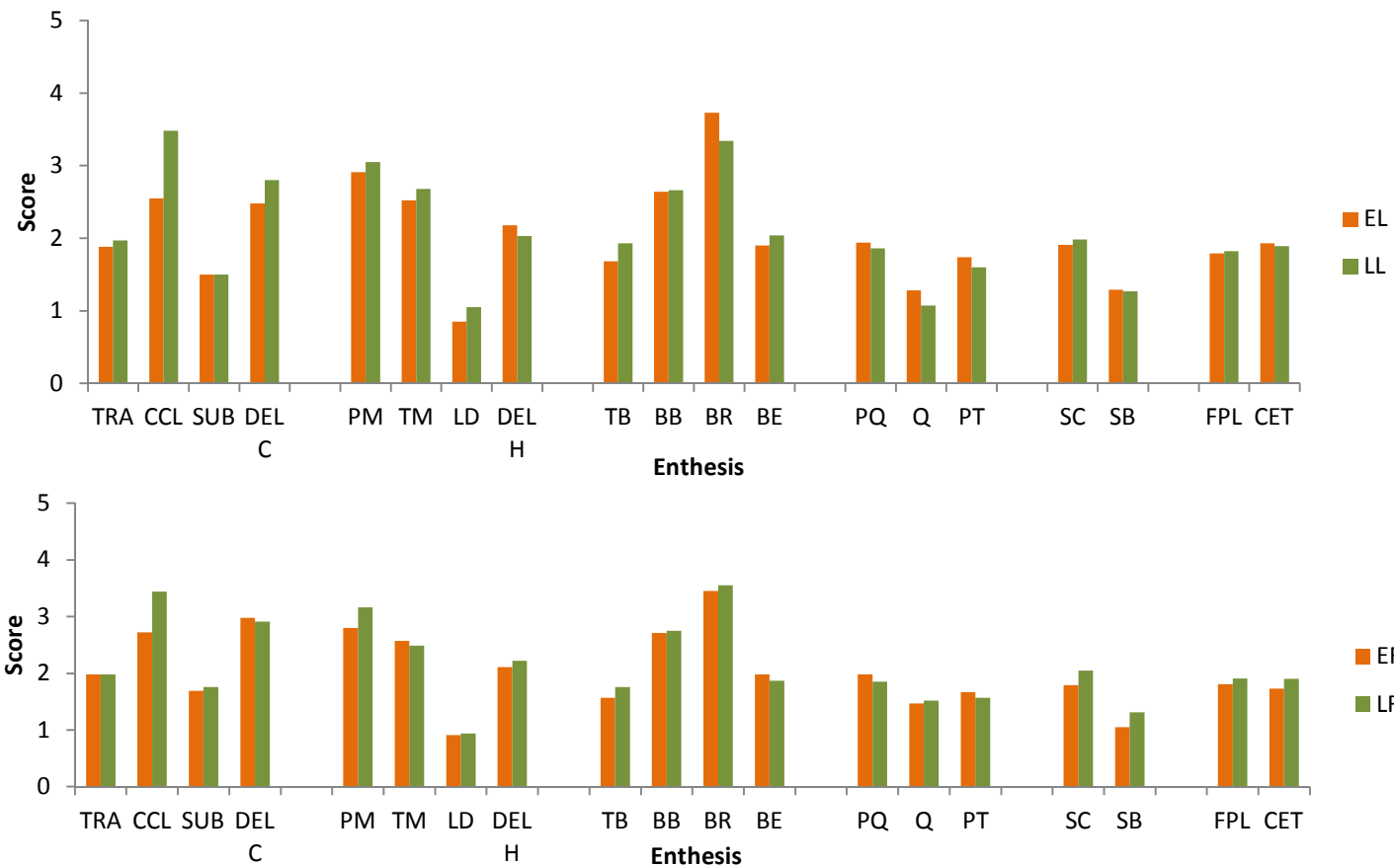
The relationship between left supinator crest score and phase was not significant ($P=0.160$ $n=117$). There was no difference between right supinator crest scores over time. The supinator crest had a greater degree of asymmetry in the late phase (early $d=0.07$, late $d=0.26$) but the difference was not statistically significant.

The pronator quadratus scores did not correlate with phase and did not change over time. The late phase had greater asymmetry in pronator quadratus scores (early $d=0.08$ late $d=0.13$) but asymmetry was low and did not differ between phases.

The left early brachialis score was greatest, but did not demonstrate a significant temporal correlation. The right brachialis score was larger in the late phase but not significantly. Greater brachialis asymmetry was observed in the early phase (early $d=0.39$, late $d=0.10$). Although not quite statistically significant, there was a trend for greater asymmetry in the early phase ($P=0.097$ $n=176$).

While the left and right tricep brachii scores were greater in the early phase, neither correlated with phase. The triceps brachii scores were greater on the right side in both phases, but greater asymmetry in scores were observed in the early phase (early $d=0.25$, late $d=0.19$). Statistically, no difference in asymmetry existed between phases.

Figure 7.2.1.8.1 demonstrates one difference in the muscle groups used in the early and late phase. On both sides, the greater costoclavicular ligament and pectoralis major scores may suggest greater mediolateral movement of the arm in the late phase.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. EL= early left, ER= early right, LL = late left, LR = late right

Figure 7.2.1.8.1 Enthesal scores presented by major muscle groups for early and late Islamic individual.

Summary

Overall, few temporal differences were observed in entheal scores, but some notable changes were highlighted. Although there was no overall temporal increase or decrease in entheal scores, notable differences include increases in the supinator brevis scores and the brachioradialis extensor scores, and reductions in the deltoid (clavicle), subclavius and quadratus scores. Generally, late phase clavicles had greater entheal scores than early phase clavicles, yet there was no increase in clavicle size (see section 7.5.1.2). The humerus, radius and ulna show no trend for increasing or decreasing entheal scores over time. However, differences in some entheal scores suggest that different muscles may have been engaged in the two time periods. Furthermore, there was no single directional change in the degree of asymmetry in entheal over time. Some entheses had greater asymmetry in the early phases whereas others were more asymmetric in the late phase. Some entheses exhibited no change over time.

7.2.2.3 Analysis of temporal changes in disaggregated enthesal scores: changing Islamic identity.

The following paragraphs explored whether enthesal scores changed over time for each sex in order to demonstrate whether gender roles changed temporally.

7.2.2.3.1 Analysis of temporal changes in female disaggregated enthesal scores: changing female Islamic identity

Sixty six females (28 early females and 38 late females) had at least one enthesal score available for comparison between phases. Table 7.2.1.9 presents the results of correlation analysis between enthesal score and phase. Only the right pectoralis major score correlated with phase being smaller in the late phase. Table 7.2.1.10 shows the difference in enthesal scores between sides and the statistical significance of this difference. Only two radial (supinator brevis and pronator quadratus) entheses had different patterns of asymmetry temporally.

Table 7.2.1.9 Correlation between enthesal score and phase for female individuals.

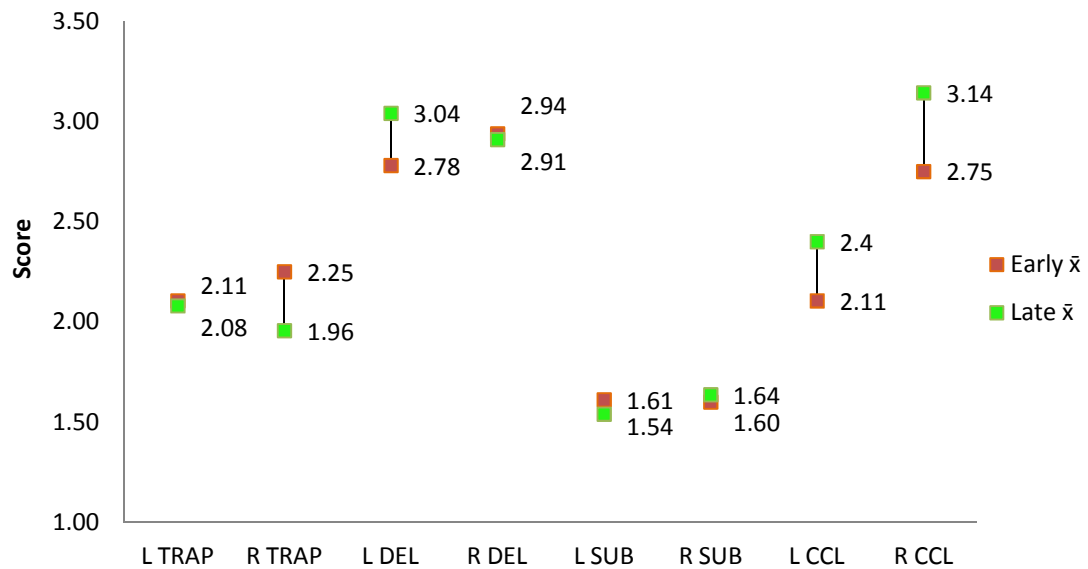
Enthesis	Left			Right		
	Correlation with phase	P	N	Correlation with phase	P	N
TRA	0.041	0.792	41	0.152	0.362	36
DEL C	-0.132	0.392	42	0.008	0.961	35
SUB	0.043	0.784	41	-0.027	0.877	34
CCL	-0.117	0.455	41	-0.172	0.348	30
DEL H	0.319	0.062	33	0.090	0.504	56
TM	-0.012	0.945	32	0.062	0.660	50
LD	0.014	0.941	27	0.376	0.084	38
PM	0.282	0.095	34	0.276	0.047	50
BE	0.069	0.712	29	0.064	0.641	53
CET	0.269	0.158	27	0.085	0.543	51
BB	-0.001	0.993	59	-0.030	0.830	50
FPL	-0.050	0.713	55	-0.026	0.856	48
PT	-0.020	0.985	59	-0.134	0.345	50
SB	0.044	0.744	55	0.267	0.058	49
Q	-0.180	0.255	40	-0.228	0.137	42
SC	0.138	0.320	60	-0.061	0.650	56
PQ	-0.045	0.786	43	-0.075	0.594	51
BR	0.189	0.180	50	-0.119	0.373	56
TB	0.128	0.412	41	0.244	0.129	38

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis, TB=triceps brachii.

Table 7.2.1.10 Female individual mean enthesal scores by phase.

Enthesis	Early							Late							P value d
	left			Right			d	left			right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	19	2.11	0.57	16	2.25	0.78	0.14	23	2.08	0.64	23	1.96	0.64	-0.12	0.331
DEL C	18	2.78	1.02	16	2.94	1.06	0.16	27	3.04	1.31	22	2.91	1.11	0.13	0.483
SUB	18	1.61	0.61	15	1.60	0.51	-0.01	26	1.54	0.51	22	1.64	0.58	0.10	0.718
CCL	19	2.11	1.10	12	2.75	1.06	0.64	25	2.40	1.29	21	3.14	1.28	0.74	0.276
DEL H	15	2.33	0.90	28	2.00	0.72	-0.33	21	1.76	0.70	31	1.84	0.64	0.08	0.666
TM	15	2.40	1.40	24	2.58	0.88	0.18	21	2.30	1.17	29	2.45	0.78	0.15	0.267
LD	12	0.92	0.67	17	1.12	0.60	0.20	18	0.89	0.96	24	0.75	0.61	-0.14	1.000
PM	15	3.20	1.32	24	2.96	0.96	-0.24	22	2.50	0.86	29	2.45	0.87	-0.05	1.000
BE	13	2.00	0.58	25	1.92	0.49	-0.08	19	1.95	0.71	31	1.87	0.62	-0.08	1.000
CET	13	2.00	0.58	25	2.00	0.71	0.00	17	1.65	0.70	29	1.72	0.70	0.07	0.334
BB	28	2.18	0.55	23	2.35	0.76	0.17	34	2.26	0.83	30	2.33	0.92	0.07	0.746
FPL	26	1.88	0.59	20	1.90	0.72	0.02	32	1.91	0.59	31	1.87	0.56	-0.04	0.769
PT	28	1.43	0.57	22	1.55	0.80	0.12	34	1.41	0.66	31	1.61	0.76	0.20	0.058
SB	28	1.46	0.84	21	1.48	0.68	0.02	30	1.37	0.67	31	1.03	0.61	-0.34	0.029
Q	19	1.11	0.99	20	1.30	0.92	0.19	24	1.42	0.88	25	1.56	0.82	0.14	0.544
SC	22	1.86	0.47	28	1.89	0.57	0.03	34	1.65	0.60	32	1.91	0.59	0.26	0.110
PQ	16	2.20	0.66	24	1.96	0.39	-0.23	25	2.10	0.58	31	2.00	0.58	-0.20	0.135
BR	21	3.76	0.89	28	3.32	0.95	-0.44	33	3.39	1.09	32	3.47	0.95	0.08	0.852
TB	17	1.71	0.47	19	2.11	0.65	-0.06	28	1.50	0.51	23	1.65	0.94	0.61	0.332

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicus longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii.

Clavicle

Key: L=left, R=right, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament

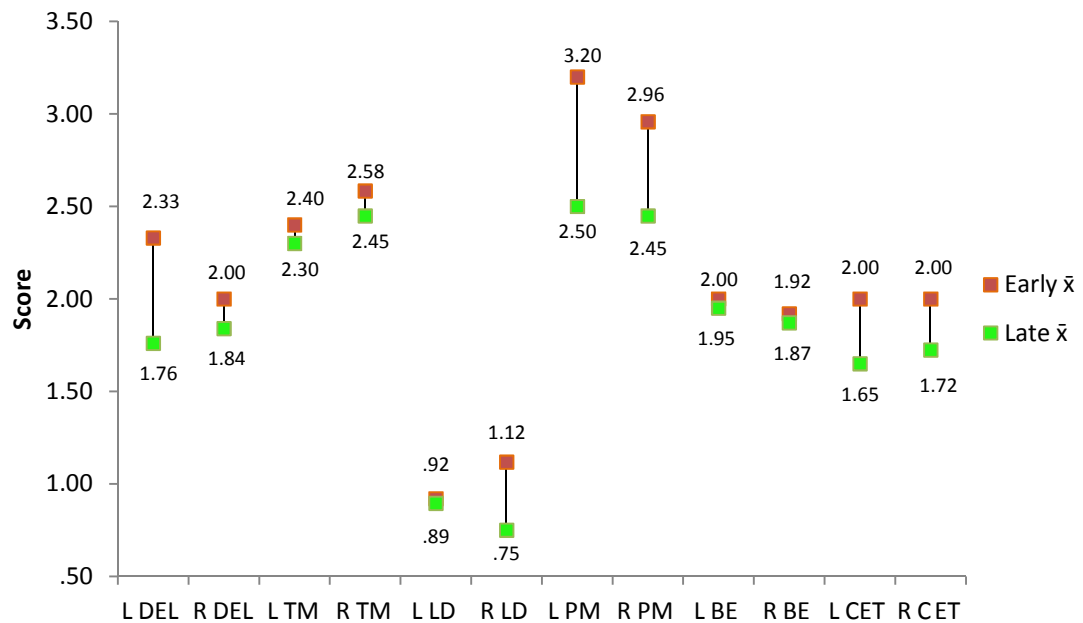
Figure 7.2.1.9 Comparison of mean clavicle enthesal scores between early and late females

Trapezius scores were greater in early females, particularly for the right side (figure 7.2.1.9). However neither side correlated with phase. Little asymmetry difference existed between phases for the trapezius scores.

Left and right deltoid scores did not correlate with phase. The early deltoid scores had slightly more asymmetry than the late deltoid scores (early $d=0.16$, late $d=0.13$) but the difference was not significant.

The subclavius scores remained constant over time. Late individuals had a greater degree of asymmetry than early individuals, but the difference was small (early $d=0.01$, late $d=0.1$) and not significant.

Left and right costoclavicular ligament scores increased in the late phase, but neither score was significantly correlated with phase. Greater asymmetry was observed in the late phase costoclavicular ligament scores (early $d=0.64$ late $d=0.74$), but the difference was not significant.

Humerus

Key: L=left, R=right, DEL=deltoid, TM=Teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon.

Figure 7.2.1.10 Comparison of mean humeral enthesal scores between early and late females

Deltoid scores were greater in early females. A weak correlation between the left deltoid attachment and phase existed ($P=0.062$ $n=33$). This relationship was not observed for the right score. In terms of asymmetry, the early females have greater deltoid score asymmetry (early $d=0.33$, late $d=0.08$), but the difference was not statistically significant.

Left and right teres major scores were greater in the females, but neither attachment showed a significant relationship with phase. Greater asymmetry was observed in early females, but the difference was small (early $d=0.18$, late $d=0.15$) and not significant.

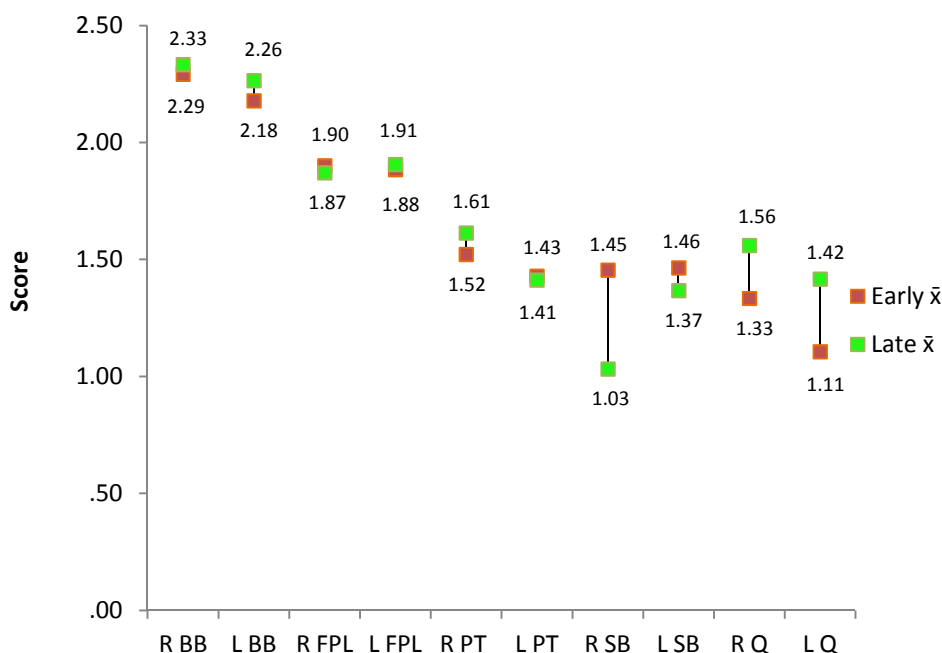
Latissimus dorsi scores decreased in late females. The right latissimus dorsi score appeared to correlate weakly with phase ($P=0.084$ $n=38$) but the left did not. Greater asymmetry was observed in the early female latissimus dorsi scores (early $d=0.2$ late $d=0.14$), but the difference between phases was not statistically significant.

Left and right pectoralis major scores decreased in late females with the right strongly correlating with phase ($P=0.047$ $n=50$). While the left pectoralis major did not correlate

with humeral size in this sample (see table 7.2.1.4), the right did, this needs to be taken into consideration. Greater asymmetry was observed in early females (early $d=0.24$, late $d=0.05$) but the difference was not statistically significant.

Early female brachioradialis extensor scores were greater than the late female brachioradialis extensor scores on both sides; however neither score correlated with phase. No difference in asymmetry was observed between phases (early and late $d=0.08$).

Early female common extensor tendon scores were greater than late female scores, but no correlation with phase existed for either side. No asymmetry existed in early female common extensor scores ($d=0.00$), but some left/right differences are observed in late females ($d=0.07$). The difference was not statistically significant.

Radius

Key: L=left R=right, BB=biceps brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus

Figure 7.2.1.11 Comparison of mean radial enthesal scores between early and late females

The biceps brachii scores did not correlate with phase; this follows the fact that there was no change in body size in females over time (section 7.5.1.3). Greater asymmetry was observed in the early phase (early $d=0.17$, late $d=0.07$), but the difference was not statistically significant.

The early female flexor pollicis longus scores were greater than the late female equivalent, but the difference was negligible and no correlation with phase on either side was identified. Little difference in asymmetry existed between phases (early $d=0.02$, late $d=0.04$).

The left and right pronator teres scores were equal between phases and exhibited no temporal relationship. Greater asymmetry existed in late females (early $d=0.01$, late $d=0.20$) but was just outside statistical significance ($P=0.058$ $n=65$), suggesting some increase in asymmetry temporally.

The right supinator brevis score was larger in early females and was extremely close to a statistical inverse correlation with time period ($P=0.058$ $n=49$). The left equivalent

also scored greater in early females but exhibited no statistical relationship with phase. Asymmetry was greater in late females (early $d=0.02$, late $d=0.34$) and the difference was significant ($P=0.029$ $n=61$), suggesting an increase in asymmetry over time.

Quadratus scores increased in the late females, yet neither left nor right quadratus scores correlated with phase. The difference between left and right scores was similar between phases, with the early females having slightly greater asymmetry (early $d=0.19$, late $d=0.14$). The difference was not statistically significant.

Ulna

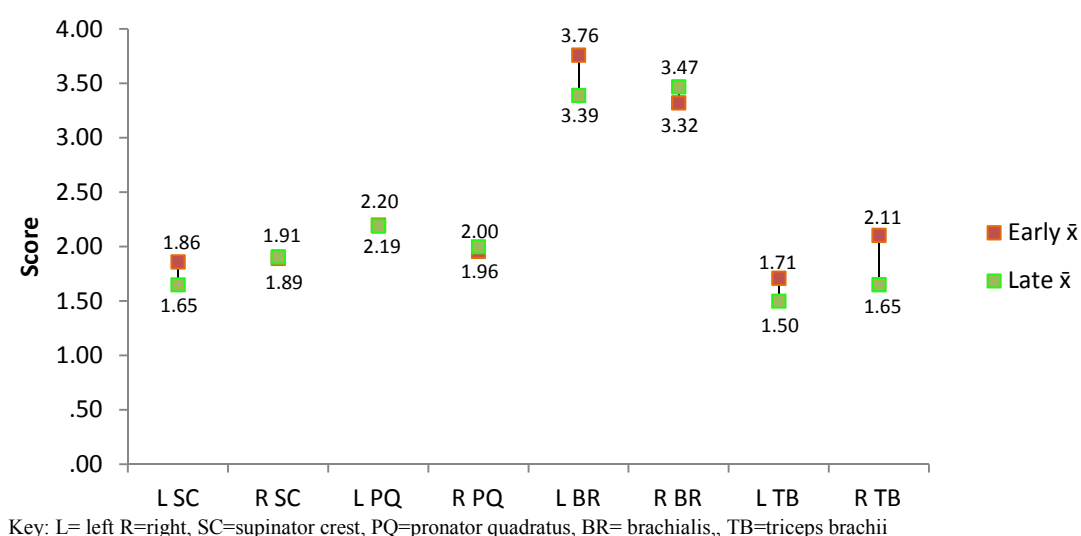


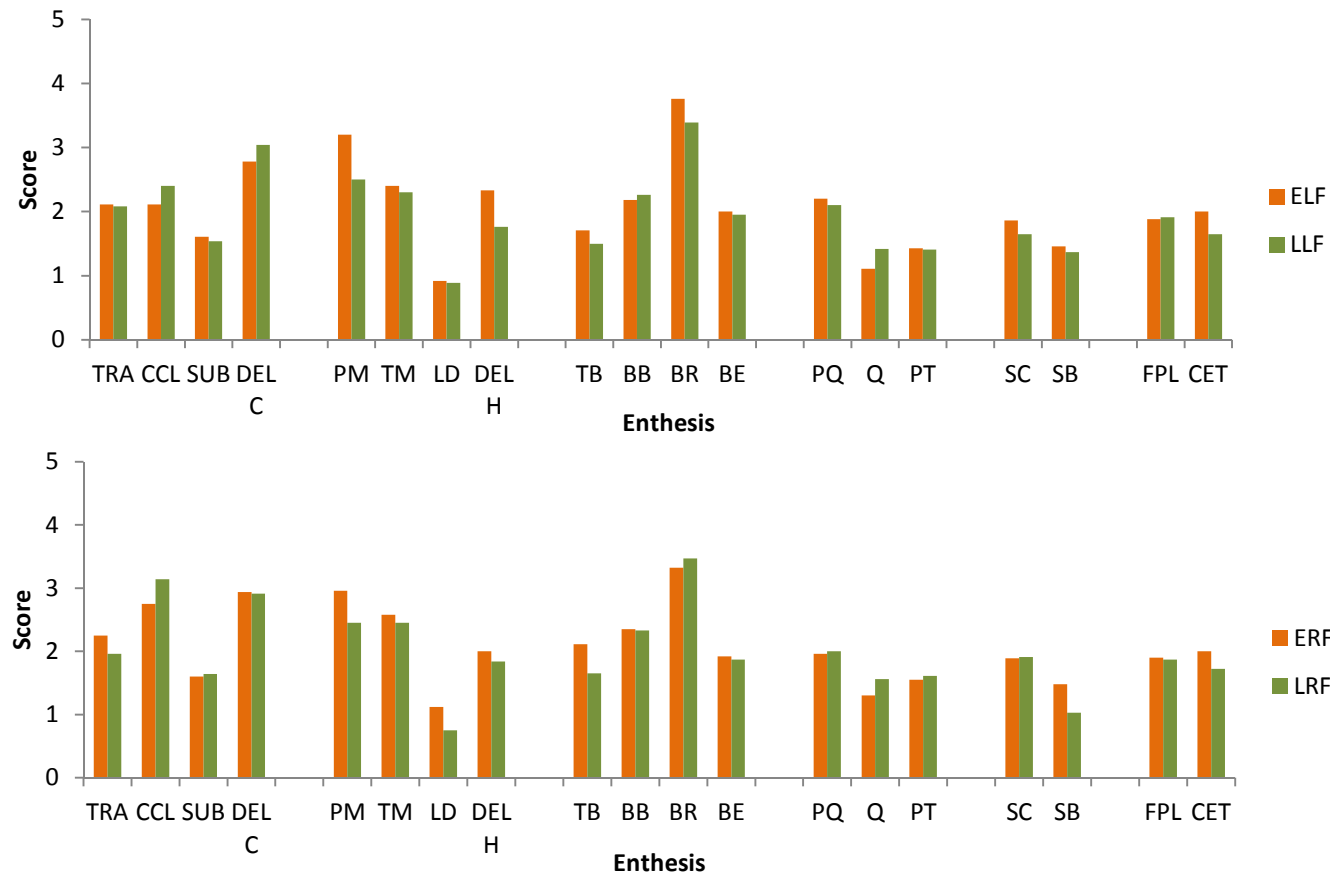
Figure 7.2.1.12 Comparison of mean ulna enthseal scores between early and late females

There was no significant difference in the left or right supinator scores over time. No difference between early and late asymmetry exists (early $d=0.03$, late $d=0.11$).

Early and late female pronator quadratus scores were similar and showed no correlation with phase. Little asymmetry existed in each phase (early $d=0.23$ late $d=0.20$) and the difference between them was not statistically significant.

The left brachialis score was larger in early females, but the right brachialis score was larger in late females. Neither left nor right brachialis scores correlated statistically with phase. Greater asymmetry is expressed in early females (early $d=0.44$, late $d=0.08$), but the difference was not statistically significant.

The left triceps brachii scored greater in early females. The right tricep brachii score was greater in late females. The left and right tricep brachii scores did not correlate statistically with phase. There was greater triceps brachii asymmetry in late females (early $d=0.06$, late $d=0.61$), but the difference was not significant.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. ELF = early left female, LLF late left female. ERF=early right female, LRF late right female.

Figure 7.2.1.12.1 Enteseal scores presented by major muscle groups for early and late Islamic females

Figure 7.2.1.12.1 demonstrates that there were some changes to female muscle group use, but there was little difference in the use of major muscle groups. On the left side, there was greater involvement of the upper arm muscles (brachioradialis extensor and pectoralis major), which may suggest more medio-lateral movement while the arm is in flexion. On the right side, greater score were observed for the shoulder elevators (costoclavicular ligament and the deltoid clavicle attachment).

Summary

Over time early females have a trend for greater mean scores than the late females, yet, with the exception of the ulna, there was little temporal change in entheal patterns. The correlation with phase was statistically significant for the right pectoralis major and the supinator brevis scores. No difference was observed for the clavicle, but the early humerus had greater mean entheal scores, especially for pectoralis major, the left deltoid attachment and the right latissimus dorsi.

7.2.2.3.2 Analysis of temporal changes in male disaggregated entheal scores: changing male Islamic identity

Seventy seven males (38 early males and 39 late males) had at least one entheses score available for comparison between phases. Table 7.2.1.11 presents the results of correlation analysis between entheses score and phase. Seven entheses demonstrated a temporal change in score for Islamic males. Table 7.2.1.12 shows the difference in entheal scores between sides and the statistical significance of this difference. Four entheses demonstrated statistically significant differences in asymmetry over time.

Table 7.2.1.11 Correlation between enthesal score and phase for male individuals.

Enthesis	Left			Right		
	Correlation with phase	P	N	Correlation with phase	P	N
TRA	-0.134	0.408	38	-0.039	0.809	38
DEL C	-0.356	0.028	36	-0.074	0.647	39
SUB	-0.357	0.022	39	-0.316	0.053	36
CCL	-0.058	0.720	39	0.158	0.359	34
DEL H	-0.180	0.293	34	-0.279	0.028	60
TM	0.099	0.572	33	-0.163	0.208	59
LD	0.094	0.629	27	0.019	0.897	45
PM	0.137	0.420	35	-0.262	0.040	60
BE	-0.139	0.434	32	0.299	0.016	62
CET	0.104	0.592	27	-0.135	0.298	59
BB	-0.048	0.699	65	-0.111	0.473	42
FPL	-0.048	0.706	63	-0.007	0.963	44
PT	0.000	0.997	69	0.128	0.382	47
SB	-0.060	0.623	68	0.038	0.801	45
Q	-0.262	0.053	53	0.014	0.941	30
SC	0.191	0.183	48	-0.040	0.765	61
PQ	0.221	0.202	33	0.050	0.702	58
BR	0.029	0.845	45	-0.167	0.179	64
TB	-0.002	0.989	37	-0.010	0.945	51

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis,, TB=triceps brachii.

Table 7.2.1.12 Male individual mean enthesal scores by phase.

Enthesis	Early male							Late male							P value
	left			right			d	left			right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	15	1.6	0.82	17	1.76	0.66	0.28	26	1.88	0.93	24	1.96	1.04	0.20	0.214
DEL C	13	2.08	1.04	18	2.72	1.13	0.84	26	2.92	1.13	24	2.88	1.12	0.16	0.380
SUB	16	1.38	1.03	18	1.44	0.71	0.47	26	1.85	0.46	21	1.86	0.48	0.42	0.386
CCL	19	3.00	1.41	17	4.12	1.22	0.13	23	3.13	1.46	20	3.65	1.63	-0.47	0.065
DEL H	18	2.05	0.91	31	2.06	0.85	0.45	19	2.50	0.62	32	2.59	0.71	0.53	0.062
TM	17	2.88	1.17	34	2.44	0.99	-0.09	19	2.79	0.98	28	2.93	1.18	0.49	0.658
LD	15	0.87	0.52	23	1.00	0.52	0.06	15	0.93	0.70	25	1.12	0.93	0.12	0.917
PM	19	3.00	1.29	34	3.12	1.01	-0.11	19	2.89	1.37	29	3.86	1.41	0.74	0.034
BE	18	1.83	0.51	33	2.15	0.67	0.23	19	2.06	0.56	32	1.88	0.55	-0.27	0.009
CET	16	1.94	0.68	30	1.80	0.71	-0.08	14	1.86	0.54	32	2.06	0.62	0.26	0.694
BB	24	3.06	1.18	19	3.00	1.33	0.18	33	3.24	1.15	25	3.16	1.22	0.16	0.195
FPL	30	1.77	0.57	18	1.67	0.59	0.14	35	1.91	0.66	28	1.75	0.65	0.08	0.449
PT	35	1.74	0.61	20	1.95	0.89	-0.02	36	1.72	0.88	29	1.72	0.8	-0.23	0.961
SB	35	1.11	0.63	21	1.10	0.70	0.15	35	1.26	0.61	26	1.08	0.56	-0.02	0.741
Q	27	1.04	0.85	12	1.25	0.75	0.57	28	1.61	0.85	20	1.35	0.81	0.10	0.050
SC	22	2.09	0.43	30	2.10	0.40	-0.19	29	1.9	0.56	34	2.10	0.83	0.00	0.464
PQ	15	1.93	0.80	27	1.78	0.85	-0.36	21	1.57	0.68	34	1.71	0.68	-0.07	0.036
BR	21	3.67	1.06	32	3.34	1.04	-0.11	27	3.56	1.05	35	3.63	0.88	0.29	0.421
TB	19	1.63	0.68	26	1.79	0.568	0.04	21	1.67	0.66	28	1.85	0.54	0.06	0.652

Key: N=number, SD=standard deviation, $\bar{x}$ =mean, d=difference between left and right scores, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis,, TB=triceps brachii

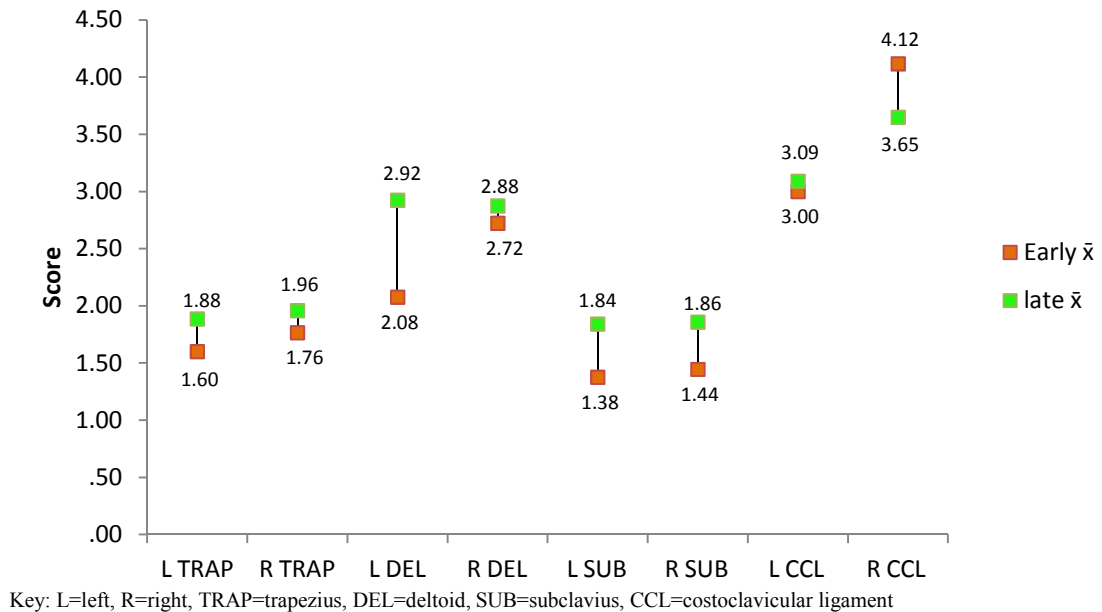
Clavicle

Figure 7.2.1.13 Comparison of mean clavicle enthesal scores between early and late males

Late phase males had greater mean trapezius scores than early males, yet the scores did not correlate with phase. Statistically, little difference existed in the degree of asymmetry between phases (early $d=0.28$, late $d=0.20$).

Deltoid scores increased in late males. This temporal correlation was statistically significant for the left deltoid (left $P=0.028$ $n=36$), but not for the right. Substantial asymmetry existed in early males, which was reduced in late males (early $d=0.84$, late $d=0.16$). This difference was just outside statistical significance ($P=0.065$ $n=81$).

Subclavius scores were larger in late males on both sides demonstrating an increase in subclavius scores over time. While the correlation was only significant for the left (left $P=0.022$ $n=39$), the right was just outside statistical significance (right $P=0.053$ $n=36$). Asymmetry was present in both phases (early $d=0.47$, late $d=0.42$), but was not different.

The left costoclavicular ligament score was larger in late males, but the correlation with phase was not statistically significant. The right equivalent score was greater in early males, but again failed to correlate with phase. Greater asymmetry existed in late males

(early $d=0.13$, late $d=0.47$), and the difference was just outside significance ($P=0.065$ $n=79$), suggesting greater asymmetry in late males.

Humerus

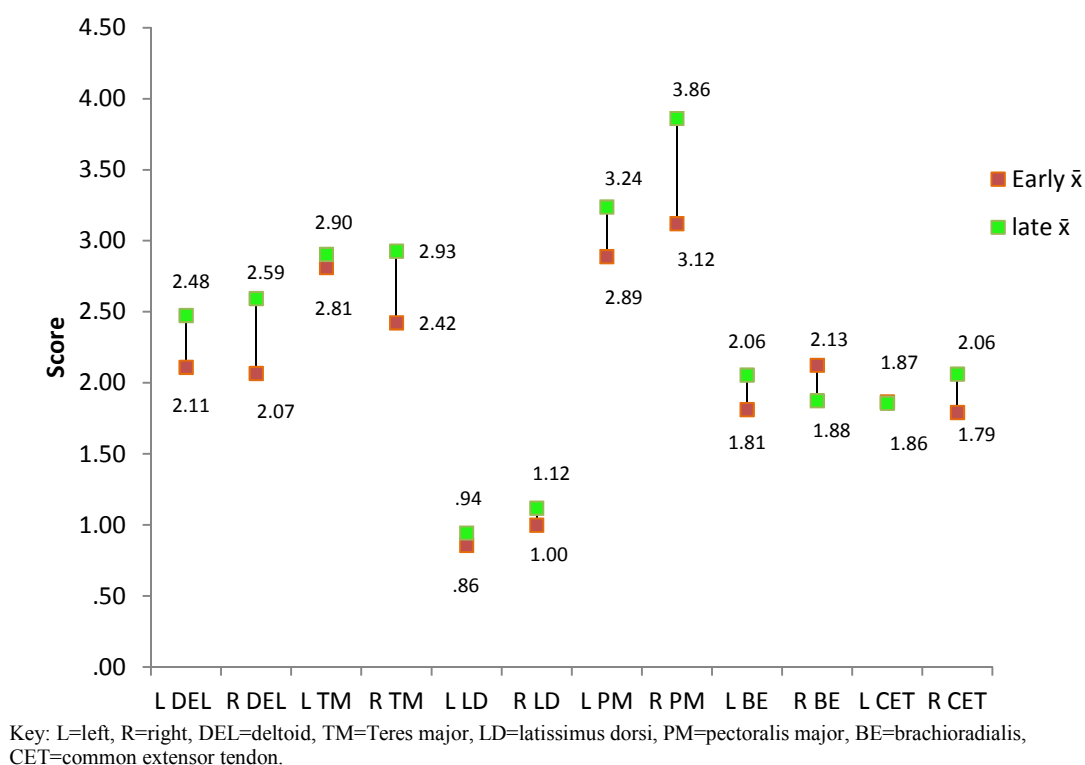


Figure 7.2.1.14 Comparison of mean humeral enteseal scores between early and late males

According to figure 7.2.1.14, late males had greater deltoid scores, but the left deltoid score did not correlate with phase, demonstrating no change over time. The right deltoid score, however, was correlated with phase, suggesting an increase in right deltoid score over time ($P=0.028$ $n=60$). Asymmetry existed in both phases and was slightly greater in late males. While not statistically significant ($P=0.062$ $n=100$) a trend is indicated where greater asymmetry exists in late male deltoid scores.

The left teres major score did not correlate with phase in males. The right teres major scored greater in late males, but did not correlate with phase. No teres major asymmetry existed in early males, but was apparent in late males (early $d=0.09$, late $d=0.49$). Regardless, the difference was not statistically significant.

The latissimus dorsi scores were greater in late males, but was not correlated with phase. No significant differences asymmetry existed between early and late males for the latissimus dorsi scores (early $d=0.06$, late $d=0.12$).

While the left pectoralis major score decreased in late males, no significant temporal relationship existed. The right pectoralis major score, however, increased in late males and was correlated with phase ($P=0.04$ $n=60$). Significantly greater asymmetry existed in late male scores (early $d=0.11$, late $d=0.74$) ($P=0.034$ $n=95$).

While the left brachioradialis extensor score increased in late males, the change was not significant. The right brachioradialis extensor did correlate with phase, being larger in early males ($P=0.016$ $n=62$). Little difference in asymmetry existed between phases (early $d=0.23$ late $d=0.27$). However, in the early phase, the left brachioradialis extensor score was greater, whereas in the late phase, the right score was greater. This difference was highly statistically significant ($P=0.009$ $n=102$) and demonstrates a reversal in the dominant side.

The left common extensor tendon score was larger in early males, but was not statistically correlated with phase. The right common extensor tendon score was greater in late males, but again did not correlate with phase. There was greater asymmetry in late male scores (early $d=0.08$, late $d=0.26$), but the difference between phases was not statistically significant.

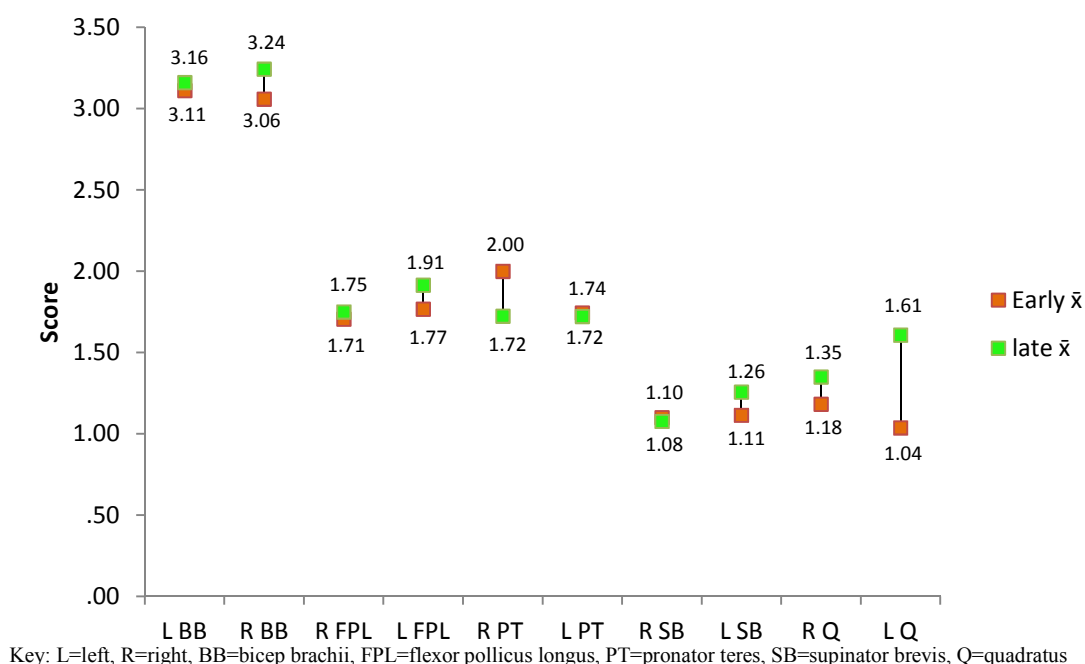
Radius

Figure 7.2.1.15 Comparison of mean radius entheasal scores between early and late males

There was no correlation between phase and biceps brachii score. This might be expected as there was no change in body size over time (see section 7.5.1.4). In terms of asymmetry, statistically no temporal change was observed for the biceps brachii scores (early $d=0.08$, late $d=0.26$).

Flexor pollicis longus scores were larger in late males, but did not correlate with phase. Statistically, no change in flexor pollicis longus asymmetry appeared between phases (early $d=0.14$, late $d=0.08$).

The left pronator teres scores were similar between phases and no correlation existed. The right pronator teres score was greater in early males, but the correlation was not statistically significant. Little asymmetry existed in early males, but increased in late males (early $d=0.02$, late $d=0.23$). The difference however was not statistically significant.

Left male supinator brevis scores increased over time, but did not correlate statistically with phase. There was no difference in right supinator brevis scores between early and

late males. Asymmetry was greater in late males (early $d=0.15$ late $d=0.23$), but was not significantly different between phases.

A correlation was identified for left quadratus score and phase ($P=0.05$ $n=53$) demonstrating a decrease in quadratus score over time. Asymmetry existed in the early males but not in the late males (early $d=0.57$, late $d=0.10$). The difference between phases, however, was not statistically significant.

Ulna

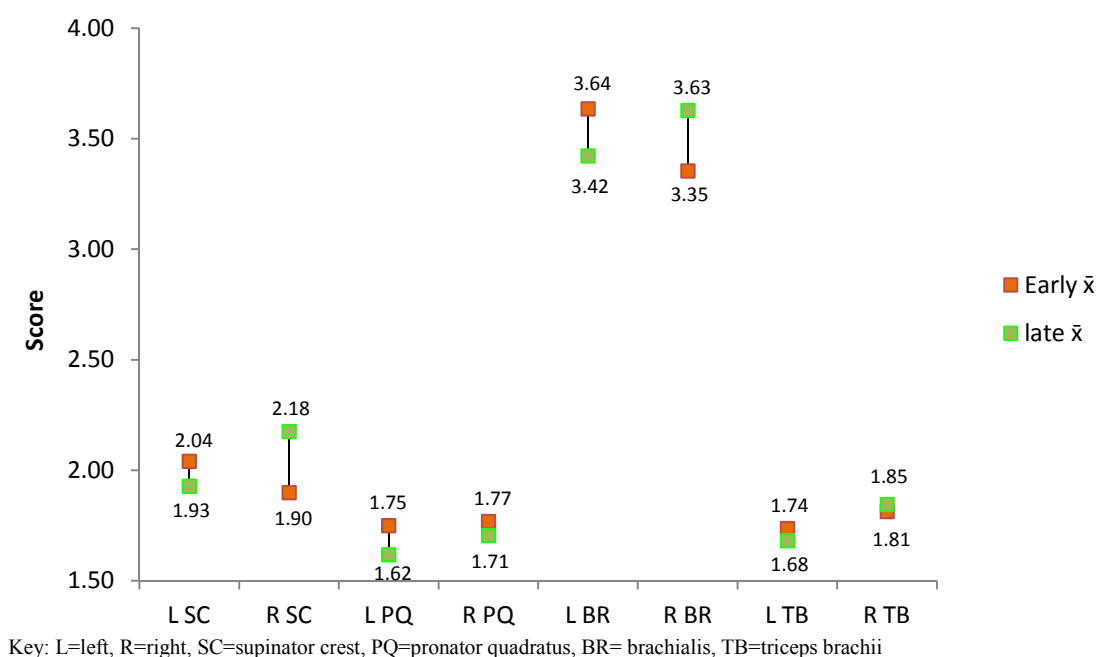


Figure 7.2.1.16 Comparison of mean ulna enteseal scores between early and late males

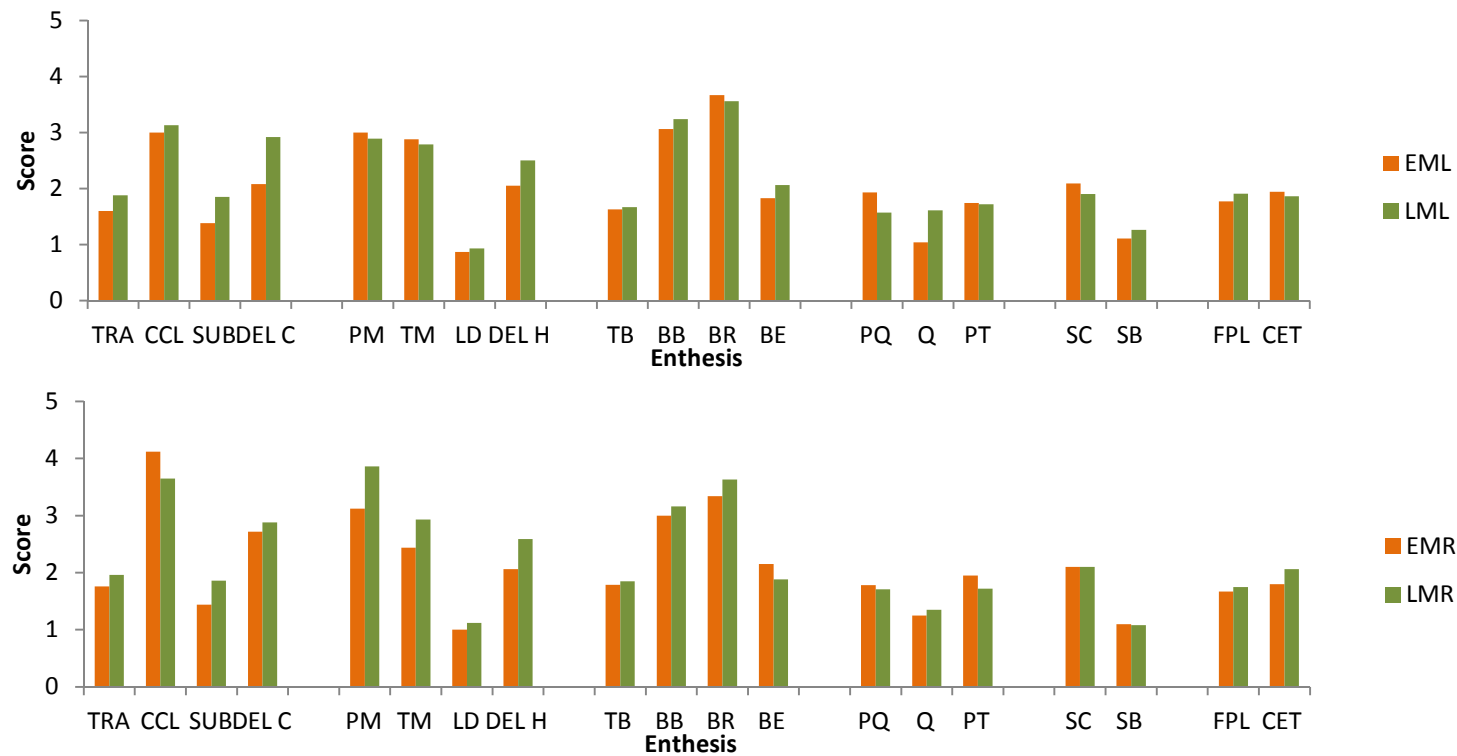
Left supinator crest scores were greater in early males, but showed no correlation with phase. The right supinator crest score did not differ between phases. Asymmetry was low in both phases, but decreased in late males (early $d=0.19$, late $d=0.01$). The asymmetry difference between phases was not significant.

Both early pronator quadratus scores were larger than the late phase equivalent, but no correlation with phase was identified. Asymmetry existed in pronator quadratus scores during the early phase but not in the late phase (early $d=0.36$, late $d=0.07$). This difference was statistically significant, implying less asymmetry existed in late males ($P=0.036$ $n=97$).

The left brachialis score was larger in early males, but was not statistically correlated with phase. The right brachialis attachment had higher scores in late males, but also failed to exhibit a statistical relationship with phase. While greater asymmetry was identified in late males (early $d=0.11$, late 0.26), the difference was not statistically significant, suggesting no temporal change in asymmetry.

There was no difference in the mean left and right tricep brachii scores between early and late males. No asymmetry existed in early or late male tricep brachii scores (early $d=0.04$; late $d=0.06$).

Figure 7.2.1.16.1 demonstrated that muscle-use patterns did change over time in males, but there was little difference in the use of major muscle groups. First the greater asymmetry in the late phase was immediately visible from figure 7.2.1.16.1. On the left side, there was little difference between phases and muscle-group use, but on the right side, the muscle group involved in medial lateral movement of the humerus demonstrated greater recruitment in late males.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. EML= early male left, LML = late male left, EMR = early male right, LMR = late male right.

Figure 7.2.1.16.1 Enthesal scores presented by major muscle groups for early and late Islamic males

Summary

Overall, late males tend to have greater scores than early males, but some variability existed. The left deltoid (clavicle), both subclavius, right deltoid (humerus), right pectoralis major and the left quadratus on the radius had statistically larger scores in late males. Only the brachioradialis extensor score was larger in early males. A number of entheses have changing patterns of asymmetry over time, including the costoclavicular ligament, the deltoid (humerus), pectoralis major, brachioradialis extensor, quadratus and the pronator quadratus. Many more differences were observed in males than in females.

7.2.2.4 Analysis of temporal changes in sex difference in disaggregated Islamic enthesal scores: temporal analysis of changing gender ideology

This section explored male and female sex differences in enthesal scores in each phase with a view to demonstrating temporal changes in gendered muscle use. Table 7.2.1.13 and 7.2.1.14 present the relationship between enthesal score and sex for each phase.

Table 7.2.1.13 Correlation of left and right enthesal scores with sex for early phase individuals

Enthesis	Left			Right		
	Correlation with sex	P value	N	Correlation with sex	P value	N
TRA	-0.177	0.219	48	-0.096	0.524	44
DEL C	-0.079	0.579	50	-0.042	0.784	43
SUB	0.316	0.025	49	0.17	0.281	40
CCL	0.263	0.074	45	0.151	0.352	38
DEL H	0.448	0.005	36	0.454	≤0.001	60
TM	0.162	0.331	36	0.136	0.319	54
LD	-0.042	0.821	30	0.163	0.268	46
PM	0.06	0.713	38	0.497	≤0.001	55
BE	0.057	0.744	33	-0.035	0.789	60
CET	0.096	0.614	28	0.081	0.537	58
BB	0.46	≤0.001	64	0.245	0.074	52
FPL	-0.05	0.692	64	-0.206	0.120	56
PT	0.145	0.234	67	0.044	0.741	57
SB	-0.049	0.701	62	-0.041	0.767	54
Q	0.057	0.691	49	-0.3210	0.171	42
SC	0.183	0.155	60	0.151	0.230	63
PQ	-0.441	0.002	43	-0.291	0.020	62
BR	0.082	0.539	57	0.070	0.575	64
TB	0.07	0.637	46	0.136	0.357	46

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis,, TB=triceps brachii

Excluding the biceps brachii, which correlates with humeral size, in the early phase six entheses were statistically correlated with sex. All scored higher in males with the exception of the left and right radial pronator quadratus which scored greater in females (see table 7.2.1.13). There was no difference in the patterns of asymmetry between the sexes for any enthesis site examined (see table 7.2.1.15).

Table 7.2.1.14 Correlation of left and right enthesal scores with sex for late phase individuals

Enthesis	Left			Right		
	Correlation with sex	P value	N	Correlation with sex	P value	N
TRA	-0.339	0.050	31	-0.307	0.088	30
DEL C	-0.292	0.117	28	-0.117	0.518	31
SUB	-0.176	0.328	31	-0.094	0.608	30
CCL	0.369	0.025	35	0.523	0.004	26
DEL H	-0.120	0.507	31	0.044	0.741	56
TM	0.230	0.212	29	-0.06	0.655	55
LD	-0.011	0.958	24	-0.025	0.880	37
PM	-0.077	0.669	31	0.128	0.341	55
BE	-0.147	0.440	28	0.24	0.072	55
CET	-0.003	0.986	26	-0.115	0.408	52
BB	0.440	≤0.001	59	0.263	0.097	39
FPL	-0.067	0.626	53	-0.167	0.324	35
PT	0.265	0.037	60	0.267	0.092	39
SB	-0.220	0.086	60	-0.255	0.108	39
Q	-0.028	0.855	43	-0.053	0.778	29
SC	0.324	0.036	40	0.265	0.048	54
PQ	-0.139	0.472	27	-0.109	0.458	47
BR	-0.080	0.622	38	0.007	0.957	56
TB	-0.075	0.672	32	-0.147	0.336	43

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis,, TB=triceps brachii

Excluding the biceps brachii which correlates with humeral size, in the late phase six markers were also correlated with sex, but these were different markers than those which correlated with sex in the early phase (table 7.2.1.14). Only the left trapezius scored greater in females, while the remainder scored higher in males. Importantly, a further five enthesal scores were close to statistically correlating with phase, more than observed in the early phase ($P \leq 0.097$) (see table 7.3.1.14). The pectoralis major also had a different pattern of laterality between the sexes in the late phase with greater asymmetry in males (see table 7.2.1.16).

Table 7.2.1.15 Means, standard deviations for early male and female enthesal scores. Asymmetry value (d) and significance.

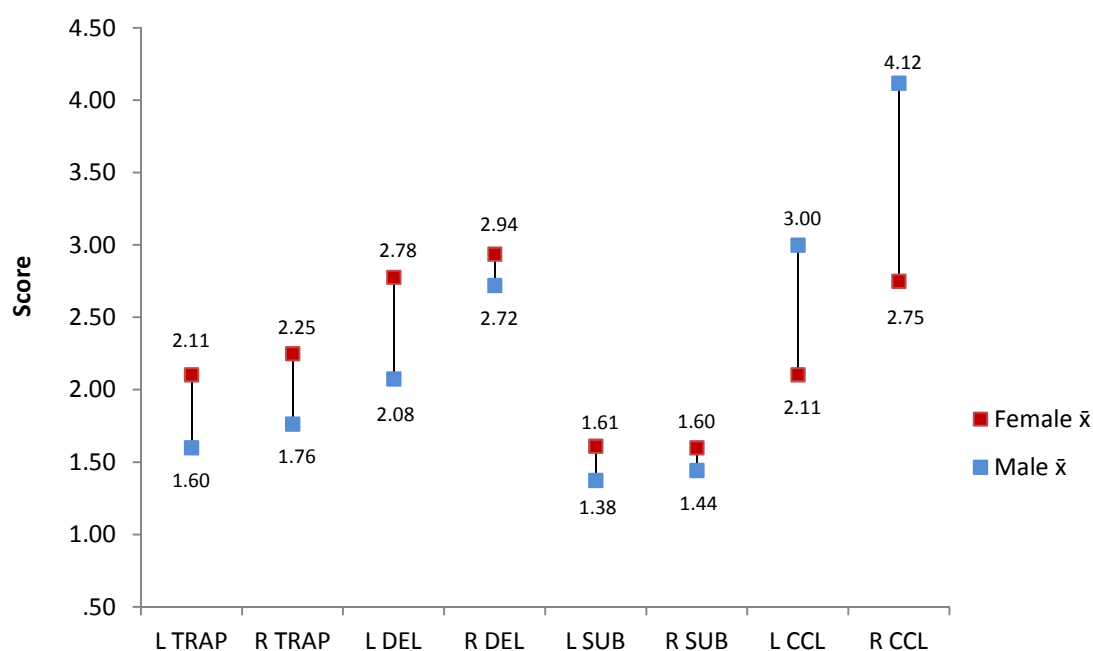
Early enthesis	Female							Male							P value
	left			right			d	left			right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	19	2.11	0.57	16	2.25	0.78	0.14	15	1.6	0.83	17	1.76	0.66	0.20	0.292
DEL C	18	2.78	1.31	16	2.94	1.06	0.16	13	2.08	1.04	18	2.72	1.13	0.16	0.791
SUB	18	1.61	0.61	15	1.60	0.51	-0.01	16	1.38	1.03	18	1.44	0.71	0.42	0.322
CCL	19	2.11	1.10	12	2.75	1.06	0.64	19	3.00	1.41	17	4.12	1.22	-0.47	0.286
DEL H	15	2.33	0.90	28	2.00	0.72	-0.33	19	2.05	0.91	31	2.06	0.85	0.53	0.806
TM	15	2.4	1.40	24	2.58	0.88	0.18	17	2.88	1.17	34	2.44	0.99	0.49	0.138
LD	12	0.92	0.67	17	1.12	0.60	0.20	15	0.87	0.52	23	1.00	0.55	0.12	0.751
PM	15	3.2	1.32	24	2.96	0.96	-0.24	19	3.00	1.29	34	3.12	1.01	0.74	0.889
BE	13	2.00	0.58	25	1.92	0.49	-0.08	18	1.83	0.51	33	2.15	0.67	-0.27	0.108
CET	13	2.00	0.58	25	2.00	0.71	0.00	16	1.94	0.68	30	1.8	0.71	0.26	0.745
BB	28	2.18	0.55	23	2.35	0.78	0.17	34	3.06	1.18	19	3.00	1.33	0.16	0.095
FPL	26	1.8	0.77	20	1.9	0.72	0.02	30	1.77	0.57	18	1.67	0.59	0.08	0.927
PT	28	1.43	0.57	22	1.55	0.80	0.12	35	1.74	0.61	20	1.95	0.89	-0.23	0.732
SB	28	1.46	0.84	21	1.48	0.68	0.02	35	1.11	0.63	21	1.1	0.70	-0.02	0.562
Q	19	1.11	0.99	20	1.3	0.92	0.19	27	1.04	0.85	12	1.25	0.75	0.10	0.782
SC	22	1.86	0.47	28	1.89	0.57	0.03	22	2.09	0.43	30	2.1	0.40	0.00	0.752
PQ	16	2.19	0.66	24	1.6	0.62	-0.23	15	1.93	0.80	27	1.78	0.85	-0.07	0.129
BR	21	3.76	0.79	28	3.32	0.95	-0.44	21	3.67	1.07	32	3.34	1.04	0.29	0.588
TB	17	1.71	0.47	19	2.11	0.94	-0.06	19	1.63	0.68	28	1.79	0.57	0.06	0.814

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicus longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii

Table 7.2.1.16 Means, standard deviations for late male and female enthesal scores. Asymmetry value (d) and significance.

Late enthesis	Female						Male								P value
	left			right			d	left			right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	25	2.08	0.64	23	1.96	0.64	0.12	26	1.88	0.99	24	1.96	1.04	-0.08	0.212
DEL C	27	3.04	1.02	22	2.91	1.11	0.13	26	2.92	1.13	24	2.88	1.12	0.04	0.621
SUB	26	1.54	0.51	22	1.64	0.58	-0.10	26	1.85	0.46	21	1.86	0.48	-0.01	0.369
CCL	25	2.40	1.29	21	3.14	1.28	-0.74	23	3.13	1.46	20	3.65	1.63	-0.52	0.300
DEL H	21	1.76	0.70	31	1.84	0.64	-0.08	18	2.50	0.62	32	2.59	0.71	-0.09	0.143
TM	20	2.30	1.17	29	2.45	0.78	-0.15	19	2.79	0.98	28	2.93	1.18	-0.14	0.206
LD	18	0.89	0.96	24	0.75	0.61	0.14	15	0.93	0.70	25	1.12	0.93	-0.19	0.676
PM	22	2.50	0.86	29	2.45	0.87	0.05	19	2.89	1.37	29	3.86	1.41	-0.97	0.005
BE	19	1.95	0.71	31	1.87	0.62	0.08	17	2.06	0.56	32	1.88	0.55	0.18	0.385
CET	17	1.65	0.70	29	1.72	0.70	-0.07	14	1.86	0.54	32	2.06	0.62	-0.20	0.591
BB	34	2.26	0.83	30	2.33	0.92	-0.07	33	3.24	1.15	25	3.16	1.28	0.08	0.685
FPL	32	1.91	0.59	31	1.87	0.56	0.04	35	1.91	0.66	28	1.75	0.65	0.16	0.978
PT	34	1.41	0.66	31	1.62	0.76	-0.21	36	1.72	0.88	29	1.72	0.80	0.00	0.116
SB	30	1.37	0.67	31	1.03	0.61	0.34	35	1.26	0.61	26	1.08	0.56	0.18	0.111
Q	24	1.42	0.88	25	1.56	0.82	-0.14	28	1.61	0.40	20	1.35	0.81	0.26	0.322
SC	34	1.65	0.60	32	1.91	0.59	-0.26	29	1.90	0.56	34	2.18	0.83	-0.28	0.605
PQ	25	2.20	0.58	31	2.00	0.58	0.20	21	1.57	0.68	34	1.71	0.68	-0.14	0.093
BR	33	3.39	1.09	32	3.47	0.95	-0.08	27	3.56	1.05	35	3.63	0.88	-0.07	0.883
TB	28	1.50	0.51	23	1.65	0.65	-0.15	21	1.67	0.66	26	1.85	0.54	-0.18	0.125

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii

Early Clavicle

Key: L=left, R=right, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament

Figure 7.2.1.17 Comparison of mean clavicle enthesal scores between early males and females

According to 7.2.1.17, the early trapezius scores showed little relationship with sex. A trend for females to have larger trapezius scores than males was identified on both sides. Male trapezius scores have greater asymmetry (female $d=0.14$, male $d=0.20$), but the difference was not statistically significant.

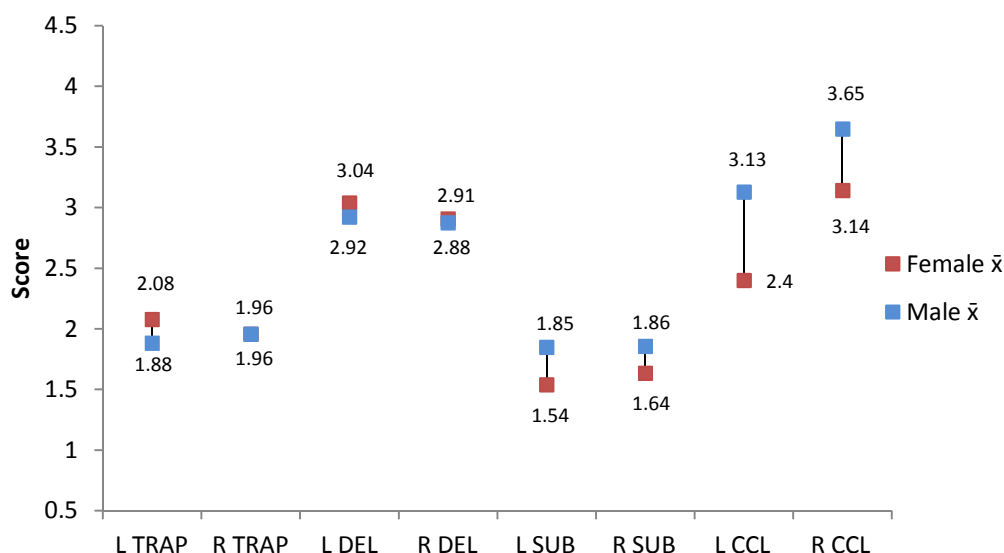
The early deltoid scores had no statistical relationship with sex. No difference in deltoid asymmetry existed between males and females (female $d=0.16$, male $d=0.16$).

Only the early left subclavius score correlated statistically with sex ($P=0.025$ $n=29$). When comparing mean subclavius scores between sexes, females outscored males. Males have far greater asymmetry than females (female $d=0.01$, male $d=0.42$), but the difference was not statistically significant.

The early left costoclavicular ligament score tended to correlate with sex ($P=0.074$ $n=45$) whereas the right did not. When comparing mean costoclavicular ligament

scores between sexes, males scored greater than females. Females had a greater costoclavicular ligament asymmetry than males (females $d=0.64$, males $d=0.49$), but the difference was not statistically significant.

Late Clavicle



Key: L=left, R=right, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament

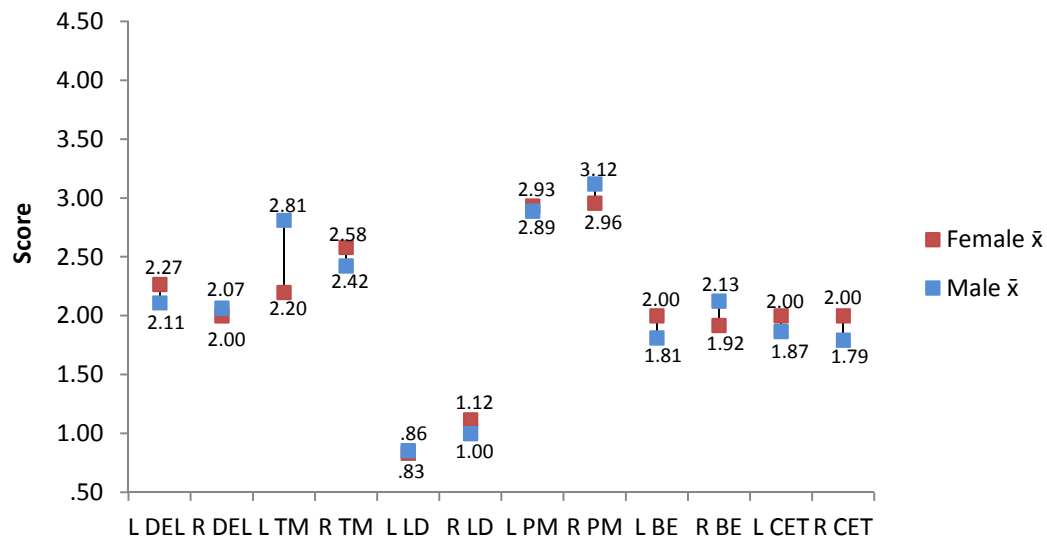
Figure 7.2.1.18 Comparison of mean clavicle enteseal scores between late males and females

When assessing late mean trapezius scores, females outscored males by 0.2 on the left and were equal in score to males on the right. Left and right trapezius scores correlated with sex. This relationship was statistically significant for the left ($P=0.05$ $n=31$) and just outside significance for the right ($P=0.088$ $n=13$). This sex difference was not observed in the early phase. In contrast to the early phase, the late-phase females had slightly more asymmetry than males (females $d=0.12$ males $d=0.08$), but the difference was not significant.

When comparing late mean deltoid scores, females outscored males by 0.12 on the left and 0.03 on the right. The left deltoids had a weak correlation with sex in the late phase ($P=0.117$ $n=28$), scoring more in females. The right deltoid scores did not correlate with sex. Asymmetry for both sexes was low (females $d=0.13$, male $d=0.04$). The difference between sexes in asymmetry was not statistically significant.

Left and right late subclavius scores did not correlate with sex, showing a reduced relationship with sex for the left subclavius over time. Comparison of mean subclavius scores demonstrated that late females have smaller subclavius scores than late males by 0.31 on the left and 0.22 on the right. Asymmetry was low for the late subclavius scores and the difference between sexes was not statistically significant (females $d=0.10$, males $d=0.01$).

Late left and right costoclavicular ligament scores correlated more strongly with sex than during the early phase (left $P=0.025$ $n=35$, right $P=0.004$ $n=26$). When comparing mean costoclavicular ligament scores, left costoclavicular ligament score were 0.73 higher in males, and right male costoclavicular ligament scores were 0.51 greater than female scores. Both sexes displayed some asymmetry at the costoclavicular ligament attachment, but the difference was not statistically significant, although late females have greater asymmetry (females $d=0.74$, males $d=0.54$).

Early Humerus

Key: L= left, R=right, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon.

Figure 7.2.1.19 Comparison of mean humeral entheasal scores between early males and females

Left and right early deltoid scores were strongly correlated with sex (left $P=0.005$ $n=36$, right $P=0.001$ $n=60$); both being larger in males. While a trend for larger deltoid scores on larger humeri was indentified, sex proved to be a far stronger factor. Males had a greater degree of asymmetry than females (females $d=0.33$, males $d=0.53$), but the difference was not significant.

Little difference existed between sexes for early right teres major scores. Although early male left teres major scores were greater than early female left teres major scores, there was no statistical relationship with sex. Early male teres major scores have greater asymmetry than early females scores (females $d=0.18$, males $d=0.49$), but the difference was not statistically significant.

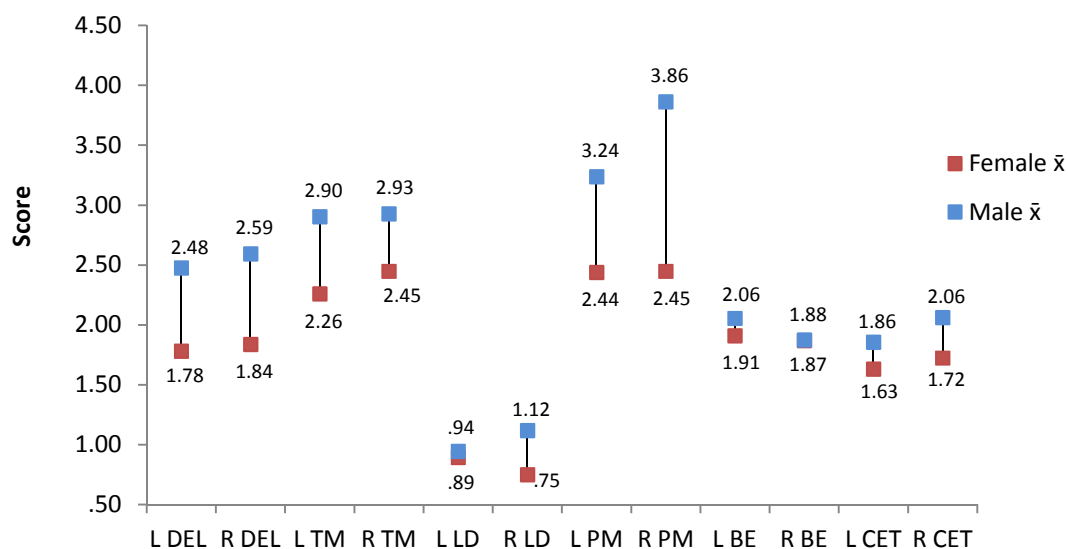
There was little difference between early male and female latissimus dorsi scores. While males score 0.11 less than females at the right latissimus dorsi attachment, there was no correlation with sex. The fact that females had a higher score than males was an interesting trend because the right latissimus dorsi was shown to correlate positively with humeral size. This would result in bigger scores in males, but here a reverse trend is demonstrated which is therefore likely to be related to activity. Males had greater

asymmetry than females (female $d=0.08$, males $d=0.27$), but this difference was not statistically significant.

The left early pectoralis major score showed no correlation with sex but the right pectoralis however did correlate with sex ($P=0.001$ $n=55$), demonstrating that early-phase males have a larger right pectoralis scores than early females. Despite asymmetry being substantially greater in males than females (females $d=0.24$, males $d=0.74$), the difference was not statistically significant.

Early brachioradialis extensor scores did not correlate with sex on either side. When comparing left mean brachioradialis extensor scores, early females outscored early males by just 0.17. On the right however, males outscore females by 0.23, suggesting early males have larger brachioradialis extensor scores than early females. Despite males having greater asymmetry than females (females $d=0.08$, males $d=0.26$), the difference was not statistically significant.

No correlation with sex was identified for either early common extensor tendon scores. When comparing male and female scores, statistically little difference was observed, despite the fact that females outscore males by 0.2 on the right and 0.06 on the left. No asymmetry existed for early females, yet some was observed for early males (females $d=0.00$, males $d=0.26$), but the difference was not significant.

Late humerus

Key: L=left, R=right, DEL=deltoid, TM=Teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon.

Figure 7.2.1.20 Comparison of mean humeral enthesal scores between late males and females

Greater sex differences were found in the late phase as was immediately observable from comparison of figures 7.2.1.19 and 7.2.1.20.

Late males have larger mean deltoid scores than late females by 0.74 on the left and 0.85 on the right, but there was no statistical relationship with sex for either score. There was no difference in asymmetry between the sexes for the deltoid scores (females $d=0.08$, males $d=0.09$).

Late males had greater mean teres major scores than late females, with the left scoring 0.64 greater, and the right scoring 0.48 greater in males. Left and right teres major scores did not correlate with sex, but showed a clearer difference between sexes than in the early phase. Statistically no difference in asymmetry existed between sexes (female $d=0.15$, males $d=0.14$).

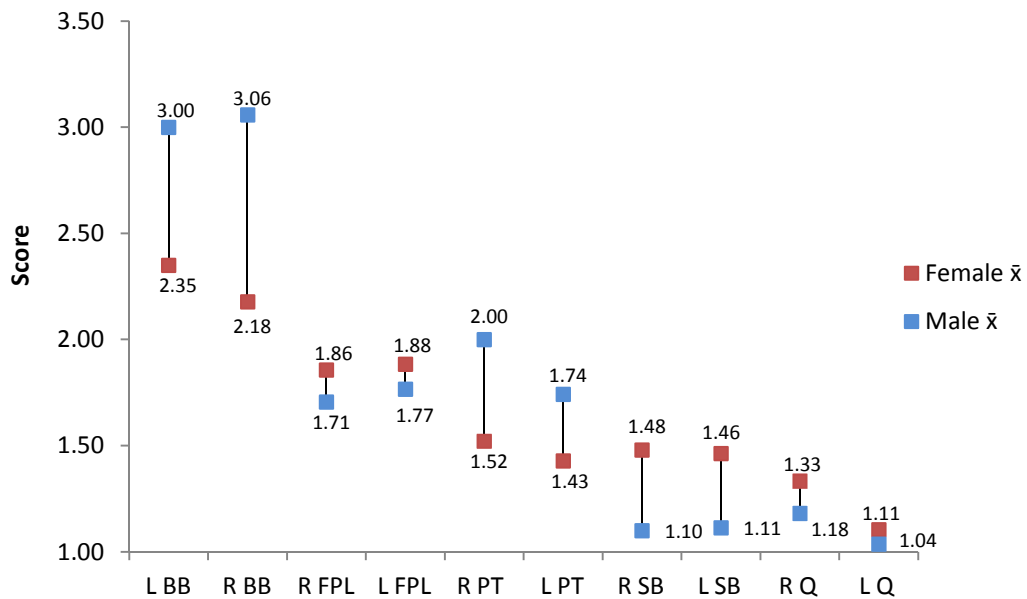
When comparing mean latissimus dorsi scores, males outscored females by 0.04 on the left, and 0.37 on the right. Left and right latissimus dorsi scores did not correlate with sex. This was also the case in the early phase. No statistically significant difference was

observed in the degree of asymmetry between late females and males (female $d=0.14$, males $d=0.19$).

While males outscored females at both late pectoralis major attachments (left 0.39, right 1.31), pectoralis major scores did not correlate with sex. This constitutes a loss of correlation with sex for the right pectoralis major over time. Males have significantly more asymmetry than females (female $d=0.05$, males $d=0.97$) ($P=0.005$ $n=99$). This was a far greater difference than observed in the early phase.

When considering late brachioradialis extensor scores, males scored greater than females on the left and right, but only the right score tended to significance ($P=0.072$ $n=55$). As the brachioradialis extensor score correlated positively with humeral size (table 7.2.1.4), any correlation with sex has to be taken with caution, however the fact that the right marker did not correlate with humeral size suggests that sex may be a more important factor. Males had greater asymmetry than females, but the difference was low (females $d=0.08$, males $d=0.18$) and not statistically significant.

When comparing late mean common extensor tendon scores, males outscored females by 0.21 on the left and 0.34 on the right, but the difference was not statistically significant. Interestingly and contrastingly, females outscored males in the early phase. Asymmetry was low for both sexes (females $d=0.07$, males 0.02), and the difference between the sexes in asymmetry was not statistically significant.

Early Radius

Key: L=left R=right, BB=biceps brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus

Figure 7.2.1.21 Comparison of mean radius enthesal scores between early males and females

Early biceps brachii scores correlated with sex (left $P \leq 0.001$ $n=64$, right $P=0.072$ $n=52$). Caution needs to be exerted as the biceps brachii had a strong correlation to humeral size (see table 7.2.1.5 page 167). While little difference in asymmetry scores existed between males and females for the early biceps brachii scores (females $d=0.17$, males $d=0.16$), a trend for greater asymmetry is seen in females ($P=0.075$ $n=89$).

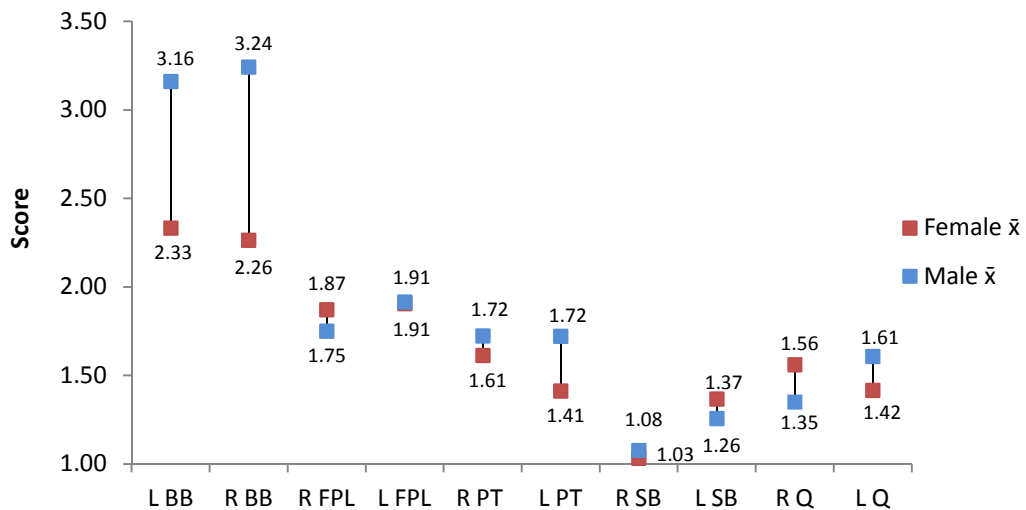
Early flexor pollicis longus scores had no correlation with sex. Little asymmetry was experienced by males or females (females $d=0.02$, males $d=0.08$), and the difference in asymmetry between the sexes was not significant.

Early males scored greater than early females at both pronator teres attachments. However neither pronator teres scores correlated with sex. Early males had greater asymmetry than early females (females $d=0.12$, males $d=0.23$), but the difference was not statistically significant.

When comparing early supinator brevis scores, early females outscored early males by 0.35 on the left, and 0.37 on the right, but neither difference correlated with sex. There was no significant asymmetry for either sex (females $d=0.02$, males $d=0.02$).

Little difference in early quadratus scores existed between males and females (left=0.07, right=0.05). Accordingly, there was no relationship between quadratus scores and sex. Early females have greater quadratus asymmetry than males (female $d=0.19$, males $d=0.10$), but the difference was not statistically significant.

Late Radius



Key: L=left R=right, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus

Figure 7.2.1.22 Comparison of mean radial enthesal scores between late males and females

The difference between male and female radial enthesal scores decreased in the late phase as was immediately observable from figure 7.2.1.21 and 7.2.1.22. Greater differences in asymmetry exist in the late phase individuals.

When comparing mean late bicep brachii scores, males outscored females (left 0.98, right 0.83). The late left bicep brachii score correlated with sex ($P \leq 0.001$ $n=59$). The late right bicep brachii correlated with sex, but was outside significance ($P=0.097$ $n=39$). These observations are similar to those observed in the early phase, and probably related to the strong correlation between biceps brachii scores and humeral size.

Statistically, no sex difference in asymmetry existed between sexes (females $d=0.07$, males $d=0.08$).

Late male and female left flexor pollicis longus scores were equal, but females scored 0.12 higher than males for the right flexor pollicis longus. Neither left nor right flexor pollicis longus scores correlated with sex. This was the same pattern as observed in the early phase. Male flexor pollicis longus scores have greater asymmetry than females (females $d=0.04$, males $d=0.16$), but the difference was not statistically significant.

Both late pronator teres scores correlated with sex, but this was only statistically significant for the left score (left: $P=0.037$ $n=60$, right: $P=0.097$ $n=39$). The results suggested that late-phase males tended to have larger left pronator teres scores than females. Females had slight asymmetry in pronator teres scores, whereas no asymmetry existed for males (females $d=0.21$, males $d=0.00$). This difference was not significant statistically.

Late left female mean supinator brevis scores were 0.09 greater than male scores, but right female mean scores were 0.05 smaller than male mean scores. Left and right supinator brevis scores correlated with sex, but did not reach statistical significance (left: $P=0.086$ $n=60$, right: $P=0.108$ $n=39$). This relationship with sex was not identified in the early phase. Females had greater asymmetry than males for supinator brevis scores (females $d=0.34$, males $d=0.18$), and although not quite statistically significant, there was a trend for females to have greater asymmetry than males ($P=0.111$ $n=122$). This difference in asymmetry was not observed in the early phase.

Late left male quadratus scores were on average 0.19 greater than the female equivalent. However, females scored 0.21 more on the right quadratus than males. Regardless, quadratus scores did not statistically correlate with sex. This means that the relationship between quadratus score and sex identified in the early phase had been lost in the late phase. Greater asymmetry was expressed in male scores than female scores (female $d=0.14$, male $d=0.26$); however the difference, like the early phase, was not statistically significant.

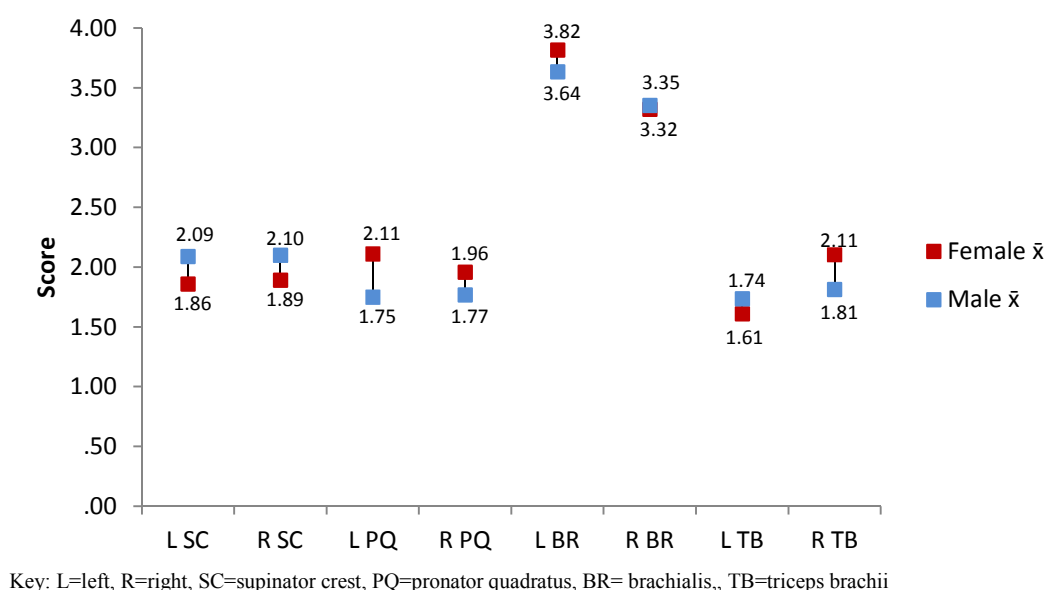
Early Ulna

Figure 7.2.1.23 Comparison of mean ulna entheasal scores between early males and females

Early male supinator crests scored 0.23 more on the left, and 0.21 on the right than female supinator crests. No correlation with sex was observed for either supinator crest score. Little asymmetry was observed (female $d=0.03$, males $d=0.00$). Unsurprisingly, the difference was not statistically significant.

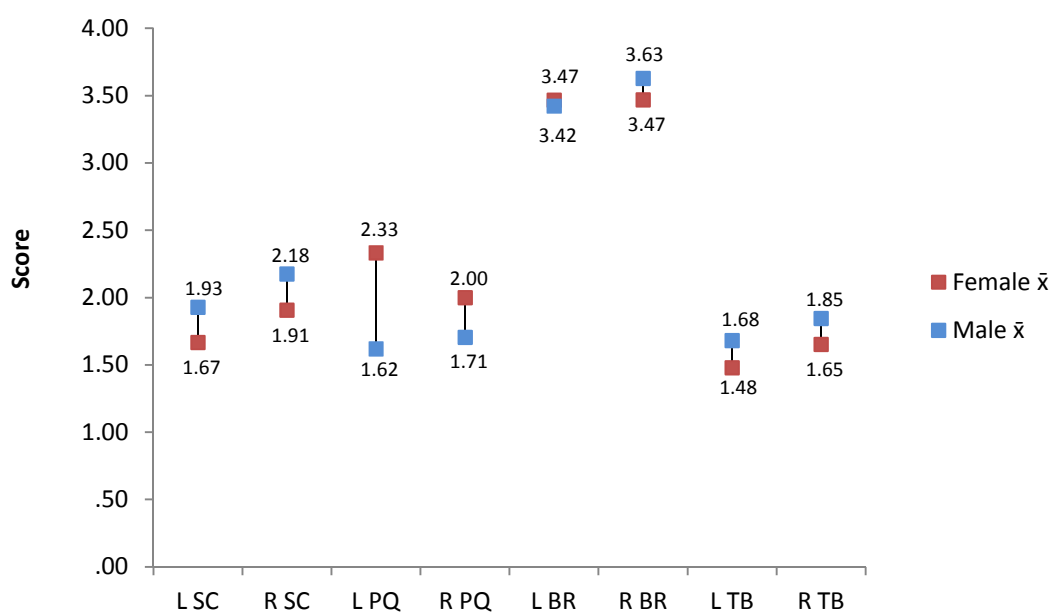
When comparing early mean pronator quadratus scores, females outscored males on the left side by 0.26. Males outscored females by 0.18 on the right. Left and right pronator quadratus scores demonstrated a strong statistically significant correlation with sex (left: $P=0.002$ $n=43$, right: $P=0.02$ $n=62$). Females had greater asymmetry than males (females $d=0.23$ males $d=0.07$). The difference was not statistically significant.

When comparing early mean brachialis scores, the left scored 0.09 more in females. On the right, the brachialis scored 0.02 higher in males. Left and right brachialis scores showed no correlation with sex. Females also had greater asymmetry than males at the brachialis attachments (female $d=0.44$, males $d=0.29$), but the difference was not statistically significant.

On both sides, early mean triceps brachii scores were greater in females. Early left and right tricep brachii scores did not correlate with sex. While the larger score differed as

to which side it was derived from (see figure 7.2.1.23), males and females had the same degree of asymmetry (females $d=0.06$, males $d=0.06$). The difference was not statistically significant.

Late Ulna



Key: L=left, R=right, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii

Figure 7.2.1.24 Comparison of mean ulna enthesal scores between late males and females

The late left mean supinator crest score was 0.35 higher in males, demonstrating a trend for greater scores in males. The right attachment also scored higher in males by 0.27. Left and right supinator crest scores strongly correlated with sex (left: $P=0.036$ $n=40$, right: $P=0.048$ $n=54$). This was a greater correlation with sex than expressed in the early phase. A similar degree of asymmetry was expressed for males and females, with the left scoring higher in both sexes (female $d=0.26$, males $d=0.23$). The difference was not statistically significant. This was also observed in the early phase, but the degree of asymmetry increased in both sexes during the late phase.

Late females outscored late males at both pronator quadratus attachments. However, male scores had a greater standard deviation than female scores, which may insinuate that an outlier could have biased mean pronator quadratus scores. Nevertheless, left and

right pronator quadratus scores did not correlate statistically with sex. This suggested a temporal loss of sex difference in pronator quadratus scores. Late females had greater pronator quadratus asymmetry than late males (females $d=0.20$, males $d=0.14$).

Although not statistically significant, a trend for greater asymmetry was expressed in females ($P=0.093$ $n=111$), a trend also observed in the early phase.

Late left and right brachialis scores did not correlate with sex. While the side with the largest score differed between sexes (female right, male left), the degree of asymmetry was similar between the sexes (female $d=0.07$, males $d=0.08$), and the difference was not statistically significant.

Late males outscored females by 0.17 at left triceps brachii attachment, and 0.2 for the right triceps brachii attachment. The triceps brachii scores did not correlate with sex on either side. A similar degree of asymmetry was experienced by males and females (females $d=0.15$ males $d=0.18$) and the difference was not statistically significant. This was similar to the early phase.

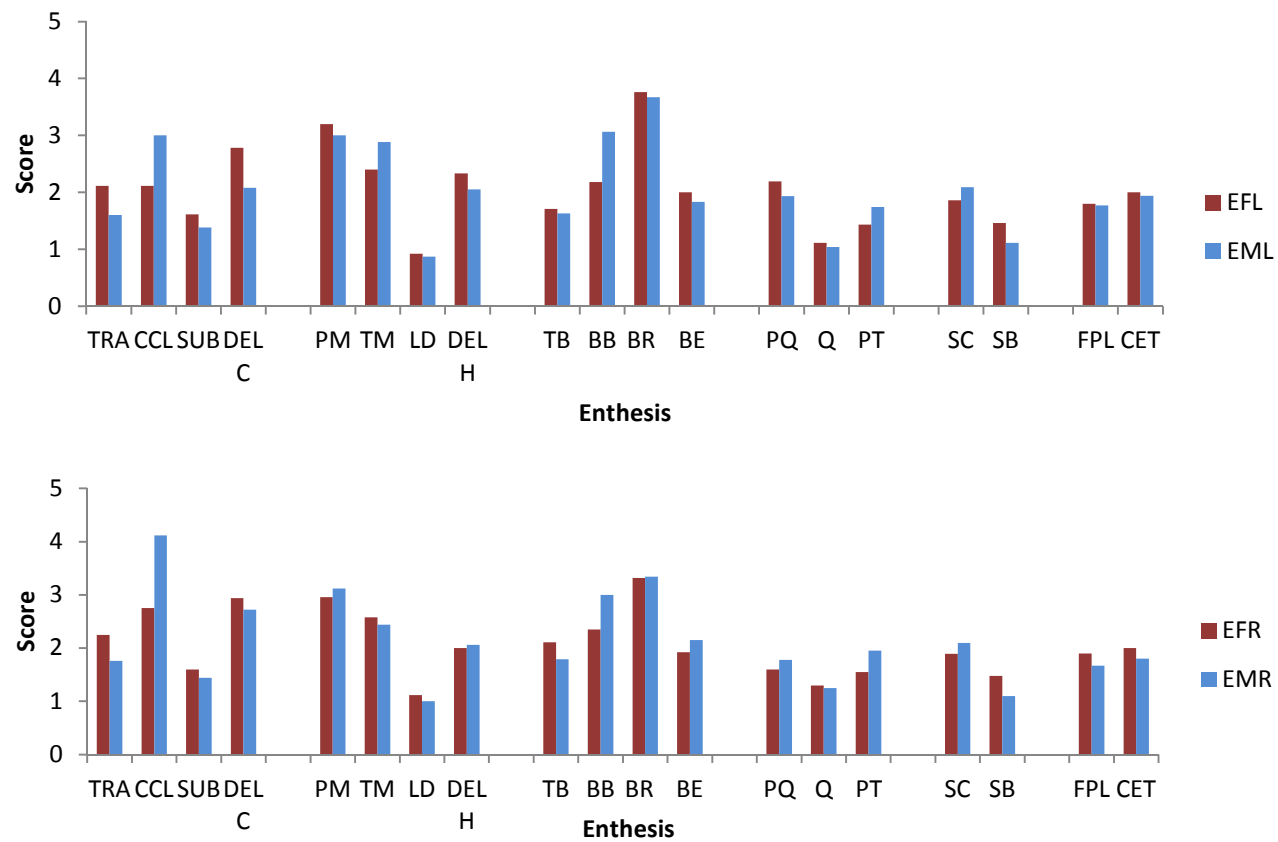
Figure 7.2.1.24.1 demonstrated that in the early phase there were some differences in the muscle group patterns between men and women. On the left side, there was greater shoulder elevation in females than males, who had equal scores between muscles involved in shoulder elevation and medio-lateral arm movement. On both sides, females had high brachialis and triceps brachii scores and comparatively high scores for the supinators of the forearms than males. This suggests that elbow flexion and extension and forearm movement was a significant part of female movement on the left side. On the right side, men display higher scores for the medio-lateral movement in comparison to those involved in arm extension and flexion.

In the late phase, there were fewer differences between men and women (figure 7.2.1.24.2). Regarding the left arm, there was little difference between men and women for the muscle groups used, however, on both sides, there was a clear demonstration of the asymmetry in the muscles used in medio-lateral movement of the humerus in males. In addition, males had a different pattern involving the costoclavicular ligament, pectoralis major and the teres major. This suggested difference in medio-lateral movement of the upper arm between the sexes.

Summary

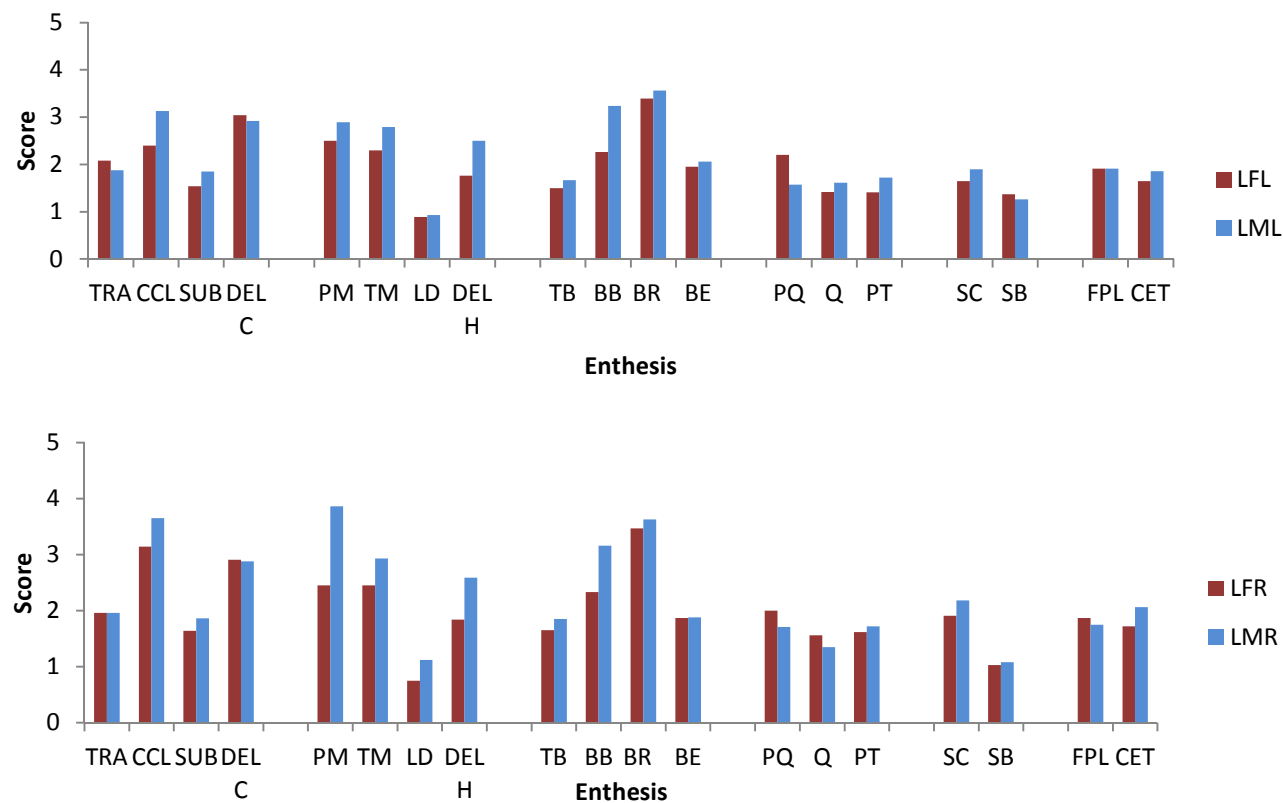
No single directional change was observed for the difference between males and females over time. While the sex difference was clearer in the late phase for the clavicle entheses, the radial entheses had greater sex difference in the early phase. The degree of sex difference expressed at ulna and humeral entheses does not differ between phases, suggesting that some activities may have changed over time.

When assessing the entheses which had scores with a statistical relationship with sex, different attachments correlated with sex in each phase. The biceps brachii was the only enthesis to have a statistical relationship with sex in both phases, but this likely reflects the relationship between humeral size and biceps brachii scores. The stronger relationship between proximal humerus enteseal scores and sex implies a greater sex difference in the early phase at this region.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. EFL = early female late, EML= Early male left, EFR = early female right, EMR = early male right.

Figure 7.2.1.24.1 Enthesal scores presented by major muscle groups for early males and females



Key: TRAP=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. LFL = late female left, LML = late male left, LFR =late female right, LMR = late male right.

Figure 7.2.1.24.2 Entheseal scores presented by major muscle groups for late males and females.

7.2.2.5 Analysis of sex differences in disaggregated enthesal scores between Visigothic males and females: analysis of Visigothic gender division

This subsection presents results of the analyses of enthesal scores of Visigothic females and males. In order to understand whether the gendered difference patterns of muscle use altered with the arrival of Islam, it was imperative that the gender difference in muscle use prior to Islam was defined. As such, a comparison of Visigothic male and female enthesal scores was carried out to highlight the Visigothic sex and gender differences. Forty one Visigothic females and 42 Visigothic males had at least one enthesal score available for analysis. Table 7.2.1.17 presents the correlation between sex and enthesal score.

Table 7.2.1.17 Correlation with sex for disaggregated Visigothic male and female enthesal scores.

Enthesis	Left			Right		
	Coefficient	P value sex	n	Coefficient	P value sex	n
TRA	0.223	0.104	48	-0.050	0.722	47
DEL C	0.111	0.463	44	-0.690	0.651	43
SUB	0.239	0.122	41	-0.120	0.502	34
CCL	0.176	0.237	45	0.100	0.507	44
DEL H	0.165	0.241	50	0.075	0.639	39
TM	0.047	0.781	36	0.114	0.533	30
LD	0.156	0.610	11	0.478	0.061	14
PM	0.345	0.029	39	0.371	0.012	43
BE	0.064	0.721	32	-0.020	0.915	30
CET	-0.260	0.499	7	0.162	0.635	11
BB	0.389	0.060	46	0.355	0.014	45
FPL	0.211	0.18	40	0.183	0.271	36
PT	0.306	0.074	33	0.028	0.88	29
SB	0.367	0.197	12	0.179	0.62	8
Q	-0.060	0.804	16	0.125	0.61	17
SC	0.052	0.779	30	0.125	0.48	32
PQ	0.119	0.581	22	-0.050	0.835	21
BR	-0.05	0.704	52	0.188	0.244	38
TB	0.81	0.742	17	0.440	0.077	15

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis, TB=triceps brachii

Statistically, three entheses correlated with sex in the Visigothic sample. This was both pectoralis majors and the right biceps brachii. The left pronator teres, left biceps brachii, the right latissimus dorsi and the right triceps brachii had a trend for males to have greater scores than females. There was no difference in asymmetry for any entheses.

Table 7.2.1.18. Means standard deviations for Visigothic males and females, asymmetry value (d) and significance.

Enthesis	Female							Male							d P value
	Left			right			d	left			right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	24	3.42	1.28	24	3.58	1.38	-0.16	27	4.04	0.98	26	3.5	1.74	0.54	0.699
DEL C	24	1.92	0.65	20	2.00	0.73	-0.08	23	1.96	0.77	26	1.9	0.74	0.06	0.717
SUB	21	1.19	0.81	20	1.50	1.10	-0.31	23	1.83	1.43	17	1.29	0.47	0.54	0.335
CCL	30	3.67	1.55	26	4.15	1.29	-0.48	18	3.94	1.43	21	4.33	1.24	-0.39	0.564
DEL H	24	2.13	0.90	20	2.20	1.06	-0.07	29	2.48	0.91	22	2.41	1.22	0.07	0.571
TM	18	3.06	1.80	17	3.00	1.77	0.06	20	3.70	1.26	16	3.38	1.36	0.32	0.417
LD	6	1.00	0.00	9	1.00	0.50	0.00	8	1.13	0.35	8	2.13	1.55	-1.00	0.414
PM	20	2.20	1.96	23	2.43	1.08	-0.23	21	3.33	1.53	23	3.57	1.34	-0.24	0.739
BE	13	1.92	0.28	10	2.00	0.82	-0.08	21	2.05	0.38	23	2.26	0.76	-0.21	0.513
CET	3	1.67	0.58	5	1.40	0.55	-0.27	7	1.57	0.54	6	1.67	0.82	-0.10	0.683
BB	21	3.00	1.23	22	3.09	1.15	-0.09	28	4.11	1.24	26	4.15	1.08	-0.04	0.732
FPL	20	1.20	0.41	16	1.44	0.63	-0.24	23	1.48	0.67	23	1.87	0.92	-0.39	0.288
PT	18	2.17	1.51	11	2.64	1.57	-0.47	18	3.17	1.25	21	3.05	1.50	0.12	0.460
SB	8	0.88	0.35	6	1.00	0.00	0.88	7	1.14	0.38	8	1.00	0.00	0.14	0.480
Q	9	0.78	0.97	9	0.56	0.73	0.22	10	0.70	0.68	11	0.73	0.63	-0.03	1.000
SC	16	1.69	0.48	15	1.87	0.35	-0.18	17	1.76	0.56	20	2.10	0.91	-0.34	0.066
PQ	10	1.30	0.49	12	1.58	0.52	-0.28	15	1.67	0.72	12	2.00	1.13	-0.33	0.260
BR	27	4.67	0.73	19	4.47	1.02	0.20	28	4.39	0.96	22	4.50	0.74	-0.11	0.580
TB	10	1.20	0.42	8	1.13	0.35	0.07	10	1.40	0.52	11	1.45	0.52	-0.05	1.000

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii

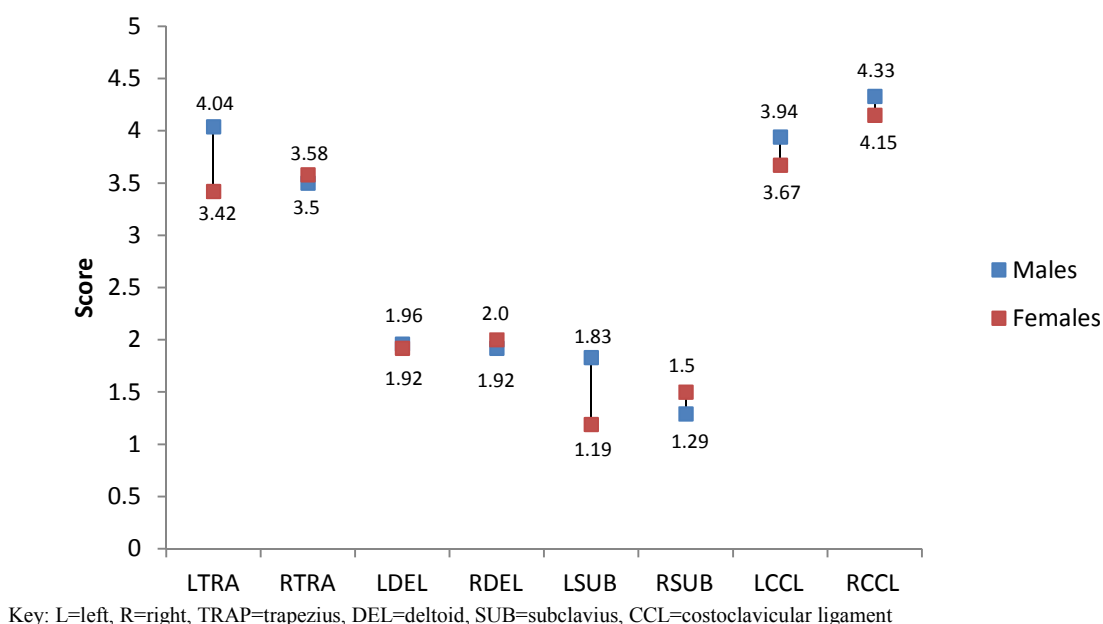
Clavicle

Figure 7.2.1.25 Comparison of mean clavicle enteseal scores between Visigothic males and females

It was clear from figure 7.2.1.25 that males had greater scores than females for the left trapezius but not the right trapezius. The left trapezius had a weak correlation with sex ($P=0.104$ $n=48$), whereas the right did not. Males displayed a greater degree of trapezius asymmetry than females (females $d=0.16$, males $d=0.54$). The difference between sexes however, was not statistically significant.

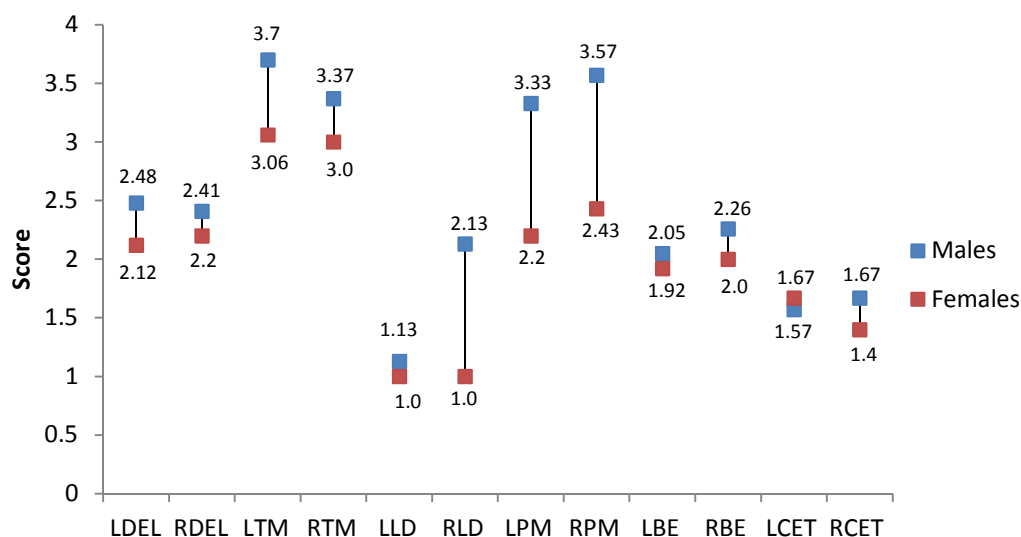
Left and right deltoid scores were not correlated with sex and were extremely similar between sexes. Asymmetry in deltoid scores was low for males and females, and was not statistically significantly different (females $d=0.08$, males $d=0.06$).

There was no correlation between sex and subclavius scores, although males had greater scores (figure 7.2.1.25). In males, the left subclavius scores were greater than the right, whereas in females, the reverse trend was observed. Males had greater asymmetry than females (females $d=0.31$, males $d=0.54$), but the difference was not statistically significant.

While males outscored females at both costoclavicular ligaments, no correlation between score and sex was observed. For both sexes, the right costoclavicular ligament score was greater than the left costoclavicular ligament score. While, both sexes

displayed some asymmetry in costoclavicular ligament scores, the difference in the degree of asymmetry between sexes was not significant.

Humerus



Key: L= left, R=right, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon.

Figure 7.2.1.26 Comparison of mean humeral enteseal scores between Visigothic males and females

According to figure 7.2.1.26, no correlation between sex and deltoid score existed. The degree of asymmetry was low for both sexes. While the direction of asymmetry was reversed in females, the difference between the sexes was not significant.

Males outscored females on both sides for the teres major attachment, but no correlation with sex was observed. Little asymmetry was observed in female teres major scores. Male teres major scores did display some asymmetry (females $d=0.06$, males $d=0.32$), but the difference was not statistically significant.

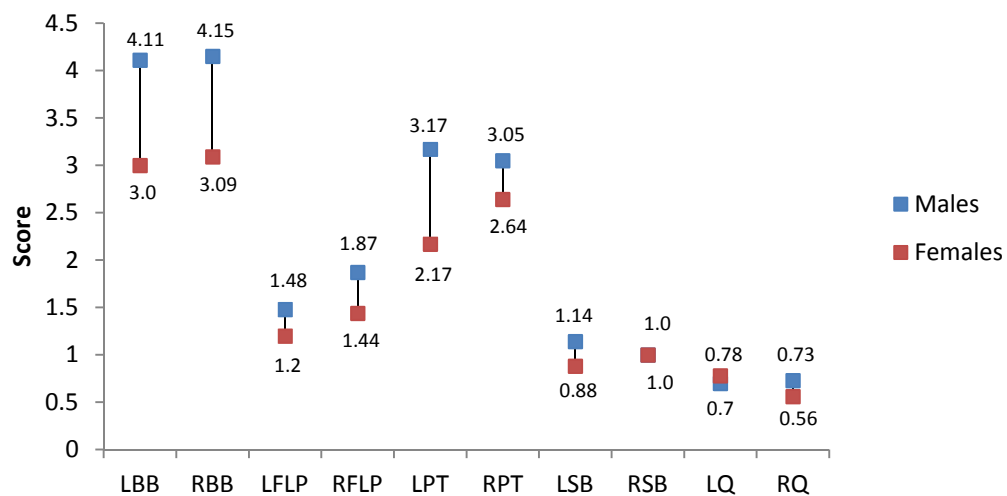
Males outscored females at both latissimus dorsi attachments. While the left latissimus dorsi did not correlate with sex, a weak correlation was found for the right latissimus dorsi score and sex ($P=0.061$ $n=14$). Males display a marked asymmetry (females $d=0.00$, males $d=1.00$), but the difference was not statistically significant.

Males outscored females at both pectoralis major attachments. This difference was statistically significant for both sides (left: $P=0.029$ $n=39$, right: $P=0.012$ $n=43$). Males and females had the same pattern of asymmetry (females $d=0.23$ males 0.24).

Males outscored females for both brachioradialis extensor attachments, but the score difference was low (figure 7.2.1.26). Neither score correlated with sex. Greater asymmetry was observed in males (female $d=0.08$, males $d=0.21$), but the difference between the sexes was not significant.

Females had greater left common extensor tendon score than males, whereas males outscored females at the right attachment. Neither scores however correlated with sex. Females had a greater degree of common extensor tendon asymmetry (females $d=0.27$, males $d=0.10$), but the difference was not significant.

Radius



Key: L=left R=right, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus

Figure 7.2.1.27 Comparison of mean radial enteseal scores between Visigothic males and females

Left and right biceps brachii scores correlated strongly with sex (left: $P=0.06$ $n=46$, right: $P=0.016$ $n=45$), with the right especially, which exhibited significance. The biceps brachii attachments had strong correlations with humeral size in the Islamic group, and it was therefore difficult to comment on this trend. Very little biceps brachii

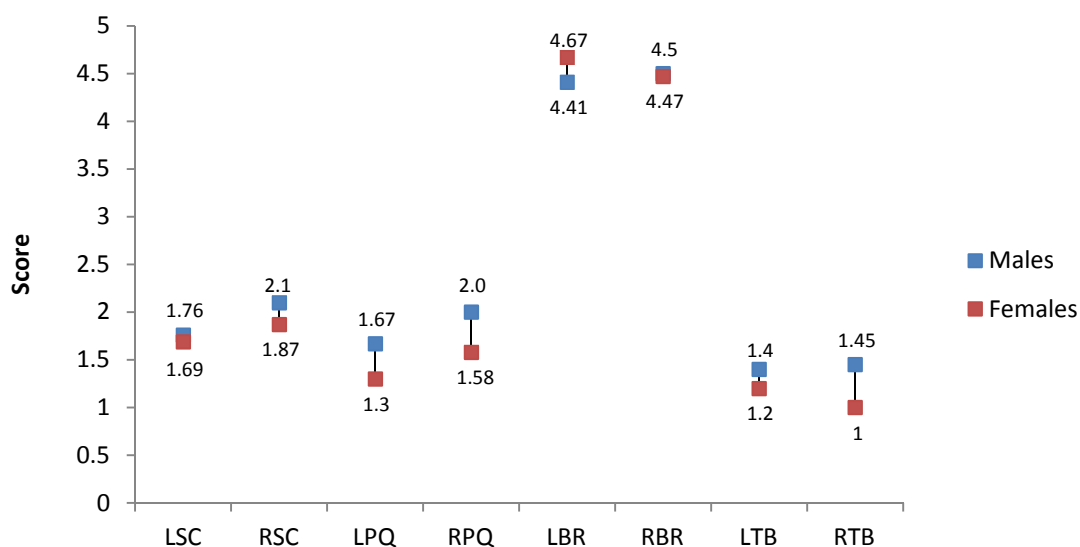
score asymmetry was expressed by either sex (females $d=0.09$, males $d=0.04$), and the difference was not statistically significant.

Males outscored females at both flexor pollicis longus attachments. No correlation between score and sex was identified. While males had greater asymmetry than females (females $d=0.24$, male $d=0.39$). The difference was not significant.

The pronator teres attachments scored higher in males than females. While the right pronator teres score did not correlate with sex, the left score was just outside the level of statistical significance ($P=0.074$ $n=33$). Males experienced very little asymmetry, although left-right difference was more evident in females (females $d=0.47$, males $d=0.12$). The difference between sexes was not significant.

Little sex difference in supinator brevis scores was observable (Figure 7.2.1.27). Males outscored females at the left attachment. The sexes had equal right scores. Females had far greater supinator brevis asymmetry than males (females $d=0.88$, males $d=0.14$), but the difference was not significant.

Quadratus scores differed little between sexes, showing no correlation with sex. The left quadratus was the only radial muscle attachment where females outscored males, but the difference was extremely low (table 7.2.1.18, figure 7.2.1.27). Both sexes had little asymmetry (females $d=0.22$, males $d=0.03$), and the difference between the sexes was not significant.

Ulna

Key: L=left, R=right, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii

Figure 7.2.1.28 Comparison of mean ulna enthesal scores between Visigothic males and females

While males outscored females at the supinator crest attachments, the difference was not significant (figure 7.2.1.28). Males demonstrated greater supinator crest asymmetry than females (females $d=0.18$, males $d=0.34$), and the difference was close to significance ($P=0.060$ $n=68$).

Males outscored females at both pronator quadratus attachments, however, neither pronator quadratus score correlated with sex. The degree of asymmetry did not differ statistically between sexes (females $d=0.29$, males $d=0.33$).

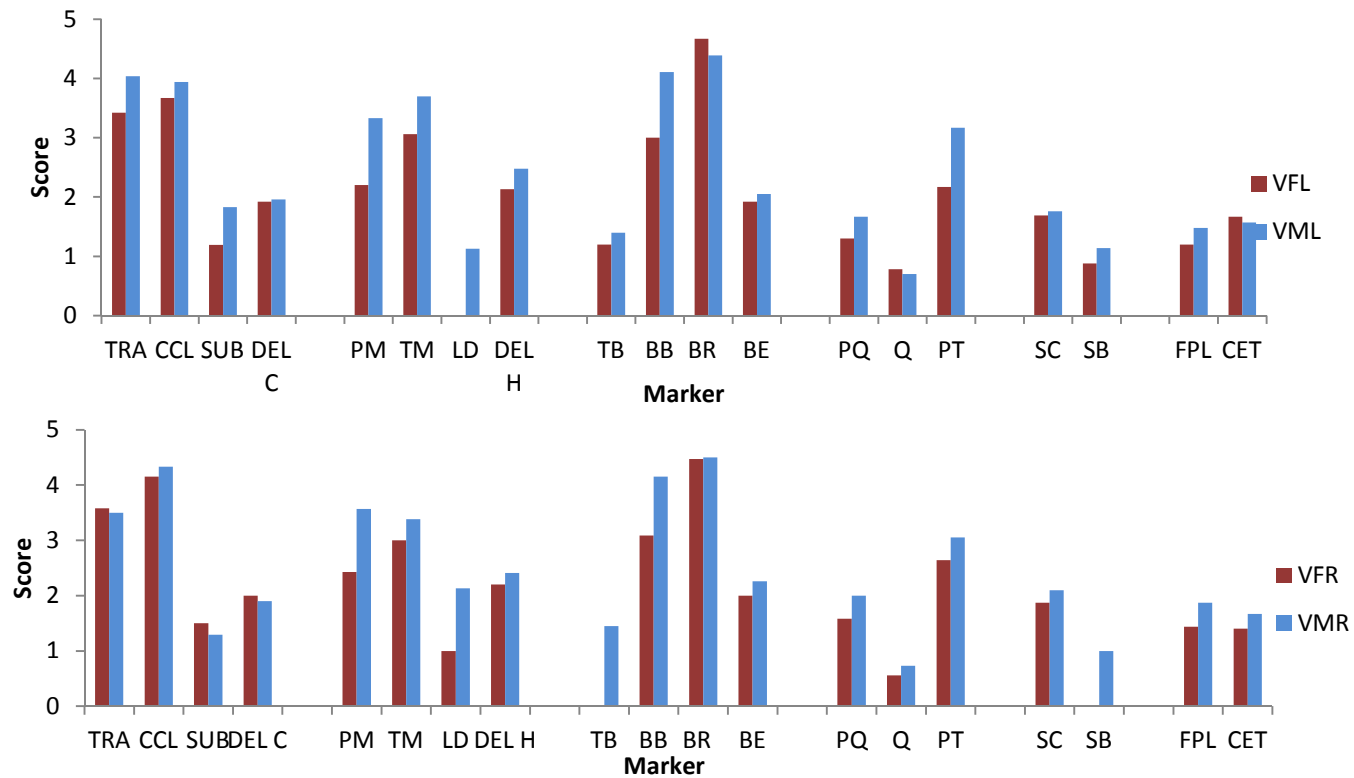
Females had higher left brachialis scores, and males had marginally higher right brachialis scores. Neither score however, correlated statistically with sex. Females displayed more brachialis score asymmetry than males (female $d=0.20$, males $d=0.11$), but the difference was not significant.

Triceps brachii scores were greater in males than females. This was more evident for the right ulna. While there was no correlation between sex and left triceps brachii score, right triceps brachii scores did show a correlation with sex, although just outside significance ($P=0.077$ $n=15$). There was little triceps brachii asymmetry in either sex (females $d=0.07$, males $d=0.05$).

Figure 7.2.1.28.1 demonstrates that there was some difference in the muscle groups used between Visigothic males and females. On both sides, the three muscle groups associated with movement of the shoulder and humerus had similar scores in males, whereas in females, brachialis (a muscle involved in arm flexion) scores were greatest. As the scores for the medio-lateral movement of the arm are lower in females than in males, it suggests that arm flexion may have dominated female upper body movement. The greater scores of the medio-lateral shoulder movement muscles in males, suggests that the movement of the shoulder dominated male upper body movement.

Summary

Three significant differences and four close to significant differences were observed between Visigothic sexes. Two significant differences were observed for entheses that had demonstrated a strong correlation with humeral size in the Islamic sample (biceps brachii). A further two entheses that were close to statistical significance also had a strong correlation with humeral size (left biceps brachii and right latissimus dorsi). Caution was therefore needed in the interpretation of these results. Overall little difference in enthesal scores existed between Visigothic males and females, except that males have higher scores than females for all but five entheses. Where females do outscore males, the difference was negligible, and it would be more accurate to suggest equal scores between the sexes. There was also little difference in the patterns of muscle use between the sexes. Patterns of muscle use thus appear to be similar between sexes in the Visigothic group.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. VFL= Visigothic female left, VML = Visigothic male left, VFR = Visigothic female right, VMR = Visigothic male right.

Figure 7.2.1.28.1 Enthesal scores presented by major muscle groups for Visigothic males and females

7.2.3 Interfaith comparison of enthseal scores: Comparison of Visigothic and Islamic disaggregated enthseal scores

This section directly compares the scores of Visigothic and Islamic individuals to demonstrate whether muscle use changed specifically for either sex with the emergence of Islam. Islamic and Visigothic females are compared prior to the males of each group.

7.2.3.1 Comparison of Visigothic female and Islamic female enthseal scores: temporal changes in female gender ideology

Twenty of the muscle markers assessed in Visigothic and Islamic females had statistically significantly different scores (see table 7.2.1.19). The subclavius and the costoclavicular ligament scores had different patterns of asymmetry; the subclavius was more asymmetric in Visigothic females, and the costoclavicular ligament was more asymmetrical in Islamic females (see table 7.2.1.20).

Table 7.2.1.19 Correlation between faith group and mean enthesal score for Islamic and Visigothic females.

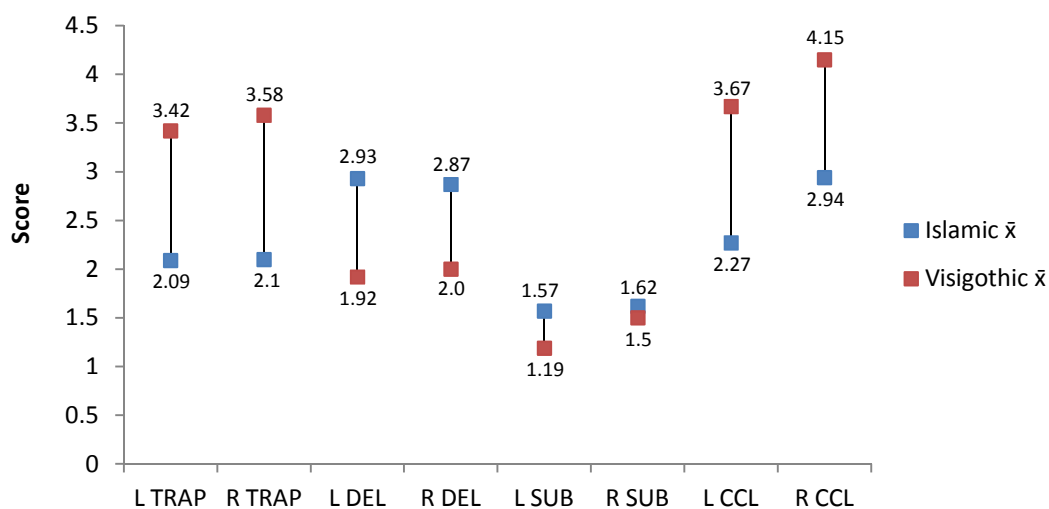
Female enthesis	Left			Right		
	Coefficient	P value	n	Coefficient	P value	n
TRA	0.574	≤0.001	65	0.579	≤0.001	59
DEL C	-0.432	≤0.001	66	-0.364	0.006	54
SUB	-0.254	0.043	62	0.083	0.553	52
CCL	0.448	≤0.001	71	0.506	≤0.001	56
DEL H	0.135	0.305	58	0.162	0.156	76
TM	0.314	0.021	52	0.182	0.135	67
LD	0.121	0.488	33	0.08	0.586	47
PM	-0.163	0.220	56	-0.073	0.536	73
BE	0.005	0.975	46	0.126	0.318	63
CET	-0.020	0.910	33	-0.127	0.343	56
BB	0.321	0.005	72	0.333	0.002	81
FPL	-0.460	≤0.001	69	-0.245	0.036	71
PT	0.320	0.007	69	0.376	0.001	70
SB	-0.161	0.220	58	-0.08	0.532	61
Q	-0.301	0.027	52	-0.327	0.019	49
SC	0.0036	0.897	65	0.003	0.979	71
PQ	-0.541	≤0.001	45	-0.249	0.046	63
BR	-0.468	≤0.001	75	0.436	≤0.001	75
TB	-0.249	0.079	50	-0.349	0.016	45

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis,, TB=triceps brachii.

Table 7.2.1.20 Female mean enthesal scores, standard deviation, side, number and asymmetry (d) by time phase.

Female entesis	Visigothic							Islamic							P values for d
	left			right			d	Left			right			d	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	24	3.42	1.28	24	3.58	1.38	-0.16	44	2.09	0.6	40	2.10	0.67	0.01	0.247
DEL C	24	1.92	0.65	20	2.00	0.73	-0.08	45	2.93	1.14	39	2.87	1.11	0.06	0.956
SUB	21	1.19	0.81	20	1.50	1.10	-0.31	44	1.57	0.55	37	1.62	0.55	0.05	≤0.001
CCL	30	3.67	1.52	26	4.15	1.29	-0.48	44	2.27	1.21	35	2.94	1.28	0.67	≤0.001
DEL H	24	2.12	0.90	20	2.20	1.06	-0.08	38	1.97	0.82	59	1.92	0.68	0.05	0.351
TM	18	3.06	1.80	17	3.00	1.77	0.06	38	2.34	1.15	53	2.51	0.82	0.27	0.598
LD	6	1.00	0.00	9	1.00	0.50	0.00	31	0.87	0.85	41	0.90	0.63	0.03	0.899
PM	20	2.20	1.20	23	2.43	1.08	-0.23	40	2.63	0.95	53	2.68	0.94	0.05	0.344
BE	13	1.92	0.28	10	2.00	0.82	-0.08	36	1.94	0.63	56	1.89	0.56	0.05	0.336
CET	3	1.67	0.58	5	1.40	0.55	0.27	33	1.79	0.65	54	1.85	0.71	0.06	0.120
BB	21	3.00	1.23	22	3.09	1.15	-0.09	54	2.31	0.87	62	2.23	0.71	0.08	0.575
FPL	20	1.20	0.41	16	1.44	0.63	-0.24	58	1.90	0.67	52	1.87	0.63	0.03	0.174
PT	18	2.17	1.51	11	2.64	1.57	-0.47	62	1.42	0.62	54	1.57	0.77	0.05	0.507
SB	8	0.88	0.35	6	1.00	0.00	-0.12	58	1.41	0.75	53	1.21	0.66	0.20	0.421
Q	9	0.78	0.97	9	0.56	0.73	0.22	43	1.28	0.93	46	1.46	0.86	0.22	0.806
SC	16	1.69	0.48	15	1.87	0.35	-0.18	53	1.72	0.53	60	1.90	0.57	0.18	0.563
PQ	10	1.30	0.48	12	1.58	0.52	-0.28	53	2.23	0.58	55	1.98	0.59	0.25	0.457
BR	27	4.67	0.73	19	4.47	1.02	0.20	53	3.62	0.99	60	3.40	0.94	0.22	0.404
TB	10	1.20	0.42	7	1.00	0.00	0.20	43	1.53	0.51	42	1.86	0.81	0.33	0.594

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicus longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii, N= number, SD = standard deviation, $\bar{x}$ = mean

Clavicle

Key: L=left, R=right, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament

Figure 7.2.1.29 Comparison of mean clavicle enthesal scores between Islamic and Visigothic females

Visigothic females outscored Islamic females at both trapezius attachments. The trapezius scores did correlate with faith group indicating that an overall decreasing trapezius score can be observed in the Islamic females (left: $P \leq 0.001$ $n=65$, right: $P \leq 0.001$ $n=59$). While greater asymmetry was expressed in Visigothic females, the difference in asymmetry between faith groups was not significant (Islamic $d=0.01$, Visigothic $d=0.16$).

Visigothic females had the lowest mean deltoid scores (figure 7.2.1.29). Deltoid score correlated with faith group demonstrating increasing deltoid score temporally (left: $P \leq 0.001$ $n=66$, right: $P \leq 0.006$ $n=54$). Little asymmetry existed for either faith group, with the difference not reaching significance (Islamic $d=0.06$, Visigothic $d=0.08$).

Left subclavius scores increased in the Islamic females, exhibiting a relationship with religious group ($P=0.087$ $n=62$). No correlation was observed for the right subclavius score. Only the Visigothic women had asymmetric subclavius scores (Islamic $d=0.05$, Visigothic $d=0.31$). This difference was strongly significant ($P \leq 0.001$ $n=122$).

Statistically, there was a strong correlation between faith group and both costoclavicular ligament scores, indicating that Islamic females had smaller costoclavicular ligament scores than Visigothic females (left $P \leq 0.001$ $n=70$, right $P \leq 0.001$ $n=56$). Visigothic

women were also significantly more asymmetrical than the Islamic women (Visigothic $d=1.29$, Islamic $d=0.67$), ($P=0.001$ $n=135$).

Humerus

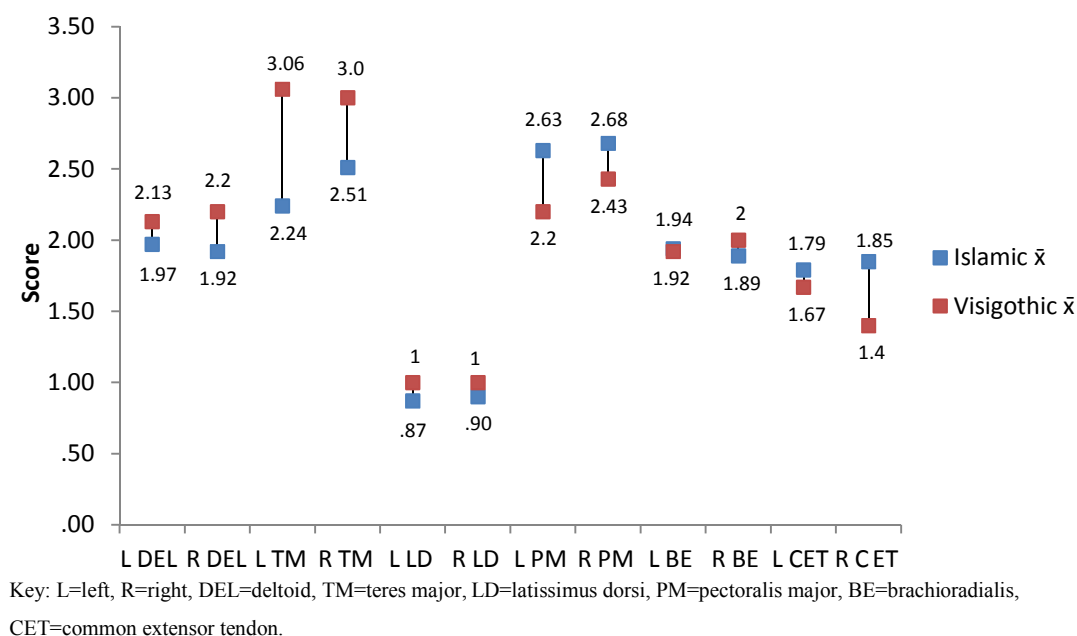


Figure 7.2.1.30 Comparison of mean humeral enthesal scores between Islamic and Visigothic females

Deltoid scores were similar over time. Both faith groups experienced little deltoid asymmetry (Islamic $d=0.05$, Visigothic $d=0.08$) and the difference between groups was not statistically significant.

Visigothic females had the largest teres major scores. The Spearman's correlation test indicated that the left teres major score decreased significantly in the Islamic phase ($P=0.021$ $n=52$). On the right side, the correlation was not statistically significant ($P=0.136$ $n=67$). Islamic females had a greater degree of asymmetry (Islamic $d=0.27$, Visigothic $d=0.06$). The difference was not significant.

Little difference existed in latissimus dorsi scores between the faith groups. Asymmetry was also extremely similar between faith groups (Islamic $d=0.00$, Visigothic $d=0.03$), and did not differ statistically.

Islamic females had greater pectoralis major scores, but the difference between faith groups was minimal and not significant. While Visigothic women had greater pectoralis

major score asymmetry than Islamic women (Islamic $d=0.05$, Visigothic $d=0.23$), the difference was not statistically significant.

Brachioradialis extensor scores were similar between faith groups (see table 7.2.1.19), and no correlation between brachioradialis extensor scores and faith group existed. Both faith groups had little asymmetry, and the difference was not significant (Islamic $d=0.08$ Visigothic $d=0.05$).

Islamic females had the greatest left and right common extensor tendon scores, but the difference was not statistically significant. Visigothic women had greater common extensor tendon score asymmetry (Visigothic $d=0.27$, Islamic $d=0.06$). The difference was not significant.

Radius

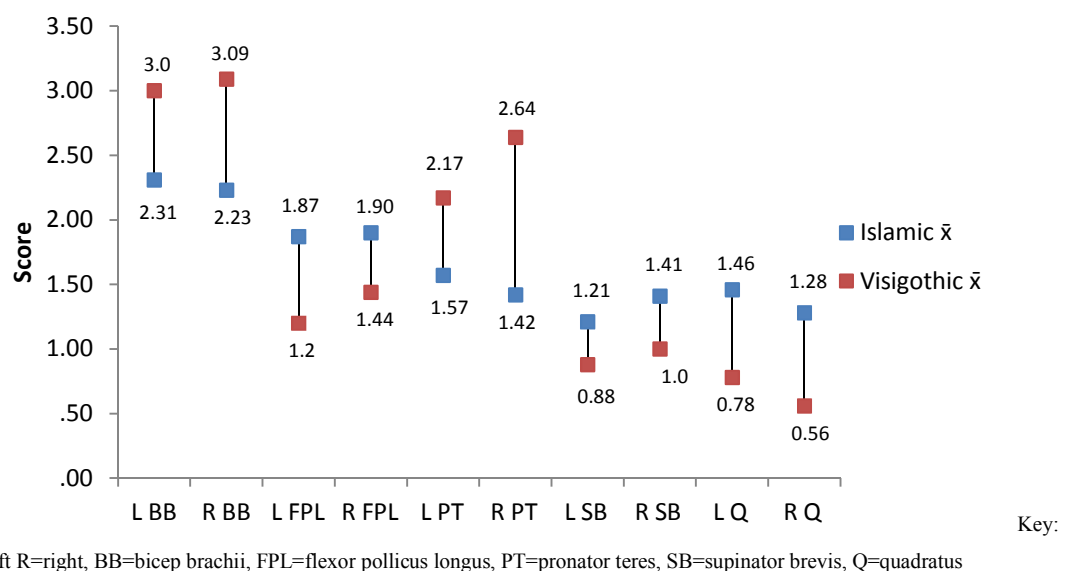


Figure 7.2.1.31 Comparison of mean radial entheal scores between Islamic and Visigothic females

Visigothic females had greater biceps brachii scores than the Islamic females, with scores exhibiting a strong correlation with faith group (left: $P=0.023$ $n=72$, right: $P=0.002$ $n=81$), demonstrating a decrease in biceps brachii score from the Visigothic period through the Islamic period. Considering the relationship between biceps brachii scores and humeral size, this may suggest a decrease in Islamic body size, however no significant difference in humeral size was identified in section 7.5.3 (with the exception of an outlier). The apparent multi-factorial nature of entheal expression at the biceps

brachii therefore makes it difficult to understand this trend. Little asymmetry was expressed in both faith groups (Islamic $d=0.08$, Visigothic $d=0.09$), and the asymmetry difference was not significant.

Visigothic females had the lowest flexor pollicis longus scores. A strong correlation between flexor pollicis longus score and faith group was identified on both sides (left $P \leq 0.001$ $n=69$ right $P=0.036$ $n=71$), indicating that flexor pollicis longus score increased in the Islamic period. Islamic women had symmetric flexor pollicis longus scores, but Visigothic women were asymmetric (Islamic $d=0.03$, Visigothic $d=0.23$). The difference, however, was not significant.

Visigothic females' pronator teres scores were greater than Islamic female scores. The left and right pronator teres scores correlated with faith group (left $P=0.007$ $n=69$, right $P=0.001$ $n=70$), demonstrating a decrease in pronator teres scores in the Islamic females. Visigothic females' pronator teres scores had greater asymmetry (Islamic $d=0.05$, Visigothic $d=0.47$) but the difference was not statistically significant.

Islamic females had greater mean supinator brevis scores than Visigothic females. The scores however did not correlate statistically with faith group, suggesting no significant change over time. The degree of asymmetry was similar between faith groups, and the difference that existed was not significant (Islamic $d=0.2$, Visigothic $d=0.12$).

Visigothic females had the lowest quadratus scores. A correlation between faith group and quadratus scores was observed (left: $P=0.027$ $n=52$, right: $P=0.019$ $n=49$), indicating that quadratus scores increased in the Islamic period. No difference in asymmetry between faith groups existed (Islamic and Visigothic $d=0.22$).

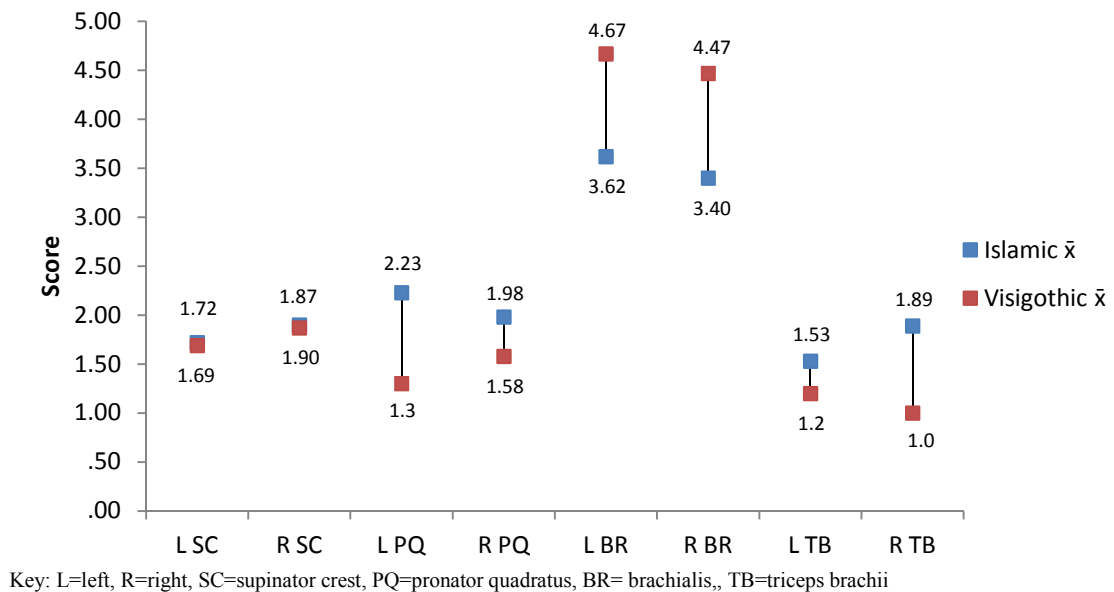
Ulna

Figure 7.2.1.32 Comparison of mean radial enthesal scores between Islamic and Visigothic females

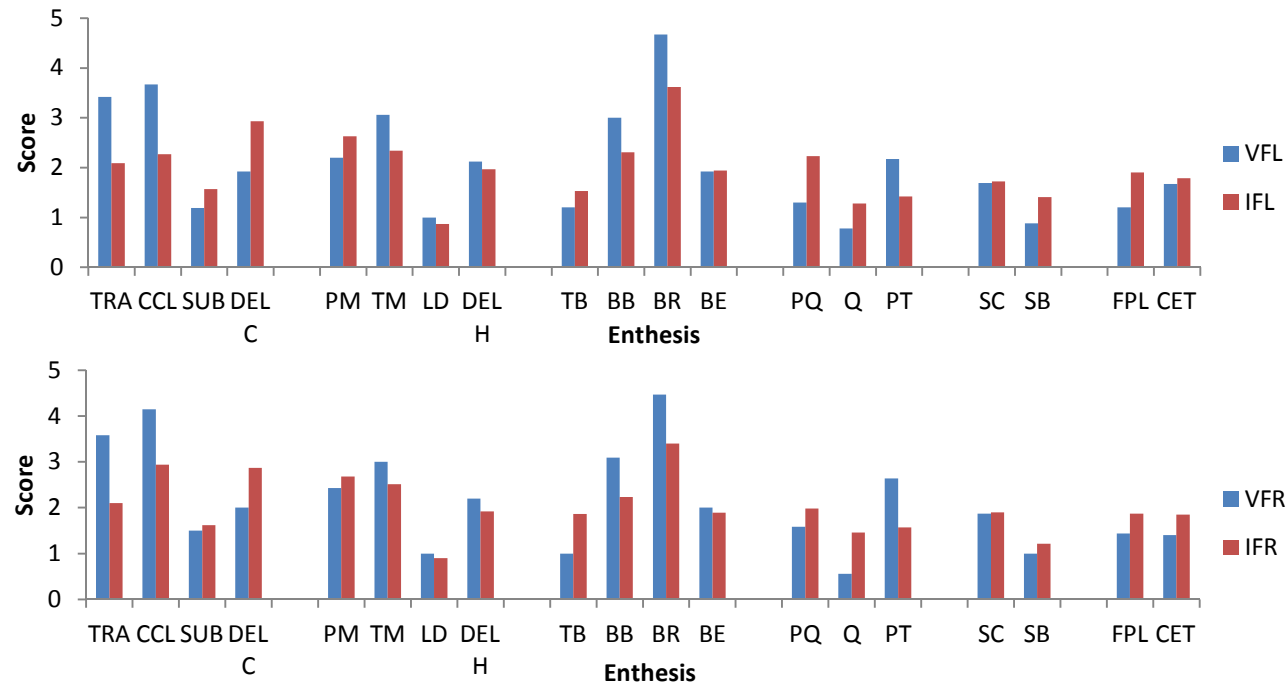
According to figure 7.2.1.32, Islamic and Visigothic females had similar mean supinator crest scores and no correlation with phase was identified. No difference existed in the degree of asymmetry experienced by Islamic and Visigothic women (Islamic and Visigothic $d=0.18$).

Islamic females had greater pronator quadratus scores than Visigothic females (left: $P \leq 0.001$ $n=45$, right: $P=0.046$ $n=63$). Although a similar degree of asymmetry was observed between faith groups (Islamic $d=0.25$, Visigothic $d=0.28$), the left pronator quadratus scores were greater in Islamic women whereas the right scored greater in Visigothic women. The difference, however, proved not to be statistically significant.

Brachialis scores were greater in Visigothic females. This temporal reduction in brachialis scores was supported by a statistically significant negative correlation with faith group (left: $P \leq 0.001$ $n=75$, right: $P \leq 0.001$ $n=75$). Brachialis score asymmetry was similar between faith groups (Islamic $d=0.22$, Visigothic $d=0.20$). Both triceps brachii scores decreased over time. This was indicated by the negative correlation of triceps brachii score and faith group. This was statistically significant for the right attachment and was close to significance for the left attachment (left: $P=0.079$ $n=50$, right: $P=0.016$ $n=45$). Islamic females had a greater degree of triceps brachii asymmetry than

Visigothic females (Islamic $d=0.33$, Visigothic $d=0.2$). Furthermore, Islamic females had greater scores on the right and Visigothic women had greater scores on the left. The difference, however, was not statistically significant.

Figure 7.2.1.32.1 demonstrates that, on both sides, there was a greater variation in the scores of different muscles groups in the Visigothic females. The muscles involved in shoulder elevation and in medio-lateral movement of the humerus are higher in Visigothic women than in Islamic females. The brachioradialis extensor attachment appeared to be a strong feature of both the Islamic and Visigothic groups, inferring that elbow flexion was a critical movement in both groups. Higher Islamic triceps brachii, supinator and pronator scores suggest that forearm use was a feature of Islamic female behaviour.



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoid, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoid, TB=triceps brachii, BB=bicep brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. VFL = Visigothic female left, IFL = Islamic female left, VFR = Visigothic female right, IFR = Islamic female right

Figure 7.2.1.32.1 Enthesal scores presented by major muscle groups for Visigothic and Islamic females.

Summary

There were a number of differences observed between Islamic women and Visigothic women. In terms of overall enteseal score, neither group had higher enteseal scores than the other consistently. While some enteses scored greater in Islamic women, including the deltoid attachment on the clavicle, the subclavius, the pronator quadratus and the flexor pollicis longus, others scored greater in Visigothic women, including the brachioradialis, costoclavicular ligament and the trapezius. The attachments of the distal humerus, the supinator brevis and the deltoid attachment scores of the humerus did not change over time at all. This suggests similarity and differences in female working patterns.

In terms of asymmetry, only the clavicle had significant differences between the two faith groups, but general asymmetry was greater in the Visigothic females for the radius and humerus.

7.2.3.2 Comparison of Visigothic male and Islamic male enthesal scores: changes in male gender ideology

Table 7.2.1.21 Correlation between enthesal score and faith group for Islamic and Visigothic males

Enthesis	Left			Right		
	Coefficient	P value	n	Coefficient	P value	n
TRA	0.762	≤0.001	65	0.55	≤0.001	60
DEL C	-0.304	0.017	59	-0.41	0.001	62
SUB	0.108	0.398	60	-0.272	0.047	52
CCL	0.234	0.077	55	0.105	0.452	52
DEL H	-0.01	0.936	63	0.044	0.693	80
TM	0.272	0.045	53	0.309	0.007	73
LD	0.155	0.347	37	0.477	≤0.001	51
PM	-0.032	0.815	56	0.022	0.884	81
BE	0.139	0.315	34	0.193	0.075	84
CET	-0.225	0.187	52	-0.038	0.761	64
BB	0.332	0.005	67	-0.252	0.016	89
FPL	-0.189	0.126	65	0.009	0.937	84
PT	0.546	≤0.001	63	0.376	≤0.001	87
SB	0.065	0.647	50	-0.106	0.36	75
Q	-0.372	0.018	38	-0.348	0.005	62
SC	-0.148	0.232	64	-0.024	0.827	81
PQ	-0.002	0.991	49	0.113	0.345	70
BR	-0.337	0.003	71	0.436	≤0.001	86
TB	-0.154	0.291	47	-0.263	0.036	62

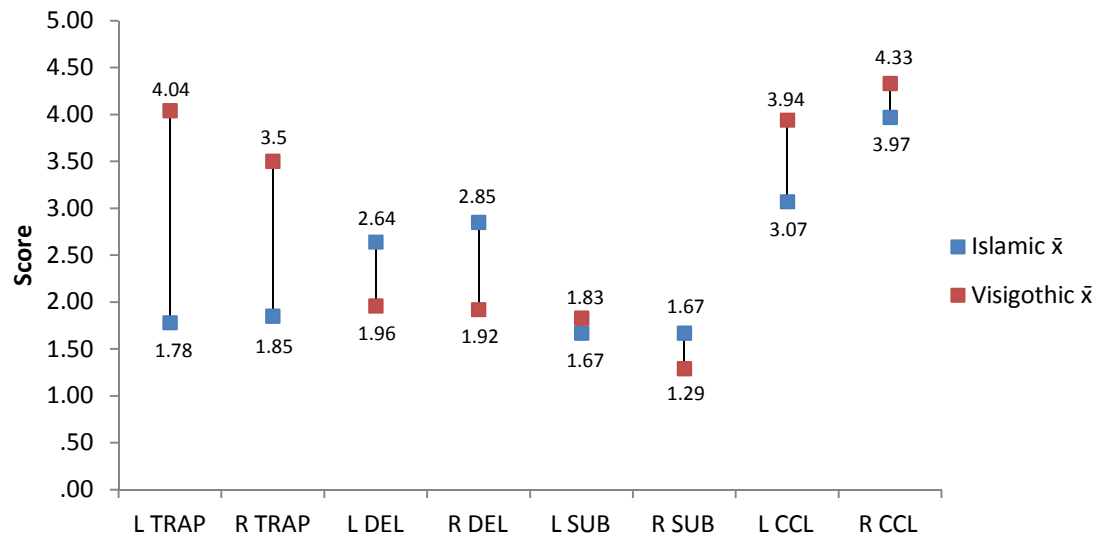
Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR=brachialis, TB=triceps brachii

Seventeen enthesal scores had a significant correlation with faith group (see table 7.2.1.21), inferring a temporal change in muscle use. Three markers had a change of asymmetry over time, with the subclavius and flexor pollicis longus losing asymmetry in the Islamic group and the costoclavicular ligament becoming more asymmetrical in the Islamic group (see table 7.2.1.22).

Table 7.2.1.22 Mean enthesal scores, standard deviation and asymmetry scores for Islamic and Visigothic males

Enthesis	Visigothic							Islamic							
	left			right			d	Left			Right			d	P value d
	N	$\bar{x}$	SD	N	$\bar{x}$	SD		N	$\bar{x}$	SD	N	$\bar{x}$	SD		
TRA	27	4.04	0.98	26	3.50	1.74	0.54	41	1.78	0.94	40	1.85	0.92	0.07	0.997
DEL C	23	1.96	0.77	26	1.90	0.74	0.06	39	2.64	1.16	41	2.85	1.09	0.21	0.281
SUB	23	1.83	1.43	17	1.29	0.47	0.54	42	1.67	0.75	39	1.57	0.62	0.10	≤0.001
CCL	18	3.94	1.43	21	4.33	1.24	-0.39	42	3.07	1.42	35	3.97	1.34	0.90	≤0.001
DEL H	29	2.48	0.91	22	2.41	1.22	0.07	40	2.30	0.79	62	2.33	0.82	0.03	0.617
TM	20	3.70	1.26	16	3.38	1.36	0.32	38	2.83	1.10	62	2.66	1.10	0.19	0.778
LD	8	1.13	0.35	8	2.13	1.55	-1.00	33	0.91	0.58	48	1.06	0.76	0.15	0.294
PM	21	3.33	1.53	23	3.57	1.34	-0.24	40	3.08	1.40	63	3.46	1.26	0.38	0.737
BE	21	2.05	0.38	23	2.26	0.76	-0.21	35	1.94	0.54	65	2.02	0.63	0.08	0.941
CET	7	1.57	0.54	6	1.67	0.82	-0.10	30	1.90	0.61	62	1.94	0.67	0.04	0.922
BB	28	4.11	1.24	26	4.15	1.08	-0.04	44	3.11	1.26	68	3.15	1.15	0.04	0.348
FPL	23	1.48	0.67	23	1.87	0.92	-0.39	66	1.85	0.61	46	1.74	0.61	0.11	0.003
PT	18	3.17	1.25	21	3.05	1.50	0.12	72	1.72	0.76	49	1.84	0.83	0.12	0.656
SB	7	1.14	0.38	8	1.00	0.00	0.14	71	1.20	0.62	47	1.09	0.62	0.11	0.702
Q	10	0.70	0.68	11	0.73	0.63	-0.03	56	1.34	0.79	32	1.31	0.78	0.03	0.854
SC	17	1.76	0.56	20	2.10	0.91	-0.34	54	1.98	0.53	64	2.14	0.66	0.16	0.174
PQ	15	1.67	0.72	12	2.00	1.13	-0.33	54	1.71	0.73	61	1.74	0.75	0.03	0.521
BR	28	4.39	0.96	22	4.50	0.74	-0.11	54	3.52	1.07	67	3.50	0.96	0.02	0.137
TB	10	1.40	0.52	11	1.45	0.52	-0.05	42	1.69	0.64	54	1.81	0.55	0.12	0.294

Key: TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon, BB=bicep brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus, SC=supinator crest, PQ=pronator quadratus, BR= brachialis,, TB=triceps brachii N= number, SD = standard deviation, $\bar{x}$ = mean

Clavicle

Key: L=left, R=right, TRAP=trapezius, DEL=deltoid, SUB=subclavius, CCL=costoclavicular ligament

Figure 7.2.1.33 Comparison of mean clavicle enthesal scores between Islamic and Visigothic males

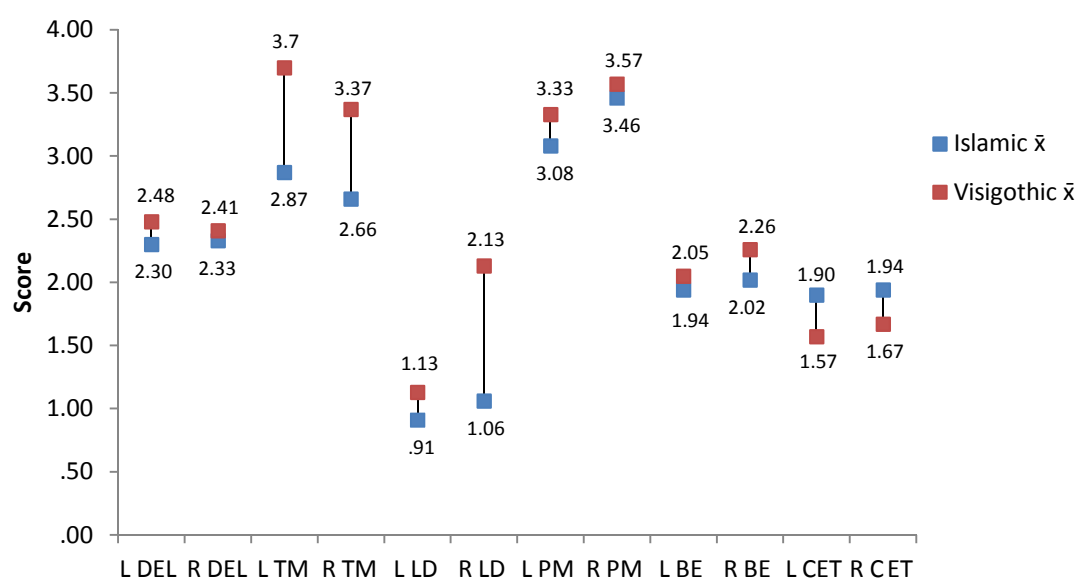
Visigothic males substantially outsourced Islamic males at both trapezius attachments. A strong correlation between faith group and trapezius score was identified, indicating a decrease in trapezius score in the Islamic phase (left: $P \leq 0.001$ $n=65$, right: $P \leq 0.001$ $n=60$). Asymmetry was low in Islamic males and more pronounced in Visigothic males (Islamic $d=0.07$, Visigothic $d=0.54$). Despite this, there was no statistical difference between the two faith groups for asymmetry.

Islamic males statistically had greater deltoid scores than Visigothic males (left $P \leq 0.001$ $n=60$, right $P=0.001$ $n=62$). Asymmetry, however, was similar between the two faith groups (Islamic $d=0.21$, Visigothic $d=0.06$).

Little score difference existed between Visigothic and Islamic males for the subclavius scores. Islamic males scored marginally more than Visigothic males on the right. Visigothic males scored slightly greater on average than Islamic males for the left subclavius. Nevertheless, there was no correlation between subclavius scores and faith group. The degree of asymmetry was greater in the Visigothic group (Islamic $d=0.10$ Visigothic $d=0.54$) and was highly significant ($P \leq 0.001$ $n=121$) suggesting asymmetrical use in Visigothic men.

Visigothic men had greater mean costoclavicular ligament scores on both sides. There was a weak correlation between left costoclavicular score and faith group ($P=0.077$ $n=55$). The right costoclavicular ligament score did not correlate with faith group. Costoclavicular ligament score asymmetry was greater in Islamic individuals (Islamic $d=0.90$, Visigothic $d=0.39$). The difference was highly significant ($P\leq 0.001$ $n=116$), demonstrating a clear difference in costoclavicular ligament use between faith groups.

Humerus



Key: L=left, R=right, DEL=deltoid, TM=teres major, LD=latissimus dorsi, PM=pectoralis major, BE=brachioradialis, CET=common extensor tendon.

Figure 7.2.1.34 Comparison of mean humeral enthesal scores between Islamic and Visigothic males

Deltoid scores, although slightly greater in Visigothic males, were similar between the two faith groups (figure 7.2.1.34) and showed no correlation with faith group. The difference in the degree of asymmetry observed between faith groups was not statistically significant (Islamic $d=0.03$, Visigothic $d=0.07$).

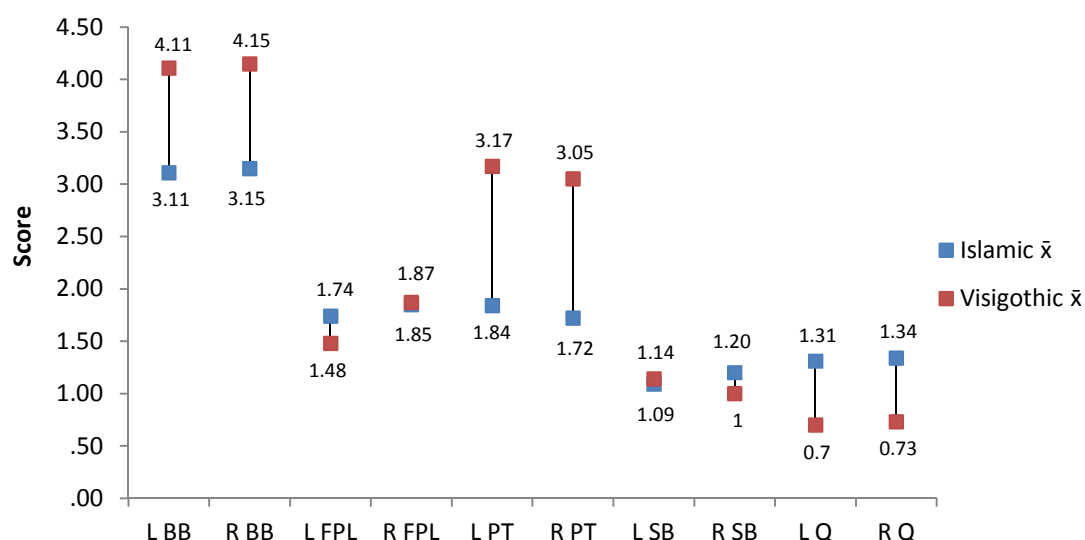
Teres major scores were greater in Visigothic males. A significant correlation between teres major score and faith group existed (left: $P=0.045$ $n=53$, right: $P=0.007$ $n=73$). Visigothic males also presented with greater asymmetry than Islamic males (Islamic $d=0.19$, Visigothic $d=0.32$). This difference, however, was not statistically significant.

Little difference existed between faith groups for left latissimus dorsi scores and no correlation with faith was identified. However a strong correlation between faith and right latissimus dorsi score was identified, with a decrease in the score of the right latissimus dorsi in the Islamic group ($P \leq 0.001$ $n=51$). Substantial asymmetry differences can be observed for the latissimus dorsi scores (Islamic $d=0.15$ Visigothic $d=1.00$), but the difference was not statistically significant.

Pectoralis major scores were similar between males, having no correlation with faith group. Islamic males had greater asymmetry than Visigothic males (Islamic $d=0.38$, Visigothic $d=0.24$), but the difference was not significant.

Left brachioradialis extensor scores were similar between Visigothic and Islamic males, exhibiting no correlation with faith group. A relationship between right brachioradialis extensor score and faith group was noted, but it was not significant ($P=0.075$ $n=84$). Islamic males had greater brachioradialis extensor score asymmetry (Islamic $d=0.21$, Visigothic $d=0.08$) but the difference between faith groups was not significant.

Islamic males had greater common extensor tendon scores than Visigothic males on both sides, but there was no correlation between score and faith group. Asymmetry in common extensor tendon scores was consistent between Islamic and Visigothic men (Islamic $d=0.04$, Visigothic $d=0.10$).

Radius

Key: L=left R=right, BB=biceps brachii, FPL=flexor pollicis longus, PT=pronator teres, SB=supinator brevis, Q=quadratus

Figure 7.2.1.35 Comparison of mean radial enteseal scores between Islamic and Visigothic males

According to figure 7.2.1.35, Visigothic males had greater mean biceps brachii scores than Islamic males. Biceps brachii mean scores and faith group are correlated, demonstrating a reduction in biceps brachii scores over time (left: $P \leq 0.001$ $n=67$, right: $P=0.016$ $n=89$). There was no difference in the degree of asymmetry between faith groups (Islamic $d=0.04$, Visigothic $d=0.04$). The relationship between score and body size has already been noted and discussed, but no change in male body size was identified in section 7.5.4.

Little difference existed between faith groups for flexor pollicis longus scores, despite Islamic males scoring greater on the left. There was no correlation between flexor pollicis longus score and faith group. Significantly, greater asymmetry existed in Visigothic males (Islamic $d=0.16$, Visigothic $d=0.34$) ($P=0.003$ $n=158$), inferring a loss of asymmetry over time.

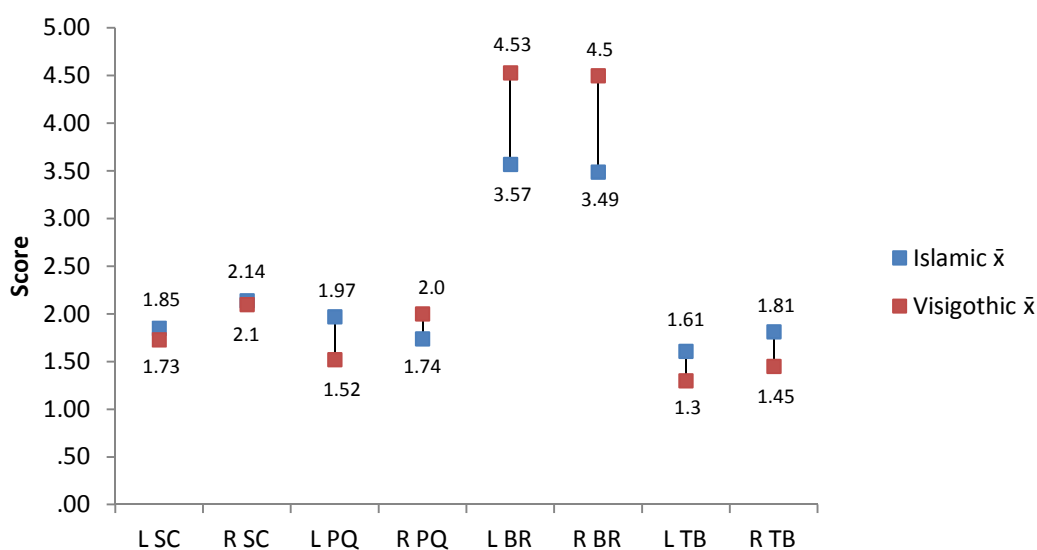
Visigothic males substantially outscored Islamic males at the pronator teres muscle attachments on both sides. A significant correlation was identified between faith group and pronator teres scores, suggesting that pronator teres scores decreased in the Islamic phase (left: $P \leq 0.001$ $n=63$, right: $P \leq 0.001$ $n=87$). Despite great differences between

pronator teres scores, the degree of asymmetry remained the same with the emergence of Islam (Islamic $d=0.12$, Visigothic $d=0.12$).

Figure 7.2.1.35 demonstrated that there was little difference in supinator brevis scores between the Visigothic males and Islamic males. Unsurprisingly, supinator brevis scores did not correlate with faith group. No significant difference in supinator brevis asymmetry existed between faith groups (Islamic $d=0.11$, Visigothic $d=0.14$).

Islamic males had greater mean quadratus scores than Visigothic males, and for both left and right attachments, a significant correlation was identified, suggesting that over time, quadratus scores increased (Left: $P \leq 0.018$ $n=38$, Right: $P=0.008$ $n=82$). There was no difference in the degree of asymmetry experienced between faith groups (Islamic $d=0.03$, Visigothic $d=0.03$).

Ulna



Key L=left R=right, SC=supinator crest, PQ=pronator quadratus, BR=brachialis, TB=triceps brachii

Figure 7.2.1.36 Comparison of mean ulna enteseal scores between Islamic and Visigothic males

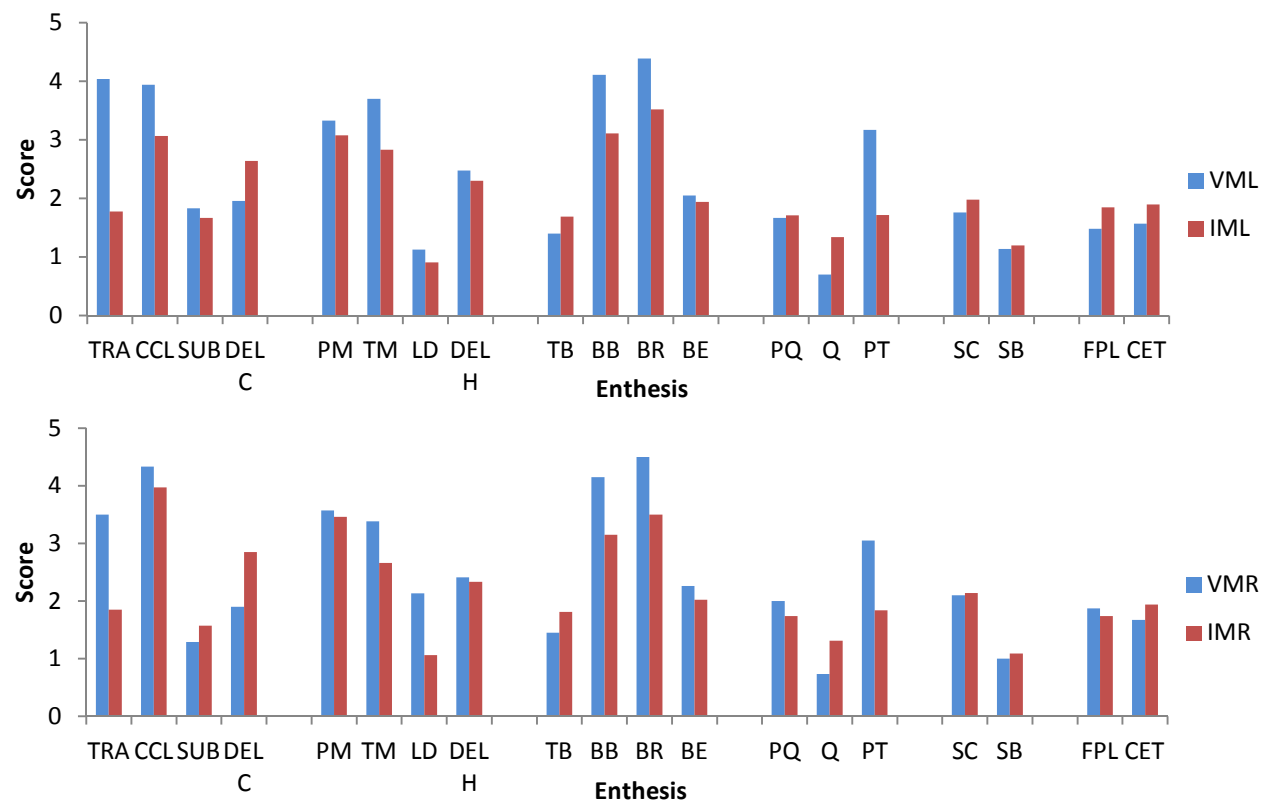
There was no correlation between supinator crest score and faith group. Visigothic males experience greater asymmetry at supinator crest attachments, but the difference was not statistically significant (Islamic $d=0.16$, Visigothic $d=0.34$).

Although Islamic males had larger pronator quadratus scores than Visigothic males, no correlation with faith group existed. While in Islamic males the left pronator quadratus

score was greatest, in Visigothic males the right pronator quadratus was greatest, but the asymmetry difference between faith groups was not statistically significant (Islamic $d=0.03$, Visigothic $d=0.03$).

Visigothic males had larger brachialis scores than Islamic males. The correlation between brachialis and faith group was highly statistically significant (left: $P=0.003$, $n=49$, right: $P\leq 0.001$ $n=86$) demonstrating that brachialis scores decreased in the Islamic phase. Little difference in asymmetry scores existed between faith groups (Islamic $d=0.02$, Visigothic $d=0.11$).

Islamic males had greater triceps brachii scores than Visigothic males. Left triceps brachii scores did not correlate statistically with faith group, whereas the right triceps brachii statistically significantly correlated with faith group ($P=0.036$ $n=62$). This demonstrates that there was an increase in the score of the right tricep brachii in the Islamic phase. No significant difference in asymmetry was identified between faith groups (Islamic $d=0.12$, Visigothic $d=0.05$).



Key: TRA=trapezius, CCL=costoclavicular ligament SUB=subclavius DEL C=deltoide clavicle, TM=teres major, PM=pectoralis major, LD=latissimus dorsi, DEL H=deltoide humerus, TB=triceps brachii, BB=biceps brachii, BR=brachialis, BE=brachioradialis, PQ=pronator quadrates, Q=quadratus, PT=pronator teres, SC=supinator crest, SB=supinator brevis, CET=common extensor tendon, FPL=flexor pollicis longus. VML=Visigothic male right, IML=Islamic male left, VMR=Visigothic male right, IMR=Islamic male right

Figure 7.2.1.36.1 Enteseal scores presented by major muscle groups for Visigothic and Islamic females.

Figure 7.2.1.36.1 demonstrates that there were some differences in muscle-use patterns between the Visigothic and Islamic males. The pronators of the forearm score proportionally higher in comparison to other muscle groups in the Visigothic men. In addition, the left trapezuis, pectoralis major and teres major score higher in Visigothic men, which may infer greater superior inferior movement of the arm in Visigothic males. On both sides, the brachioradialis extensor and biceps brachii score proportionally higher than the entheses that represent medio-lateral upper arm movement, This is not observed in the Islamic group and may infer greater arm flexion in the Visigothic group. Although it was difficult to be certain due to the relationship between biceps brachii scores and body size.

Summary

Fewer statistically significant differences existed between the Visigothic and Islamic males than the equivalent female comparison. In general, Visigothic men appear to have greater enteseal scores than Islamic men. This was especially at muscle attachments associated with forearm movement and elbow flexion (teres major, bicep brachii, pronator teres, the brachialis). Notable differences included the degree of asymmetry at the costoclavicular ligament entheses in Islamic males, but also the greater asymmetry of Visigothic men at the subclavius and the flexor pollicis longus sites. Visigothic males also appear to have greater general asymmetry for humeral enteseal scores which, accompanied with greater enteseal scores, may infer greater asymmetric, and more loaded physical activity than experienced by Islamic males.

7.3 The results of non-pathological articular modification analysis

This section explores whether differences in activity patterns are observable from non-pathological articular modifications. This therefore highlights whether there were differences in posture adoption between any of the comparison groups outlined in section 6.3.1.

7.3.1 Analysis of sex differences in non-pathological modification scores in Islamic group: analysis of Islamic gender division.

Seventy two females and 92 males had femora available for analysis. A Fisher's exact test indicates that the difference between the male and female numbers was not statistically significant ($P=0.379$ $n=332$).

Osteochondritis modifications on the femoral condyles

Table 7.3.1 Femoral condyle osteochondritis types by sex, side, position and type and Fisher's exact scores

Condyle and sex	A	%A	F	%F	I	%I	NGB	%NGB	P value	N
Female left medial	36	92.3	1	2.6	0	0.0	2	5.1	1.0000	39
Male left medial	47	92.2	0	0.0	4	7.8	0	0.0		51
Female left lateral	35	87.5	1	2.5	4	10.0	0	0.0	1.0000	40
Male left lateral	39	86.7	0	0.0	5	11.1	1	2.2		45
Female right medial	33	94.3	0	0.0	0	0.0	2	5.7	1.0000	35
Male right medial	40	93.0	0	0.0	1	2.3	2	4.7		43
Female right lateral	44	86.3	1	1.95	5	9.8	1	1.9	1.0000	51
Male right lateral	51	86.4	3	5.1	3	5.1	2	3.4		59
Total	325	89.5	6	1.7	22	6.1	10	2.8	1.0000	363

Key: A=absent, F=facet, I=imprint, NGB=new bone growth.

Overall there was no difference in the prevalence of osteochondritis modifications on male and females condyles ($P=1.000$ $n=363$) (table 7.3.1). Due to the number of categories with 0 observations, it was not possible to carry out chi-squared tests.

Left medial: Four males had imprints, whereas one female had a facet and two females had new bone growth. The prevalence of modifications was similar for men and women (92.2% males and 92.3% females) and not statistically significant ($P=1.000$ $n=90$).

Left lateral: Five male condyles had imprints and one had new bone growth; one female condyle had a facet and four female condyles had imprints. The prevalence of

osteocondritic modifications was comparable between men (86.7%) and women (87.5%), and not statistically significant ($P=1.000$ $n=85$).

Right medial: Men and women had the same prevalence of modifications on the right medial femoral condyles (males 93%, females 94.3%); no significant differences existed ($P=1.000$ $n=78$).

Right lateral: The overall prevalence of modifications was the same between men and women (males 86.4%, female 86.3%), and did not differ ($P=1.000$ $n=110$).

While no significant differences existed, caution needs to be exercised as the number of observations for each type of modification was low.

Tibial imprints on the supracondylar surface of the femur

Table 7.3.2 Supracondylar tibial imprints by sex, side, position and type.

Supracondylar surface	A	%A	E	%E	I	%I	P	%P	P value	N
Female left medial	18	58.1	12	38.7	1	3.2	0	0.0	1.000	31
Male left medial	25	59.5	10	23.8	5	11.9	2	4.8		42
Female left lateral	16	50.0	13	40.6	3	9.4	0	0.0	0.820	32
Male left lateral	22	44.9	22	44.9	4	8.2	1	2.0		49
Female right medial	24	82.7	4	13.8	1	3.5	0	0.0	0.278	29
Male right medial	35	92.1	2	5.3	0	0.0	1	2.6		38
Female right lateral	35	92.1	2	5.3	0	0.0	1	2.6	0.678	38
Male right lateral	55	93.2	3	5.1	1	1.7	0	0.0		59
Total	230	72.3	68	21.4	15	4.7	5	1.6	0.800	318

Key: A=absent, E=extension, I=imprint, P=pitting. 3df for χ^2 tests

Seventy two females and 92 males had 318 observable supracondylar surfaces. There were no statistically significant differences in the overall prevalence of tibial imprint modifications between males and females (27.2% and 28.5% respectively) (table 7.3.2). Due to the number of categories with 0 observations, it was not possible to carry out chi-squared tests for tibial imprints.

Left medial: The overall prevalence of tibial imprint modifications on the left medial supracondylar surface was similar between men and women (41.9% females and 40.5% males). There was no difference in the prevalence of modifications between sexes ($P=1.000$ $n=73$). A large percentage of both sexes had tibial extensions (38.7% females

and 23.8% males). Imprints were less frequent (3.2% females and 11.9% males). Only males (4.8%) had pitting on the left medial supracondylar surface.

Left lateral: The overall number of tibial imprint modifications was similar between sexes for the left lateral supracondylar surface (males 55.1%, females 50%) and the difference was insignificant ($P=0.820$ $n=81$). Furthermore, the prevalence of modification types was similar between sexes (table 7.3.2).

Right medial: The overall prevalence of right medial supracondylar modifications was 7.9% for males and 17.3% for females. This difference was not significant ($P=0.272$ $n=68$).

Right lateral: 6.8% of male right lateral supracondylar surfaces had a tibial imprint modification, in comparison to 7.9% of female supracondylar surfaces. Again, this was not significantly different ($P=0.678$ $n=97$). The prevalence of each type of tibial imprint modification was similar between sexes (table 7.3.2).

Vastus notches on the patella

Table 7.3.3 Vastus notch prevalence by side, sex and type.

Vastus notch	S	%S	L	%L	A	%A	χ^2	P value	N
Female right	11	28.2	4	10.3	24	61.5	1.581	0.454	39
Male right	18	36.0	4	8.0	28	56.0			50
Female left	11	32.3	5	14.7	18	52.9	2.756	0.252	34
Male left	22	42.3	5	9.6	25	48.1			52
Total	62	35.4	18	10.3	95	54.3	2.993	0.224	175

Key: S= small, L= Large, A = absent, N = number.

Seventy three female and 102 male patellae were observable. Overall there was no statistically significant difference ($P=0.539$ $n=175$) in the prevalence of vastus notches between men (48%) and women (42.5%). There was no prevalence variation between sexes on the left or right side for the sizes of the vastus notch (left: $\chi^2= 2.756$ $P=0.252$ 2df, right: $\chi^2= 1.581$ $P=0.454$ 2df) (table 7.3.3).

Medial tibial squatting facets

Ninety five female and 106 male medial tibiae were observable. There was no statistical difference in the number of medial squatting facets between men (5.7%) and women (3.2%) ($P=0.504$, $n=201$). There was no difference in the prevalence of medial squatting

facets between men and women on the left or the right side (left: $P=1.000$ $n=106$, right: $P=0.223$ $n=95$) (table 7.3.4).

Table 7.3.4 Medial squatting facets by sex, side and presence with Fisher's exact scores

Medial tibial squatting facets	Absent	%absent	Present	%present	P value	N
Female right	41	97.6	1	3.4	0.223	42
Male right	48	90.6	5	9.4		53
Female left	51	96.2	2	3.8	1.000	53
Male left	52	98.1	1	1.9		53
Total	192	95.5%	9	4.5	0.504	201

Lateral tibial squatting facets

Table 7.3.5 Lateral tibial squatting facets by side, sex and type with chi-squared scores

Lateral tibial squatting facets	A	%A	1	%1	2	%2	3	%3	χ^2	P value	Total
Female right	3	6.1	6	12.2	38	77.6	2	4.1	6.480	0.093	49
Male right	5	8.3	16	26.2	39	63.9	1	1.6			61
Female left	2	3.9	6	11.8	41	80.4	2	3.9	5.362	0.147	51
Male left	3	5.9	12	23.5	35	68.6	1	2.0			51
Total	13	6.1	40	18.9	153	72.2	6	2.8	-	0.577	212

Key: A=absent, 1=small, 2 = large, 3=extreme, impinging on tibial shaft.

One hundred female and 102 male lateral tibiae were observable. 92% of male tibiae and 95% of female tibiae scored positively for lateral tibial squatting facets (table 7.3.5). A Fisher's exact test indicated that this sex difference was not statistically significant ($P=0.577$ $n=212$). There was no difference in the sizes of squatting facet between men and women on either the left or right tibia (left: $\chi^2=5.36$ $P=0.147$ 3df, right: $\chi^2=6.480$ $P=0.093$ 3df).

Talus squatting facet

Table 7.3.6 Talus squatting facet by side, sex and type and chi-squared scores

Talus squatting facet	A	%A	C	%C	P	%P	χ^2	P Value	Total
Female left	1	2.0	35	71.5	13	26.5	3.922	0.141	49
Male left	3	5.1	30	50.8	26	44.1			59
Female right	1	1.8	35	63.6	19	34.6	19.901	≤ 0.001	55
Male right	5	7.9	28	44.4	30	80.7			63
Total	10	4.4	128	56.7	88	38.9	-	0.113	226

Key: A=absent, C=congenital, P=pressure

One hundred and four female and 122 male tali were observable. While more male tali were without facets than female tali (male 6.5% females 1.9%), there was no difference in the number of tali with squatting facets between males and females ($P=0.113$ $n=226$) (table 7.3.6). However, there was a difference in the pattern of prevalence for the type of squatting facet between men and women ($\chi^2=17.224$ $P\leq 0.001$ 2df). Females had a higher prevalence of congenital type facets whereas men had higher prevalence of pressure facets and tali without facets.

Left: No difference in the type of facets on the left talus existed for men and women ($\chi^2=3.920$ $P=0.141$ 2df).

Right: The proportions of the facet types did differ statistically between sexes for the right talus ($\chi^2=19.901$ $P\leq 0.001$ 2df). Males have more pressure facets than females, who themselves had a high prevalence of congenital facets.

When examining the prevalence of congenital and pressure facets only, there was a difference between the sexes on the left, but not the right talus (left $P=0.046$ $n=104$, right $P=0.089$ $n=112$). This suggested an asymmetry difference between the sexes in the type of facets experienced.

Metatarsal extensions

Table 7.3.7 Islamic metatarsal extension by position and sex and Fisher's exact scores

Metatarsal	Female				Male				P value	N
	A	%A	P	%P	A	%A	P	%P		
L5	19	76.0	7	24.0	18	56.0	14	44.0	0.273	58
L4	9	33.0	18	67.0	13	39.0	20	61.0	0.789	60
L3	9	30.0	21	70.0	14	50.0	14	50.0	0.179	58
L2	10	32.0	21	68.0	21	54.0	18	46.0	0.002	60
L1	9	27.0	24	73.0	9	23.0	31	77.0	0.786	73
R1	11	28.0	27	72.0	6	15.0	32	85.0	0.271	76
R2	13	33.0	26	67.0	17	45.0	21	55.0	0.355	77
R3	9	25.0	27	75.0	17	44.0	22	56.0	0.147	76
R4	12	34.0	23	66.0	23	53.0	20	47.0	0.112	78
R5	24	68.0	11	32.0	27	69.0	12	31.0	1.000	74
Total	125	38.0	205	62.0	165	44.0	204	56	0.077	699

Key: L = left, R = right, A = absent, P = Present, N= number

330 female and 369 male metatarsals were observable. Women had a higher prevalence of metatarsal extensions than men (females 62%, males 56%). However, according to a

Fisher's exact test, this was not significantly different ($P=0.077$ $n=699$). In terms of individual metatarsals, the only position where men and women had a statistically significant difference in the prevalence of metatarsal extensions was the second left metatarsal, where females had more ($P=0.002$ $n=60$) (table 7.3.7).

Phalangeal wedging

Table 7.3.8 Phalangeal wedging by position and sex with Fisher's exact scores

Phalanx position	Female				Male				P value	N
	A	%A	P	%P	A	%A	P	%P		
L5	19	90.5	2	9.5	23	88.5	3	11.5	1.000	47
L4	15	60.0	10	40.0	14	53.8	12	46.2	0.779	51
L3	9	47.4	10	52.6	12	50.0	12	50.0	1.000	43
L2	12	50.0	12	50.0	15	45.4	18	54.5	0.792	57
L1	5	15.6	27	84.4	4	11.4	31	88.6	0.727	68
R1	4	12.1	29	87.9	3	8.8	31	91.2	0.709	67
R2	11	36.7	19	63.3	13	37.1	22	42.9	1.000	65
R3	12	60.0	8	40.0	19	57.6	14	42.4	1.000	53
R4	16	61.5	10	38.5	19	61.3	12	38.7	1.000	57
R5	21	80.8	5	19.2	22	78.6	6	21.4	1.000	54
Total	124	48.4	132	51.6	144	47.2	161	42.8	0.799	561

Key: L = left, R = right, A = absent, P = present, N = number

Two hundred and thirty six female and 305 male proximal phalanges were observable. Like metatarsal extensions, women had a higher prevalence of wedged phalanges than men (women 51.6%, men 42.8%) but this difference was not statistically significant ($P=0.799$ $n=561$). There was no sex difference in the prevalence of wedged phalanges at equivalent left and right positions (table 7.3.8 for P values).

Summary of Islamic sex comparison

Statistically significant differences were observed at two joint surfaces between men and women; the overall prevalence and types of squatting facets on the talus and extensions to the second metatarsal distal surface. This suggests some difference in activity patterns between males and females.

7.3.2 Temporal differences in non-pathological articular modifications between early and late Islamic individuals: analysis of changing social organisation

166 individuals, 75 early-period individuals and 91 late-period, were available for analysis. The difference in individual numbers between phases was not statistically significant ($P=0.442$ $n=332$).

Osteochondritis modification on the femoral condyles

Table 7.3.9 Osteochondritis by phase, side, position and type with Fisher's exact scores.

Femoral condyle	A	%A	F	%F	I	%I	NBG	%NBG	P value	Total
Late Left Medial	50	92.5	0	0.0	2	3.7	2	3.7	1.000	54
Early Left Medial	33	91.6	1	2.8	2	5.6	0	0.0		36
Late Left Lateral	42	85.7	1	2.1	6	12.2	0	0.0	0.753	49
Early Left Lateral	32	88.9	0	0.0	3	8.3	1	2.8		36
Late Right Medial	38	86.3	0	0.0	2	4.5	4	9.1	0.031	44
Early Right Medial	35	100	0	0.0	0	0.0	0	0.0		35
Late Right Lateral	55	91.7	1	1.7	2	3.3	2	3.3	0.168	60
Early Right Lateral	46	82.1	3	5.4	6	10.7	1	1.8		56
Total	331	89.5	6	1.6	23	6.2	10	2.7	1.000	370

Key: A= absent, F= facet, I= imprint, NBG = new bone growth.

Two hundred and seven late and 163 early femoral condyles were observable. There was no difference in the total number of osteochondritic modifications between early phase and late phase individuals ($P=1.000$ $n=370$). As many modification categories contained 0 observations, it was not possible to statistically compare phases and modification types using chi-squared tests. See table 7.3.9 for Fisher's exact scores for the analysis of over prevalence of osteochondritis modifications for each femoral condyle.

Left Medial: Overall, the prevalence of osteochondritic modifications appears similar over time (7.5% early and 8.4% late), and was not statistically different ($P=1.000$ $n=90$). The only facet on the left medial condyle was in the early phase. Both phases had two individuals with imprints (3.7 % early, 5.6% late). Only two individuals (3.7%) had new bone growth on the left medial condyle in the early phase.

Left lateral: The appearance of osteochondritic modifications was similar between phases (late 11.1%, early 14.3%). and did not differ statistically ($P=0.753$ $n=85$). The late phase had six left condyles with imprints (12.2%) and one condyle with a facet

(2.1%). The early phase had three condyles (8.3%) with imprints and one with new bone growth (2.8%).

Right medial: The overall prevalence of modifications on the right medial condyle was 14.7%. During the late phase, 13.7% of individuals had a modification whereas none were observed in the early phase. This was statistically different ($P=0.031$ $n=49$) and demonstrates a temporal difference in the appearance of modifications on the right medial condyle.

Right lateral: Despite the early phase having more modifications (late 8.3%, early 17.9%), the difference was not statistically significant ($P=0.168$, $n=116$). The prevalence of imprints increased in the late phase from 3.3% (early) to 10.7% (late). Also the number of facets increased from 1.7% in the early phase to 5.4% in the late phase.

Tibial imprints on the supracondylar surface of the femur

Table 7.3.10 Tibial imprint by phase, size, position, type and chi-squared and P-values.

Supracondylar surface	A	%A	E	%E	I	%I	P	%P	χ^2	P value	Total
Late Left Medial	28	58.3	15	31.3	3	6.2	2	4.2	1.570	0.667	48
Early Left Medial	20	62.5	8	25	3	9.4	1	3.1			32
Late Left Lateral	21	44.7	22	46.9	3	6.4	1	2.1	1.260	0.832	47
Early Left Lateral	19	47.5	16	40	4	10	1	2.5			40
Late Right Medial	36	85.7	6	14.3	0	0	0	0	-	-	42
Early Right Medial	24	85.8	3	10.7	1	3.6	0	0			28
Late Right Lateral	55	93.2	3	5.1	0	0	1	1.7	-	-	59
Early Right Lateral	40	90.9	3	6.8	1	2.3	0	0			44
Total	243	71.5	76	22.4	15	4.4	6	1.7	-	1.0000	340

Key: A=absent, E=extension, I=imprint, P=pitting.

One hundred and ninety six late and 144 early supracondylar surfaces were observable. According to a Fisher's exact test there was no difference between phases in terms of the overall prevalence of tibial imprint modifications (early 32.1% late 26.3%) despite early phase individuals having more modifications ($P=1.000$ $n=340$) (table 7.3.10).

Left medial: Although left medial tibial modifications were more prevalent in the late phase (41.7% late, 37.5% early) according to a Fisher's exact test, the difference was not statistically different ($P=0.109$ $n=80$). The prevalence of each type of modification on the left medial condyle was similar between phases (see table 7.3.18) and a chi-

squared test indicated that the prevalence of modification types did not change over time ($\chi^2=1.57$, $P=0.667$ 3df).

Left lateral: During the early phase, left lateral tibial imprint modifications were less prevalent than during the late phase (52.5% early 55.3% late) but the difference was not significantly different ($P=0.832$ $n=87$). Extensions were more commonly seen in the late phase (46.9 % late 40% early), but imprints and pitting were more prevalent in the early phase (imprint: 10% early 6.4% late, pitting: 2.5% early 2.1% late). The types of modification on the left lateral condyle between phases was not significantly different ($\chi^2=1.264$ $P=0.832$ 3df).

Right medial: There was just 0.1% difference in the overall presence of right medial condyle modifications between early-phase (14.2%) and late phase (14.3%). This difference was not statistically significant ($P=1.000$ $n=70$). No chi-squared test could be performed.

Right lateral: 9.1% of early right lateral condyles had modifications, whereas only 6.8% of late right lateral condyles had modifications. Despite the lower prevalence in the late-phase, the difference was not significant ($P=0.721$ $n=103$). 6.8% of the early phase condyles had extensions in comparison to 5.1% of late condyles. While 2.3% of the early right lateral modifications were imprints, no imprints appeared on late-phase right lateral condyles. Just one (1.7%) late-phase right lateral condyle had pitting. As two categories contained no observations (early pitting and late imprint) it was not possible to carry out chi-squared tests.

There was no temporal change in the overall prevalence of tibial modifications or the types of modifications experienced on each condyle.

Vastus notches on the patella

Table 7.3.11 Vastus notch by phase, side and type

Vastus notch	S	%S	L	%L	A	%A	χ^2	P value	Total
Late left	20	41.2	3	6.3	25	52.1	8.068	≤0.001	48
Early left	13	30.2	7	16.3	23	53.5			43
Late right	15	29.4	4	7.8	32	62.7	2.758	0.252	51
Early right	17	39.5	4	9.3	22	51.2			43
Total	65	35.1	18	9.7	102	55.2	-	0.187	185

Key: S= small, L= Large, A = Absent.

Ninety nine late and 86 early patellae were observable (table 7.3.11). There was no temporal difference in the number of patellae with vastus notches despite the early phase having a higher prevalence of vastus notches (early 47%, late 42%) ($P=0.187$ $n=185$).

Left: There was no difference in the prevalence of vastus notches on the left patella (early 46.5% late 47.9%) (table 7.3.11). There was a higher prevalence of small facets in the late phase (late 41.2% early 30.2%) but a higher prevalence of large facets in the early phase (early 16.3% late 6.3%). This difference was statistically significant ($\chi^2=8.068$ $P=0.002$ 2df). Therefore the size of the vastus notch on the left patella decreased with time.

Right: Early-phase individuals had more vastus notches than late individuals on the right patella (early 48.8%, late 37.3%) (table 7.3.11). The early phase individuals had a greater prevalence of small facets (early 39.5%, late 29.4%) and large facets (early 9.3%, late 7.8%) than the late individuals. The difference in the facet sizes was not statistically significant between phases ($\chi^2=2.758$ $P=0.252$ 2df) and did not change over time.

Medial squatting facets on the tibia

Table 7.3.12 Medial tibial squatting facets by phase, side and type.

Phase and Side	Absent	%Absent	Present	%Present	P value	Total
Late left	59	96.7	2	3.3	1.000	61
Early left	44	98.8	1	1.2		45
Late right	50	92.6	4	7.4	0.696	54
Early right	39	95.1	2	4.9		41
Total	192	95.5	9	4.5	0.735	201

One hundred and fifteen late and 86 early medial tibiae were observable. Even though there were more medial squatting facets in the early phase (early 5.2% late 3.5%), the difference in the prevalence between phases was not significant ($P=0.735$, $n=201$).

Left: With just 2.1% difference in medial squatting facet prevalence between the early phase and the late phase, no statistical difference between phases existed ($P=1.000$ $n=106$) (see table 7.3.12).

Right: 7.4% of early-phase right tibiae had a medial squatting facet, in comparison to 4.9 % in the late phase. Although there was a slight difference in prevalence, the difference was not statistically significant ($P=0.696$ $n=95$) (see table 7.3.12).

Lateral tibial squatting facets

Table 7.3.13 Lateral tibial squatting facets by phase, side and type.

Phase and side	1	1%	2	2%	3	3%	A	%A	χ^2	P value	Total
Late left	13	22	44	74.6	2	3.4	0	0.0	12.686	0.005	59
Early left	5	11.6	32	74.4	1	2.3	5	11.6			43
Late right	17	26.1	42	64.6	2	3.1	4	6.1	15.780	0.001	65
Early right	5	11.1	35	77.8	1	2.2	4	8.9			45
Total	40	18.9	153	72.2	6	2.8	13	6.1	-	0.077	212

Key: 1 = small, 2=large, 3=extreme, extending on to tibial shaft, A=absent.

One hundred and twenty four late and 88 early lateral tibiae were observable. There was 4.8% difference in the overall prevalence of the lateral tibial squatting facet between phases (early 92%, late 96.8%) ($P=0.077$ $n=212$) which, although not statistically significant, suggests a trend towards an increase in facets over time. See table 7.3.13 for prevalence of tibial imprints.

Left: For the left tibia facet types, a difference between phases was found ($\chi^2=12.686$ $P=0.005$ 3df), which results from all late left tibiae having facets in comparison with 88.4% of early-phase tibiae. Furthermore, small facets were more prevalent in the late phase (late 22%, early 11.6%). Although the number of large facets (early 74.4%, late 74.6%) and extreme facets (early 2.3% late 3.4%) was similar between phases, there is a temporal increase in small facets.

Right: The difference between phases for the prevalence of each type of facet on the right tibiae was significantly different ($\chi^2=15.780$ $P=0.001$ 3df). While there was very little difference in the number of extreme facets (early 2.2%, late 3.1%), the late phase had a higher prevalence of smaller facets than the early phase (late 26.1% in comparison to 11.1% early). The early phase had a higher prevalence of large facets (late 64.4%, early 77.8%). It seems the size of facets decreases over time, but the overall prevalence of facets increases.

Talus squatting facets

Table 7.3.14 Talus squatting facets by phase, side and type.

Phase and side	A	%A	C	%C	P	%P	χ^2	P value	Total
Early left	2	3.7	40	63.5	21	33.3	1.621	0.445	63
Late left	2	4.4	25	55.6	18	40.0			45
Early right	3	4.4	35	51.5	30	44.1	0.909	0.635	68
Late right	3	6.0	28	56	19	38.0			50
Total	10	4.4	128	56.7	88	38.9		0.746	226

Key: A=absent, C=congenital, P=pressure.

One hundred and twenty one late and 95 early tali were observable. The overall prevalence of talus squatting facets was higher in the late phase (early 94.8%, late 96.2%), but the difference was not statistically significant ($P=0.746$ $n=226$). See table 7.3.14 for talus squatting facet prevalence.

Left: For the left tali, there were equal numbers of tali without facets in each phase (early 4.4%, late 3.7%). There was a higher prevalence of congenital facets in the late phase (late 63.5%, early 55.6%), but a lower prevalence of pressure facets (late 33.3%, early 40%). This difference was not significant ($\chi^2=1.621$ $P=0.445$ 2df). When considering differences in the prevalence of congenital and pressure facets, there was also no statistically significant change over time ($P=0.538$ $n=104$).

Right: The prevalence of tali without facets was also similar between phases on the right side (early 6%, late 4.4%). In both phases, the congenital facet was most common. There was a decrease in pressure facets in the late phase, and a small increase in tali without facets. The difference in the type of facets in each phase was not significant ($\chi^2=0.909$ $P=0.635$ 2df). When considering the prevalence of congenital and pressure facets only, the difference between early and late phases was still not significant ($P=0.566$ $n=112$).

Extension to the distal metatarsal surface

Three hundred and thirty five early and 387 late metatarsals were observable. Table 7.3.15 displays the total number of metatarsals and total number of metatarsal extensions. There were statistically more metatarsals with extensions in the late phase (early 54.2%, late 63.3%) ($P=0.012$ $n=722$), indicating an increase in flexion of the toes. In terms of individual metatarsal positions, only the left fifth metatarsal was

significantly different between the early phase and late phase, being more prevalent in the late phase (early 20.7%, late 50.0%). Apart from the left 5th metatarsal, the patterning of extensions appears constant over time.

Table 7.3.15 Metatarsal extension prevalence by phase, position and side.

Metatarsal position	Early				Late				Total	P value	N
	A	%A	P	%P	A	%A	P	%P			
L1	8	32.2	28	77.8	11	27.5	29	72.5	76	0.791	76
R1	11	30.6	25	69.4	6	14.6	35	85.4	77	0.107	77
L2	19	44.1	15	55.9	13	35.1	24	64.9	71	0.098	71
R2	12	35.3	22	64.7	18	48.9	26	59.1	78	0.646	78
L3	13	46.4	15	53.6	10	31.2	22	68.8	60	0.291	60
R3	13	35.1	24	64.9	14	33.3	28	66.7	79	1.000	79
L4	12	40.0	18	60.0	10	31.2	22	68.8	62	0.597	62
R4	18	48.6	19	51.4	17	38.6	27	61.4	81	0.379	81
L5	23	79.3	6	20.7	16	50.0	16	50.0	61	0.032	61
R5	25	74.5	9	26.5	27	62.8	16	37.2	77	0.340	77
Total	154	45.8	181	54.2	142	36.7	245	63.3	722	0.012	722

Key: L=left, R=right, A=absent, P=present, N=number.

Wedging to the proximal surface of the proximal phalanges

Table 7.3.16 Phalangeal wedging by phase, side and position and Fisher's exact scores.

Phalanx position and side	Early				Late				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	5	15.2	28	84.8	4	11.1	32	88.9	0.705	57
R1	4	12.5	28	87.5	4	11.1	32	88.9	1.000	68
L2	14	56.0	11	44.0	13	39.4	20	60.6	0.289	58
R2	14	45.2	17	44.8	11	30.6	25	69.4	0.311	67
L3	11	50.0	11	50.0	10	45.5	12	54.5	1.000	44
R3	17	56.7	13	43.3	15	60.0	10	40.0	1.000	55
L4	14	53.8	12	46.2	15	57.7	11	42.3	1.000	52
R4	16	57.1	12	42.9	19	65.5	10	34.5	0.592	57
L5	16	80.0	4	20.0	26	96.3	1	3.7	0.148	47
R5	22	51.5	5	48.5	21	77.8	6	22.2	1.000	54
Total	133	48.5	141	51.5	138	46.5	159	53.5	0.675	571

Key: L = left, R = right, A = absent, P = present, N= number

274 early and 297 late phalanges were observable. Phalangeal wedging was more prevalent in the late phase (early 51.5%, late 53.5%) (table 7.3.16), but not significant statistically so (P=0.675 n=571). There were no significant differences between phase and wedging of the phalanges at any ray position (table 7.3.16).

Summary of Islamic-phase comparison

A number of joint modifications change prevalence over time. There was an increase in osteochondritis modifications on the right medial condyle, a decrease in the size of the left vastus notch, an increase in the prevalence of lateral tibial squatting facets and an increase in the number of metatarsal extensions in the late phase. This demonstrates a change in activity patterns between phases, possibly involving greater ankle and toe hyperdorsiflexion in the late phase.

7.3.3 Analysis of the temporal difference in non-pathological articular modifications for Islamic males and females: changing Islamic identity

For some articular modifications (osteochondritis and medial tibial squatting facet), the prevalence rate was so low, it prevented analysis of the data by sex and phase. Accordingly, osteochondritis imprints and medial tibial squatting facets were not analysed by phase and sex.

7.3.3.1 Analysis of temporal changes in female non-pathological articular modifications: changing female Islamic identity

There was no significant difference in the number of early females and late-phase females studied ($P=0.510$ $n=74$) (early females 32, late females 42).

Tibial imprints on the supracondylar surfaces of the femur

Table 7.3.17 Female tibial imprints early/late comparison and Fisher's exact test results.

Supracondylar surface	a	%a	e	%e	i	%i	p	%p	P value	N
Early left lateral	6	35.3	9	52.9	2	11.8	0	0.0	0.094	34
Late left lateral	12	66.7	5	27.7	1	5.6	0	0.0		
Early left medial	8	61.5	4	30.8	1	7.7	0	0.0	1.000	34
Late left medial	12	57.1	9	42.9	0	0.0	0	0.0		
Early right lateral	14	87.5	2	24.5	0	0.0	0	0.0	0.550	41
Late right lateral	24	95.8	0	0.00	0	0.0	1	4.2		
Early right medial	10	76.9	2	15.4	1	7.7	0	0.0	0.375	32
Late right medial	17	89.5	2	20.5	0	0.0	0	0.0		
Total	88	60.3	48	32.9	9	6.2	1	0.7	0.600	146

Key: a= absent, e= extension, i=imprint, p= pitting, N = number

Late female supracondylar surfaces had more tibial imprint modifications (early 35%, late 39%), but the difference was not significant ($P=0.600$ $n=146$). As many categories

contained 0, it was not possible to carry out chi-squared test. Table 7.3.17 displays the number of affected condyles and the types of modification present.

Left lateral: Early females had more tibial imprint modifications than late females on the left lateral supracondylar surface (64.8% early, 33.3% late), but the difference was not significant ($P=0.094$ $n=84$).

Left medial: On the left medial supracondylar surface, 66.3% of early females had a tibial imprint modification in comparison to 42.9% of late female surfaces. According to a Fisher's exact test however, this difference was not significant ($P=1.000$ $n=34$).

Right lateral: 4.2% of late right lateral supracondylar surfaces and 12% of early supracondylar surfaces had modifications. The difference was not significant ($P=0.545$ $n=41$).

Right medial: 39.5% of early right medial supracondylar surfaces had modifications in comparison to 10.5% of late supracondylar surfaces. This was not statistically significant ($P=0.375$ $n=32$).

Vastus notches on the patella

Table 7.3.18 Female vastus notch early/late comparison with Fisher's exact test results.

Vastus notch	1	%1	2	2%	a	%a	P value	N
Left early female	6	35.0	2	11.8	9	52.9	1.000	34
Left late female	5	29.5	3	17.6	9	52.9		
Right early female	7	43.8	3	18.8	6	37.4	0.018	39
Right late female	4	17.4	1	4.3	18	78.3		
Total	22	30.1	9	12.4	42	57.5	0.095	73

Key: 1= small, 2= Large, a= Absent.

Table 7.3.18 presents the number of patellae observed and the number with vastus notches. There was no difference in the number of vastus notches between the early- and late-phase females ($P=0.095$ $n=73$).

Left: Early and late females had the same prevalence of vastus notches (both 47.9%) ($P=1.000$ $n=34$). The difference in the sizes of vastus notches between phases was also not significant ($\chi^2=0.662$ $P=0.719$ 2df).

Right: Early females had a higher vastus notch prevalence than late females (early 62.4%, late 22.7%), and a Fisher's exact test indicated this difference was statistically

significant ($P=0.018$ $n=39$). Furthermore, the prevalence of each facet size varied between phases ($\chi^2=17.556$ $P\leq 0.001$ 2df).

Squatting facets on the lateral tibia

Table 7.3.19 Female lateral tibial squatting facet early/late comparison and Fisher's exact test results.

Tibia	1	1%	2	2%	3	3%	A	%A	P value	N
Early left	2	9.1	17	77.3	1	45.5	2	9.1	0.181	51
Late left	4	13.8	24	82.8	1	3.4	0	0		
Early right	1	5.6	13	72.2	1	5.6	3	16.7	0.044	49
Late right	5	16.1	25	80.6	1	3.3	0	0		
Total	12	12.0	79	79.0	4	4.0	5	5.0	≤ 0.001	100

Key: 1=small, 2=large, 3=extreme, extending on to tibial shaft, A=absent, n=number.

Table 7.3.19 presents the number of tibiae examined and prevalence of each size squatting facet observed. Early females had fewer tibial squatting facets than late females, where all women had facets. This difference was statistically significant ($P\leq 0.001$ $n=100$).

Left: A similar pattern was observed on the left tibiae. No female tibiae were without facets in the late phase, but 9.1% of early female tibiae lack a facet. This pattern was not significant ($P=0.181$ $n=51$).

Right: 16.7% of early females did not have a squatting facet on the right tibiae, whereas all females from the late phase had some form of facet. This difference was statistically significant ($P=0.044$ $n=49$).

Squatting facets on the talus

Table 7.3.20 Female talus squatting facets by side, phase and type with Fisher's exact test results.

Female	a	%a	c	%c	p	%p	P value	N
Right early female	1	4.3	13	56.5	9	39.1	0.418	55
Right late female	0	0.0	22	68.8	10	31.2		
Left early female	1	4.3	13	56.5	9	39.1	0.469	49
Left late female	0	0.0	22	84.6	4	15.4		
Total	2	1.9	70	67.3	32	30.8	0.176	104

Key: a = absent c= congenital, p= pressure

Table 7.3.20 presents the prevalence of each type of talus squatting facet. There were more talus squatting facets in late females, but the difference was small (2 individuals) and not significant ($P=0.176$ $n=104$).

Right: No late females were without a squatting facet, whereas 4.3% of early female tali did not have a facet. This difference was not statistically significant ($P=0.418$ $n=55$).

Left: No late females were without a squatting facet, whereas 4.3% of early female tali did not have a facet. This difference was not statistically significant ($P=0.469$ $n=49$).

It was possible, with talus squatting facets, to carry out a further Fisher's exact test by removing the absent category, and examining the ratio of congenital to pressure facets (see table 7.3.21). For the right talus, there was still no difference between the phases and the type of facets present (early: congenital 59.1%, pressure 40.9%, late: congenital 68.8%, pressure 31.2%) ($P=0.566$ $n=54$). On the left talus, the difference between phases for the prevalence of pressure and congenital facets was outside statistical significance but was worth noting (early: congenital 84.6%, pressure 15.4%. Late: congenital 59.1%, pressure 40.9%) ($P=0.059$ $n=48$).

Table 7.3.21 Female talus squatting facet early/late comparison Fisher's exact test results

C and P only*	P value	Number observable
Left	0.059	48
Right	0.566	54

*C=congenital, P=pressure

Extension to the distal metatarsal surface

There was no significant difference in the prevalence of metatarsal extensions between phases for females. As this was just outside the level of statistical significance ($P=0.088$ $n=301$), a trend for a greater number of metatarsal extension was noted in late females.

There was no significant difference in the prevalence of metatarsal extensions for each toe position between phases (table 7.3.22). The amount and position of metatarsal extensions did not change temporally for females.

Table 7.3.22 Female metatarsal extensions by phase and position with Fisher's exact scores

Metatarsal extensions	Early				Late				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	4	26.7	11	73.3	5	27.8	13	72.2	1.000	33
R1	7	41.2	10	58.8	4	19.0	17	81.0	0.167	38
L2	7	50.0	7	50.0	3	17.6	14	82.4	0.121	31
R2	5	29.4	12	70.6	8	36.4	14	65.6	0.740	39
L3	7	41.2	10	58.8	2	15.4	11	84.6	0.229	30
R3	5	31.3	11	68.7	4	20.0	16	80.0	0.470	36
L4	6	40.0	9	60.0	3	25.0	9	75.0	0.683	27
R4	4	28.6	10	71.4	8	38.1	13	61.9	0.721	35
L5	10	83.3	2	16.7	9	64.3	5	35.7	0.391	26
R5	10	71.4	4	28.6	14	66.7	7	33.3	1.000	35
Total	65	43.0	86	57.0	60	33.5	119	66.5	0.088	301

Key: L = left, R = right, A = absent, P = present, N = number

Wedging to the proximal surface of the proximal phalanges

There was no difference in the prevalence of phalangeal wedging between early and late females ($P=0.705$ $n=256$). There was no difference in the prevalence of wedged phalanges at the equivalent left and right toe positions (table 7.3.23).

Table 7.3.23 Early versus late female phalangeal wedging prevalence and Fisher's exact results.

Female phalanx position and side	Early				Late				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	2	14.3	12	85.7	3	16.7	15	83.3	1.000	34
R1	2	14.3	12	85.7	2	10.5	17	89.5	1.000	33
L2	6	60.0	4	40.0	6	42.9	8	57.1	0.680	24
R2	4	33.3	8	66.7	7	38.9	11	61.1	1.000	29
L3	3	42.9	4	57.1	6	50.0	6	50.0	1.000	19
R3	7	63.6	4	36.4	5	55.6	4	44.4	1.000	20
L4	6	50.0	6	50.0	9	69.2	4	30.8	0.428	25
R4	6	60.0	4	40.0	10	62.5	6	37.5	1.000	26
L5	6	85.7	1	14.3	13	92.8	1	7.2	1.000	21
R5	9	75.0	3	25.0	12	85.7	2	4.3	0.635	26
Total	51	46.8	58	53.2	73	49.7	74	50.3	0.705	256

Key: L = Left, R = right, A = absent, P = present, N = number

Summary: Early/late female ARSM comparison

There were statistical differences between early and late females for the right lateral tibial squatting facet, and the overall presence and size of the right vastus notch. The

presence of metatarsal extensions exhibited a temporal trend for being more frequent in late females. This trend was also observed for the left talus, where congenital squatting facet was more in late females. This change coincided with a decrease in the number of pressure facets in late females. This indicates changes in female patterns of posture adoption over time.

7.3.3.2 Analysis of temporal changes in male non-pathological articular modifications: changing male Islamic identity

Statistically there was no difference in the number of early and late males ($P=0.768$ $n=92$) used in this analysis (43 early males, 49 late males). It was not possible to examine osteochondritis or medial tibial squatting facets.

Tibial imprints on the supracondylar surfaces of the femur

Table 7.3.24 Early versus late tibial imprint comparison and Fisher's exact scores

Male	A	%A	E	%E	I	%I	P	%P	P value	N
Early Left Lateral	13	56.5	7	30.4	2	8.7	1	4.4	0.153	50
Late Left Lateral	9	33.3	15	55.6	2	7.4	1	3.7		
Early Left Medial	12	66.7	4	22.2	2	1.1	0	0.0	0.541	43
Late Left Medial	14	56.0	6	24.0	3	12.0	2	8.0		
Early Right Lateral	25	92.6	1	3.7	1	3.7	0	0.0	1.000	60
Late Right Lateral	31	93.9	2	6.1	0	0.0	0	0.0		
Early Right Medial	14	93.3	1	6.7	0	0.0	0	0.0	1.000	43
Late Right Medial	22	88.0	3	12.0	0	0.0	0	0.0		
Total	140	71.1	39	19.8	10	5.1	4	2.0	0.255	193

Key: A=absent, E=extension, I=imprint, P=pitting. 3df for χ^2 tests

Fewer early male supracondylar surfaces had modifications in comparison to late supracondylar surfaces (early 22.9%, late 30.9%), but this difference was not statistically significant ($P=0.255$ $n=193$). Table 7.3.24 presents the types of tibial imprints and prevalence on each supracondylar surface.

Left lateral: Early males had fewer modifications than late males on the left lateral supracondylar surface (early 45.5%, late 66.7%), but the difference was not significant ($P=0.153$ $n=50$).

Left medial: Late males had more left medial tibial imprint modifications than early males (early 33.3%, late 44%), but this difference was not statistically significant ($P=0.541$ $n=43$).

Right lateral: The prevalence of tibial imprint modifications was similar between phases on the right lateral supracondylar surface (early 6.1%, late 7.4%), and the difference was not significant ($P=1.000$ $n=60$).

Right lateral: 12% of late right lateral condyles had tibial imprint modifications in comparison to 6.7% of early supracondylar surfaces. This was not significantly different ($P=1.000$ $n=40$).

Vastus notches on the patellae

Table 7.3.25 Male vastus notches by phase, type and chi-squared test values

Phase and side	1	1%	2	2%	a	%a	χ^2	P Value	N
Left early male	8	33.3	4	16.7	12	50.0	12.783	≤0.002	52
Left late male	14	50.0	1	3.6	13	46.4			
Right early male	9	34.6	1	3.8	16	61.6	5.363	0.069	50
Right late male	9	37.5	3	12.5	12	50.0			
Total	40	39.2	9	8.8	53	52.0			102

Key: 1= small, 2= Large, A = Absent.

Table 7.3.25 displays the prevalence and size of vastus notches in males. There was no difference in the overall appearance of vastus notches between phases for males (early 44%, late 48.1%) ($P=0.436$ $n=102$).

Left: 50% of early males had left vastus notches in comparison to 53.4% of late males. The difference was not significant ($P=1.000$ $n=52$). According to a chi-squared test, the size of the notch did differ between phases ($\chi^2=12.738$ $P\leq 0.002$ 2df), with fewer large notches on the left patella in the late phase (early 16.7%, late 3.6%).

Right: On the right patella, 38.4% of early males and 50% of late males had a vastus notch. The difference was not statistically significant ($P=0.569$ $n=50$). Furthermore, the prevalence of each size of vastus notch did not vary, and was outside statistical significance ($\chi^2=5.636$ $P=0.069$ 2df), but a trend for increasing prevalence of large notches on the right patellae can be observed (early 3.8%, late 12.5%).

Lateral tibial squatting facet

Table 7.3.26 Male lateral tibial squatting facets by side, phase and type with Fisher's exact scores

Phase and side	1	1%	2	2%	3	3%	A	%A	P value	N
Early left	3	14.3	15	71.4	0	0.0	3	14.2	0.064	51
Late left	9	30.0	20	66.7	1	3.3	0	0.0		
Early right	4	14.8	22	81.5	0	0.0	1	3.7	0.371	61
Late right	12	35.4	17	50.0	1	2.9	4	11.7		
Total	28	25.0	74	66.1	2	1.8	8	7.1		112

Key: 1 = small, 2=large, 3=extreme, extending on to tibial shaft, A= absent

Table 7.3.26 presents the prevalence of each size of lateral tibial squatting facets. 91.7% of early tibiae and 93.7% of late tibiae had tibial squatting facets, but the difference was not statistically significant ($P=0.723$ $n=112$). It was not possible to use chi-squared tests due to the low numbers of extreme facets and absent categories. It was possible, however, to compare the prevalence of large and small facets between phases using a Fisher's exact test.

Left: On the left tibia, 85.7% of early males had a tibial squatting facet, in comparison to 100% of late males. This difference was not statistically significant ($P=0.064$ $n=51$) but was an interesting increasing trend. The difference in the prevalence of large and small facets between phases was not significant ($P=0.324$ $n=47$).

Right: Although 96.3% of early right tibiae had facets and only 88.2% of late tibiae had facets, the prevalence difference was not significant ($P=0.371$ $n=61$). The prevalence of large and small facets was significantly different between phases ($P=0.042$ $n=55$). Temporally, there was a 34.6% decrease in prevalence of large facets and a 20.6% increase in small facets.

Talus squatting facets

Table 7.3.27 presents the prevalence and type of talus squatting facets. There was no difference in the prevalence of male talus squatting facets between phases ($P=1.000$ $n=122$).

Right: 91.7% of early right tali and 92.6% of late right tali had squatting facets, but the difference was not statistically significant ($P=1.000$ $n=63$). The type of facet appeared to vary between early and late males and the difference was just outside significance

($\chi^2=5.852$ $P=0.054$ 2df). This will be taken to imply a trend of increasing prevalence of pressure facets and a decrease in the prevalence of congenital facets in late males.

However, when examining only the prevalence of congenital and pressure facets, there was no statistical difference in prevalence between phases ($P=0.185$ $n=58$).

Left: 94.5% of early male left tali had a squatting facet in comparison to 95.5% of late male tali. The prevalence difference was not significant ($P=1.000$ $n=59$). Furthermore, there was no difference in the prevalence of each type of facet on the left tali ($\chi^2=0.707$ $P=0.702$ 2df).

Table 7.3.27 Male talus squatting facets by type, phase with chi-squared and Fisher's exact scores.

Male	a	%a	c	%c	p	%p	χ^2	P value	N
Right early male	2	7.4	15	55.6	10	37.0	5.852	0.054	63
Right late male	3	8.3	13	36.1	20	55.6			
Left early male	1	4.5	12	55.5	9	40.0	0.707	0.702	59
Left late male	2	5.4	18	48.6	17	46.0			
Total	8	6.6	58	47.5	56	45.9		1.000	122

Key: a = absent c= congenital, p= pressure

Metatarsal extensions

Table 7.3.28 Male metatarsal extensions by phase and position with Fisher's exact scores.

Metatarsal	Early				Late				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	4	19.0	17	81.0	5	26.3	14	73.7	0.712	40
R1	4	21.1	15	78.9	2	10.5	17	89.5	0.690	38
L2	12	60.0	8	40.0	9	47.4	10	52.6	0.527	39
R2	7	41.2	10	58.8	10	47.6	11	52.4	0.750	38
L3	6	42.9	5	57.1	8	47.1	9	52.9	1.000	28
R3	8	40.0	12	60.0	9	47.4	10	52.6	0.751	39
L4	6	40.0	9	60.0	7	36.8	11	64.2	1.000	33
R4	14	60.9	9	30.1	9	45.0	11	55.0	0.366	43
L5	13	76.5	4	25.5	5	25.0	15	75.0	0.003	37
R5	15	88.3	2	11.7	12	63.2	7	36.8	0.128	36
Total	89	49.4	91	50.6	76	39.8	115	60.2	0.076	371

Key: L= left, R=right, A=absent, P=present, N=number

Table 7.3.28 presents the prevalence of metatarsal extensions. There was no temporal change in the prevalence of metatarsal extensions observed in males ($P=0.076$ $n=371$), but an increasing trend in extensions was observed.

The only metatarsal position that showed any statistically significant difference in extension prevalence over time was that of the left 5th metatarsal. An increase of 49.5% was observed in the late phase, which may indicate a change in the use of the left foot ($P=0.003$ $n=36$).

Wedging to the proximal surface of the proximal phalanges

Table 7.3.29 Male phalangeal wedging by phase and position with Fisher's exact scores.

Phalanx position and side	Early				Late				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	3	15.8	16	84.2	1	6.3	15	93.7	0.608	35
R1	2	11.1	16	88.9	1	6.3	15	93.7	1.000	34
L2	8	53.3	7	46.7	7	38.9	11	61.1	0.494	33
R2	10	52.6	9	47.4	3	18.8	13	81.2	0.078	35
L3	8	53.3	7	46.7	4	44.4	5	55.6	1.000	24
R3	10	52.6	9	47.4	9	64.3	5	35.7	0.723	33
L4	8	57.1	6	42.9	6	50.0	6	50.0	1.000	26
R4	10	55.6	8	44.4	9	69.2	4	30.8	0.484	31
L5	10	76.9	3	23.1	13	100	0	0.0	0.220	26
R5	13	86.7	2	13.3	9	69.2	4	30.8	0.372	28
Total	82	49.7	83	50.3	62	44.3	78	55.7	0.359	305

Key: L= left, R= Right, A = absent, P = present, N= number

Overall, there was no statistically significant difference in number of phalanges with wedging between phases ($P=0.359$ $n=305$). When considering each toe position, none differed statistically between phases for the prevalence of wedging over time (table 7.3.39 for P values).

Summary: Early/late male ARSM comparison

Statistically significant differences for males have been demonstrated for the left vastus notch, where there was a temporal increase in notch prevalence, but the size of the notch decreased. On the right side, there was also a trend for increasing prevalence for vastus notches, and an increase in notch size over time. The right tibiae exhibited a temporal decrease in large lateral tibial squatting facets. Temporally, the left tibiae have a similar trend. The most common type of squatting facets on the right tali changed from

congenital type facets to pressure facets. Finally, extensions to the left fifth metatarsal were more prevalent in the late phase than the early phase. Overall males have more differences between phases than the females. This demonstrates potentially that there were more changes to male activity/roles over time.

7.3.4 Analysis of temporal changes in sex difference in non-pathological articular modifications: temporal analysis of changing gender ideology

As the number of observations for osteochondritic imprints and medial tibial squatting facets were so low, it was not possible to undertake any statistical analysis of temporal changes in prevalence.

Tibial imprints on the supracondylar surfaces of the femur

It was not possible to carry out any chi-squared tests for tibial imprints due to the number of categories that contained 0 observations. The following tables present the prevalence of modifications of each femoral condyle by sex.

Table 7.3.30 Left lateral tibial imprints by type, phase and sex with Fisher's exact scores.

Supracondylar surface	a	%a	e	%e	i	%i	p	%p	P value	N
Male early left lateral	13	56.5	7	30.4	2	8.7	1	4.4	0.216	40
Female early left lateral	6	35.3	9	52.9	2	11.8	0	0.0		
Male late left lateral	9	33.3	15	55.6	2	7.4	1	3.7	0.037	45
Female late left lateral	12	66.7	5	27.7	1	5.6	0	0.0		
Total	40	47.1	36	42.4	7	8.2	2	2.3		85

Key: a= absent, e = extension, i = imprint, p= pitting.

Left lateral: Despite early females having a higher prevalence of imprint modifications on the left lateral condyle than early males (female 64.7%, males 45.5%), there was no significant difference between the early phase sexes ($P=0.216$ $n=40$) (table 7.3.30). For the late individuals, 33.3% of left lateral female supracondylar surfaces had imprint modifications and males 66.7%. This was significant ($P=0.037$ $n=45$) and demonstrates a change in sex difference over time.

Table 7.3.31 Left medial tibial imprints by type, phase and sex with Fisher's exact scores.

Supracondylar surface	a	%a	e	%e	i	%i	p	%p	P value	N
Male early left medial	12	66.7	4	22.2	2	11.1	0	0.0	1.000	31
Female early left medial	8	61.5	4	30.8	1	7.7	0	0.0		
Male late left medial	14	56.0	6	24.0	3	12.0	2	8.0	1.000	46
Female late left medial	12	57.1	9	42.9	0	0.0	0	0.0		
Total	46	59.7	23	29.9	6	7.8	2	2.6		77

Key: a=absent, e=extension, i=imprint, p=pitting.

Left medial: Early males and females had a similar prevalence of tibial imprint modifications on the left medial supracondylar surface (males 38.5%, females 33.3%) and the difference was statistically insignificant ($P=1.000$ $n=31$) (table 7.3.31). This was also the case for the late left medial supracondylar surface where male and female prevalence rates are similar (males 44% females 42.9%) ($P=1.000$ $n=46$).

Table 7.3.32 Right lateral tibial imprints by type, phase and sex with Fisher's exact scores.

Supracondylar surface	a	%a	e	%e	i	%i	p	%p	P value	N
Male early right lateral	25	92.6	1	3.7	1	3.7	0	0.0	0.621	43
Female early right lateral	14	87.5	2	24.5	0	0	0	0.0		
Male late right lateral	31	93.9	2	6.1	0	0	0	0.0	1.000	58
Female late right lateral	24	95.8	0	0.0	0	0	1	4.2		
Total	79	76.7	20	19.4	3	2.9	1	1		101

Key: a=absent, e=extension, i=imprint, p=pitting.

Right lateral: Early male and female right lateral tibial imprint modification prevalence rate differed by 5.1% (females 7.4% males 12.5%). This was not significant ($P=0.621$ $n=43$) (table 7.3.32). Late males and females modification prevalence differed by 1.9% (females 4.2% males 6.1%) which was also not significant ($P=1.000$ $n=101$).

Table 7.3.33 Right medial tibial imprints by type, phase and sex with Fisher's exact scores.

Supracondylar surface	a	%a	e	%e	i	%i	p	%p	P value	N
Male early right medial	14	93.3	1	6.7	0	0.0	0	0.0	0.311	28
Female early right medial	10	76.9	2	15.4	1	7.7	0	0.0		
Male late right medial	22	88.0	3	12.0	0	0.0	0	0.0	1.000	44
Female late right medial	17	89.5	2	20.5	0	0.0	0	0.0		
Total	63	87.5	8	11.1	1	1.4	0	0		72

Key: a= absent, e = extension, i = imprint, p= pitting.

Right medial: Early males and females differ by 23.6% for the presence of tibial imprint modifications on the right medial supracondylar surface (males 6.7%, females 23.1%) (table 7.3.33). This however was not statistically significant ($P=0.311$ $n=28$). The late phase sexes also differed little in terms of tibial imprint prevalence (females 10.5%, males 12%), and were not statistically different ($P=1.000$ $n=44$).

Vastus notches on the patella

Table 7.3.34 Left vastus notch by phase and sex and chi-squared scores

Side, phase, sex	1	%1	2	%2	A	%A	χ^2	P value	Total
Left early female	6	35.3	2	11.8	9	52.9	0.546	0.761	41
Left early male	8	33.3	4	16.7	12	50.0			
Left late female	5	29.4	3	17.7	9	52.9	10.916	0.004	45
Left late male	14	50.0	1	3.6	13	46.4			
Total	33	38.4	10	11.6	43	50			86

Key: 1=small, 2=large, A=absent.

Left: Early males and females differed little in the overall prevalence of the left vastus notch (female 47.1% males 50%) and were not statistically different ($P=1.000$ $n=41$) (table 7.3.34). Furthermore, the prevalence of large, small and absent notches was not statistically different between early sexes ($\chi^2=0.546$ $P=0.761$ 2df).

Late males and females also had similar prevalence rates for the left vastus notch (females 47.1%, male 53.6%), which were not significantly different ($P=0.763$ $n=45$) (table 7.3.34). However, when comparing the sizes of notches, a chi-squared test indicated a sex difference in the patterns of notch size exists, with females having more large notches than males ($\chi^2=10.916$ $P=0.004$ 2df). This represents a change in the sex difference for the size of the left vastus notch over time.

Table 7.3.35 Right vastus notch by phase, sex and type

Side, phase, sex	1	%1	2	%2	A	%A	χ^2	P value	Total
Right early female	7	43.8	3	18.8	6	37.5	10.93	0.004	42
Right early male	9	34.6	1	3.9	16	61.5			
Right late female	4	17.4	1	4.3	18	78.3	11.78	0.003	47
Right late male	9	37.5	3	12.5	12	50.0			
Total	29	32.6	8	9.0	52	58.4			89

Key: 1=Small, 2=Large, A=Absent.

Right: According to table 7.3.35, the right vastus notch was observed in more early females than early males (females 62.5%, males 38.5%), but the difference was not

significant ($P=0.204$ $n=42$). Females statistically have more large and small notches than males ($\chi^2=10.93$ $P=0.004$ $n=42$). In the late phase, greater differences were observed. Females had fewer notches, and male vastus-notch prevalence increased temporally (females 21.7%, males 50%). This difference was just outside significance ($P=0.069$ $n=47$), but indicated a sex bias in the appearance of the right vastus notch in the late phase. In addition, like the early phase, a difference in the size of facet experienced by the sexes was observed, with males having more small and large facets than females (in reverse to the left patella) ($\chi^2=10.916$ $P=0.003$ $n=47$).

Lateral tibial squatting facets

Table 7.3.36 Left lateral tibial squatting facets by phase, sex and type and Fisher's exact scores.

Femoral condyle	1	1%	2	2%	3	3%	A	%A	P value	Total
Male early left	3	14.3	15	71.4	0	0.0	3	14.8	0.664	43
Female early left	2	9.1	17	77.3	1	4.5	2	9.1		
Male late left	9	30.0	20	66.7	1	3.3	0	0.0	1.000	59
Female late left	4	13.8	24	82.8	1	3.4	0	0.0		
Total	18	17.7	76	74.5	3	2.9	5	4.9		102

Key: 1 = small, 2=large, 3=extreme, extending on to tibial shaft, A= absent. NB χ^2 not possible due to '0' observations

Left: According to table 7.3.36, early males and females had a similar prevalence rate of left lateral tibial squatting facet (female 90.9%, male 85.2%), and the difference between sexes was not statistically significant ($P=0.664$ $n=43$). When considering the prevalence rates for large and small facets, there was no difference between early males and females ($P=1.000$ $n=37$). In the late phase, females have more large facets than males, but there was still no difference in the overall prevalence between sexes ($P=1.000$ $n=59$). When examining just the prevalence of small and large facets, there was no statistically significant difference between the late-phase sexes ($P=0.207$ $n=57$).

Table 7.3.37 Right lateral tibial squatting facets by phase, sex and type with Fisher's exact scores.

Femoral condyle	1	1%	2	2%	3	3%	A	%A	P value	Total
Male early right	4	14.8	22	81.5	0	0	1	3.7	0.286	45
Female early right	1	5.6	13	72.2	1	5.6	3	16.6		
Male late right	12	35.3	17	50.0	1	2.9	4	8.8	0.115	65
Female late right	5	16.1	25	80.6	1	3.3	0	0.0		
Total	22	20.0	77	70.0	3	2.7	8	7.3		110

Key: 1 = small, 2=large, 3=extreme, extending on to tibial shaft, A= absent. NB χ^2 not possible due to '0' observations.

Right: In the early phase, males had a higher prevalence rate of right tibial squatting facets than females (males 96.3%, females 83.4%), but the difference was not statistically significant (table 7.3.37). When comparing the prevalence of large and small facets, there was no statistical difference between early-phase sexes ($P=0.640$ $n=40$). In the late phase, all females had facets in comparison to 91.2% of males. This difference was not statistically significant. However, when examining just small and large facets, the prevalence difference was significant ($P=0.047$ $n=59$), with females having larger right tibial squatting facets than males in the late phase. This demonstrates an increase in sex differences in the late phase.

Talus squatting facets

Table 7.3.38 Left talus squatting facets by sex, phase and type and Fisher's exact scores.

Talus	absent	%A	congenital	%C	pressure	%P	P value	Total
Left early female	1	4.4	13	56.5	9	39.1	1.000	45
Left early male	1	4.5	12	54.5	9	41.0		
Left late female	0	0.0	22	84.6	4	15.4	0.507	63
Left late male	2	5.4	18	48.6	17	45.9		
Total	4	3.7	65	60.2	39	36.1		108

Key: a=absent, c=congenital, p= pressure, NB χ^2 not possible due to '0' observations

Left: There was no difference in the prevalence of left talus squatting facets between early males and females ($P=1.000$ $n=45$) (table 7.3.38). When considering prevalence of the congenital and pressure facets on the early left talus, there was still no difference between sexes ($P=1.000$, $n=47$).

There was also no difference in the types of facets on the left talus in the late phase ($P=0.507$ $n=63$). However, when considering only the pressure and congenital facets in the late individuals, the difference was statistically significant ($P=0.025$ $n=65$). This demonstrates that a sex difference appeared in the late phase for the type of facet present (see table 7.3.38).

Table 7.3.39 Right talus squatting facets by sex, phase and type and Fisher's exact scores.

Talus	A	%A	C	%C	P	%P	P value	Total
Right early female	1	4.4	13	56.5	9	39.1	1.000	50
Right early male	2	7.4	15	55.6	10	37.0		
Right late female	0	0.0	22	68.8	10	31.2	0.241	65
Right late male	3	9.1	13	39.4	20	60.6		
Total	6	5.1	63	53.4	49	41.5		118

Key: A= absent, C=congenital, P=pressure. NB χ^2 not possible due to '0' observations.

Right: In the early phase, male and female talus squatting facet prevalence did not differ (males 92.6%, females 95.6%) ($P=1.000$ $n=50$) (table 7.3.39). When considering pressure and congenital facets alone, there was still no difference between the sexes ($P=1.000$ $n=47$).

In the late phase, there was very little difference in the overall prevalence of the talus squatting facet (males 90.9%, females 100%), and no significant difference existed ($P=0.241$ $n=65$) (table 7.3.39). However, when considering the prevalence of congenital and pressure facets, there was a distinct difference between men and women, with females having more congenital facets and males having more pressure facets (table 7.3.40). This difference was significant and demonstrates, like the left talus, that there was a sexed difference in the type of facets in the late phase ($P=0.013$ $n=61$).

Table 7.3.40 Talus squatting facets prevalence of congenital and pressure types

	Early	N	Late	N
Left	$P=1.000$	47	$P=0.025$	65
Right	$P=1.000$	43	$P=0.013$	61

Key: N= number

Extensions to the distal metatarsal surface

According to table 7.3.41, there were no statistically significant differences between the early sexes for the overall appearance of metatarsal extensions ($P=0.269$ $n=331$). Furthermore, at individual metatarsal locations, there was no difference in the prevalence of extensions between early males and females (table 7.3.41).

Table 7.3.41 Early metatarsal extensions by sex with Fisher's exact scores.

Metatarsal position	Male early				Female early				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	4	19.0	17	81.0	4	26.7	11	73.3	0.694	36
R1	4	21.1	15	78.9	7	41.2	10	58.8	0.281	36
L2	12	60.0	8	40.0	7	50.0	7	50.0	0.728	34
R2	7	41.2	10	58.8	5	29.4	12	70.6	0.721	34
L3	6	54.5	5	45.5	7	41.1	10	58.9	0.700	28
R3	8	66.7	12	33.3	5	31.3	11	68.7	0.731	36
L4	6	40.0	9	60.0	6	40.0	9	60.0	1.000	30
R4	14	60.9	9	39.1	4	28.6	10	71.4	0.091	37
L5	13	76.5	4	23.5	10	83.3	2	16.7	1.000	29
R5	15	88.2	2	11.8	10	71.4	4	28.6	0.370	31
Total	89	49.4	91	50.6	65	43.0	86	57.0	0.269	331

Key: L=left, R=right, A=absent, P=present, N=number

Table 7.3.42 indicates that the overall prevalence of late metatarsal extensions did not differ significantly between sexes ($P=0.236$ $n=370$). In terms of individual metatarsal locations, only the prevalence of extensions on left 5th metatarsal differed significantly between men and women ($P=0.035$ $n=34$), although the 2nd left metatarsal ($P=0.083$ $n=36$) and the right 3rd metatarsal ($P=0.096$ $n=39$) were close to significance. A trend can be seen for females to have more metatarsal extensions than males in the late phase, unlike the early phase.

Table 7.3.42 Late metatarsal extension by sex and Fisher's exact scores.

Metatarsal position	Male late				Female late				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	5	26.3	14	79.7	5	27.8	13	72.2	1.000	37
R1	2	10.5	17	89.5	4	19.0	17	81.0	0.664	40
L2	9	47.4	10	52.6	3	17.6	14	82.4	0.083	36
R2	10	47.6	11	52.4	8	36.4	14	63.6	0.543	43
L3	8	47.1	9	52.9	2	15.4	11	84.6	0.119	30
R3	9	47.4	10	52.6	4	20.0	16	80.0	0.096	39
L4	7	38.9	11	61.1	3	25.0	9	75.0	0.694	30
R4	9	45.0	11	55.0	8	38.1	13	71.9	0.756	41
L5	5	25.0	15	75.0	9	64.3	5	35.7	0.035	34
R5	12	63.2	7	36.8	14	66.7	7	33.3	1.000	40
Total	76	39.8	115	60.2	60	33.5	119	66.5	0.236	370

Key: L = left, R = right, A = absent, P = present, N= number

Wedging to the proximal surface of the proximal phalanges

Table 7.3.43 Early phalangeal wedging by sex with Fisher's exact scores

Phalanx position and side	Early male				Early female				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	3	15.8	16	84.2	2	14.3	12	85.7	1.000	33
R1	2	11.1	16	88.9	2	14.3	12	85.7	1.000	32
L2	8	53.3	7	46.7	6	60.0	4	40.0	1.000	25
R2	10	52.6	9	47.4	4	33.3	8	66.7	0.461	31
L3	8	53.3	7	46.7	3	42.9	4	57.1	1.000	22
R3	10	52.6	9	47.4	7	63.6	4	36.4	0.708	30
L4	8	57.1	6	42.9	6	50.0	6	50.0	1.000	26
R4	10	55.6	8	44.4	6	60.0	4	40.0	1.000	28
L5	10	76.9	3	23.1	6	85.7	1	14.3	1.000	20
R5	13	86.7	2	13.3	9	75.0	3	25.0	0.628	27
Total	82	49.7	83	50.3	51	46.8	58	53.2	0.711	274

Key: L=left, R=right, A=absent, P=present, N=number

The overall prevalence of wedged phalanges did not differ between men and women of the early phase ($P=0.711$ $n=274$). Furthermore, there was no difference in the prevalence of wedged phalanges at each individual toe position between sexes (table 7.3.43).

Table 7.3.44 Late phalangeal wedging by sex with Fisher's exact scores

Phalanx position and side	Late male				Late female				P value	N
	A	%A	P	%P	A	%A	P	%P		
L1	1	6.3	15	93.7	3	16.7	15	83.3	0.604	34
R1	1	6.3	15	93.7	2	10.5	17	89.5	1.000	35
L2	7	38.9	11	61.1	6	42.9	8	57.1	1.000	32
R2	3	18.8	13	81.2	7	38.9	11	61.1	0.270	34
L3	4	44.4	5	55.6	6	50.0	6	50.0	1.000	21
R3	9	64.3	5	35.7	5	55.6	4	44.4	1.000	23
L4	6	50.0	6	50.0	9	69.2	4	30.8	0.428	25
R4	9	69.2	4	30.8	10	62.5	6	37.5	1.000	29
L5	13	100.0	0	0.0	13	92.8	1	7.2	1.000	27
R5	9	69.2	4	30.8	12	85.7	2	4.3	0.384	27
Total	62	44.3	78	55.7	73	49.7	74	50.3	0.408	287

Key: L=left, R=right, A=absent, P=present, N=number

The overall prevalence of wedged phalanges did not differ between men and women of the late phase ($P=0.408$ $n=287$). Furthermore, there was no difference in the prevalence of wedging for individual toe positions between sexes in the late phase (table 7.3.44 for

P values). There was therefore no change in gender division for this modification overtime.

Summary: Comparison of gender division between Islamic phases

Many sex differences in non-pathological articular modifications exist between males and females. Interestingly, all but one of the significant differences appears in the late phase, inferring more sex differences, and therefore greater gender division in the late phase. The only statistically significant result from the early phase was prevalence of the right vastus notch. However, the same trend was observed in the late phase, and produced an even more statistically significant result, implying a stronger relationship with sex than the early phase results.

In the late phase, there were differences in the overall prevalence of left lateral tibial imprints, where males had more modifications than females. The size of vastus notches exhibited by men and women varied on the left and right patellae in the late phase. Females have larger squatting facets than men on the right tibia. The proportions of congenital to pressure facets on the tali vary between the sexes in the late phase. Finally a trend was seen in the prevalence of metatarsal extensions in the late phase, where females have more extensions on three metatarsals than men.

7.3.5 Analysis of sex differences in non-pathological articular modifications between Visigothic males and females: analysis of Visigothic gender division

Forty three female and 49 males Visigoths were examined. The number of males and females in the sample was not statistically different ($P=0.728$ $n=92$).

Osteochondritis modifications on the femoral condyles

11.9% of female femoral condyles had osteochondritis modifications, in comparison to 8.2% of male condyles (table 7.3.45). There was no difference in osteochondritis prevalence between sexes ($P=0.660$ $n=185$). Due to the low prevalence of modifications, it was not possible to carry out chi-squared tests to assess whether sexes differ in types of osteochondritic modifications on individual condyles.

Table 7.3.45 Osteochondritis modifications by sex, type and position.

Femoral condyle	A	%A	F	%F	I	%I	NBG	%NBG	Total
Male Left medial condyle	12	92.3	0	0.0	0	0.0	1	7.7	13
Female Left medial condyle	10	9.1	0	0.0	0	0.0	1	9.1	11
Male Left lateral condyle	8	72.7	1	9.1	0	0.0	2	18.2	11
Female Left lateral condyle	9	90.0	0	0.0	0	0.0	1	10.0	10
Male Right medial condyle	17	100.0	0	0.0	0	0.0	0	0.0	17
Female Right medial condyle	13	92.9	0	0.0	1	7.1	0	0.0	14
Male Right lateral condyle	8	100.0	0	0.0	0	0.0	0	0.0	8
Female Right lateral condyle	5	71.4	0	0.0	1	14.3	1	14.3	7
Total	82	90.1	1	1.1	2	2.2	6	6.6	91

Key: A=absent, F=facet, I=imprint, NBG=new bone growth

Tibial imprints on the supracondylar surfaces of the femur

Table 7.3.46 Tibial imprints by sex, side, position and type with chi-squared results and scores.

Supracondylar surface	a	%a	e	%e	i	%i	χ^2	P value	Total
Male Left medial condyle	11	50.0	5	22.7	6	27.3	3.259	0.196	22
Female Left medial condyle	7	43.8	2	12.5	7	43.8			16
Male Left lateral condyle	14	73.7	5	26.3	0	0.0	3.592	0.166	19
Female Left lateral condyle	7	53.8	5	38.5	1	7.7			13
Male Right medial condyle	7	38.9	4	22.2	7	38.9	0.445	0.799	18
Female Right medial condyle	5	33.3	3	20.0	7	46.7			15
Male Right lateral condyle	14	100.0	0	0.0	0	0.0	-	-	14
Female Right lateral condyle	5	71.4	1	14.3	1	14.3			7
Total	70	56.3	25	20.2	29	23.3			124

Key: a=absent, e extension, i=imprint, χ^2 =chi squared value.

Although females had a higher prevalence of tibial imprints than males (52.9% female and 37% male) (table 7.3.46), this difference was not statistically significant ($P=0.098$ $n=124$).

Left medial: Females had more modifications on the left medial supracondylar surface than males (female 56.2%, and males 50%), but the difference was not statistically significant ($P=0.138$ $n=48$). Females had a higher prevalence of extensions (female 22.7%, male 12.5%), and a lower prevalence of imprints (female 27.3%, male 43.8%) than males. The difference in the types of modification was not statistically different between the sexes ($\chi^2=3.259$ $P=0.196$ 2df).

Left lateral: Females had more modifications than males (females 46.2%, male 26.3%), but the difference was not statistically significant ($P=0.283$ $n=32$). Females had more extensions than males (females 38.5%, males 26.3%) and more imprints (but this differed by a single individual). The prevalence variations in modification types on the left lateral supracondylar surfaces was, however, not statistically significant ($\chi^2=3.592$ $P=0.166$ 2df).

Right medial: 67.7% of female condyles and 61.9% of male supracondylar surfaces had tibial imprint modifications. The difference was not statistically significant ($P=1.000$ $n=33$). Males had a higher prevalence of extensions (male 22.2%, females 20%), but females had a higher prevalence of imprints (males 38.9%, females 46.7%). When comparing the prevalence of modification types between sexes, there was no difference ($\chi^2=0.448$ $P=0.799$ 2df).

Right lateral: 28.6% of female condyles had a tibial imprint modification, however, no male right lateral supracondylar surfaces were affected. The difference was not statistically different ($P=1.000$ $n=21$).

Vastus notches on the patella

Table 7.3.47 Vastus notch prevalence by sex, side and type with chi-squared results and scores

Patella	a	%a	1	1%	2	2%	χ^2	P value	Total
Male left	7	50.0	4	28.6	3	21.4	2.497	0.287	14
Female left	6	66.7	3	33.3	0	0.0			9
Male right	6	50.0	3	25.0	3	25.0	1.121	0.571	12
Female right	4	66.7	2	33.3	1	16.7			7
Total	23	54.8	12	28.6	7	16.7			42

Key: a=absent, 1=small, 2=large, χ^2 =chi squared value.

Sixteen female and 26 male patellae were observable (table 7.3.47). Females had a lower prevalence of vastus notches than males (female 31.3%, males 50%), but this difference was not significant ($P=0.530$ $n=42$).

Left: Females had a lower prevalence of left vastus notches than males. The difference in the size of the vastus notches between the sexes was not significant ($\chi^2=2.497$ $P=0.287$ 2df).

Right: Females had a lower prevalence of right vastus notches than males. The difference in the size of the vastus notches between the sexes was not significant ($\chi^2=1.121$ $P=0.571$ 2df).

Medial tibial squatting facets

Table 7.3.48 Medial tibial squatting facets prevalence and Fisher's exact scores

Tibia	A	%A	P	%P	P value	Total
Male Left	5	83.3	1	16.7	1.000	6
Female Left	3	100.0	0	0.0		3
Male Right	10	100.0	0	0.0	1.000	10
Female right	7	100.0	0	0.0		7
Total	25	96.2	1	3.8		26

Key: A=absent, P=present.

Just one tibia had a medial squatting facet (table 7.3.48).

Left: The frequency of the medial squatting facets was low with just 1 of 16 (6.3%) male individuals having the facet. There was no difference between the sexes ($P=0.100$ $n=9$).

Right: No females had a facet, and just one male tibia (16.7%) scored positive for the trait. The frequency of medial squatting facet was low and not different between the sexes ($P=0.100$ $n=17$).

Lateral tibial squatting facets

Table 7.3.49 Lateral tibial squatting facets by side, type and sex with chi-squared result and score.

Tibia	a	%a	1	1%	2	2%	3	3%	χ^2	P value	Total
Male Left	3	30.0	3	30.0	4	40.0	0	0.0	38.607	≤0.001	10
Female Left	2	16.7	1	8.3	9	75.0	0	0.0			12
Male Right	5	38.5	4	30.8	4	30.8	0	0.0			13
Female Right	1	14.3	0	0.0	5	71.4	1	14.3			7
Total	11	26.2	8	19.1	22	52.4	1	2.3			42

Key: a=absent, 1=small, 2=large, 3=extreme. χ^2 =chi squared value.

More females had lateral tibial squatting facets than males (females 84.2% and males 63.8%) (table 7.3.49). The difference between males and females was not statistically significant ($P=0.290$ $n=42$). When comparing the prevalence of each type of facet, the sexes differ statistically ($\chi^2=38.607$ $P\leq 0.001$ 3df). Females had a significantly higher

prevalence of large squatting facets in comparison to males (female 73.7%, males 36.4%). Due to the small sample size, it was not possible to statistically compare the sides separately, but a trend was observed whereby females have larger facets on both sides (table 7.3.49).

Talus squatting facets

Table 7.3.50 Presence of the talus squatting facet by sex, side and type with chi-squared results and scores.

Talus	a	%a	c	%c	p	%p	χ^2	P value	Total
Female left	4	40.0	4	40.0	2	20.0	7.860	0.020	10
Male Left	4	44.4	3	33.3	2	22.3			9
Female Right	3	27.2	4	36.4	4	36.4			11
Male Right	2	13.3	2	13.3	11	73.4			15
Total	13	28.9	13	28.9	19	42.2			45

Key: a=absent, p=pressure, c=congenital. χ^2 =chi squared value.

The overall prevalence of talus squatting facets was not significantly different between the sexes ($P=0.743$ $n=45$) with 14 of 21 (66.7%) females and 18 of 26 (69.2%) males scoring positive for a facet (table 7.3.50). It was not possible to statistically examine the types of squatting facet by side, but when combining the results for left and right, there was a difference between men and women ($\chi^2=7.860$ $P=0.020$ 2df). The females had a higher percentage of congenital facets (female 38.1%, males 19.2%), and the males have a higher percentage of pressure facets (female 28.6%, males 50%) (table 7.3.50).

Summary

It was difficult to compare the prevalence of some of the modifications due to the low numbers of observations in some categories. However females had more lateral tibial squatting facets than males. Females also had more congenital lateral tibial squatting facets than males.

7.3.6 Comparison of Visigothic female and Islamic female non-pathological articular modifications: temporal changes in female gender ideology

Islamic and Visigothic females were compared in order to see if female activities and, therefore roles, differed between the two faith groups. Due to the small sample sizes, when it was not possible to carry out chi-squared tests, Fisher's exact tests were used.

Osteochondritis modifications on the femoral condyles

Table 7.3.51 Female osteochondritis modifications by faith group and type and Fisher's exact test results.

Side	Condyle	Group	a	%a	f	%f	i	%i	NBG	%NBG	P value	Total
Left	Medial	V	10	90.9	0	0.0	0	0.0	1	9.1	1.000	11
		I	36	92.3	1	2.6	0	0.0	2	5.1		39
	Lateral	V	9	90.0	0	0.0	0	0.0	1	10	1.000	10
		I	35	87.5	1	2.5	4	10.0	0	0.0		40
Right	Medial	V	13	92.9	0	0.0	1	7.1	0	0.0	1.000	14
		I	33	94.3	0	0.0	0	0.0	2	5.7		35
	Lateral	V	5	71.4	0	0.0	1	14.3	1	14.3	0.295	7
		I	44	86.3	1	1.95	5	9.8	1	1.95		51
Total			185	89.4	3	1.5	11	5.3	8	3.8	0.771	207

Key: V=Visigothic, I=Islamic, a=absent, f=facet, i=imprint, NBG=new bone growth.

According to table 7.3.51, there was no difference in the overall prevalence of osteochondritis modifications between the two faith groups ($P=0.771$ $n=207$) or the individual condyles (see table 7.3.51 for P values).

Tibial imprints on the supracondylar surfaces of the femur

Table 7.3.52 Female tibial imprints by faith group and type and Fisher's exact test results.

Side	Condyle	Group	a	%a	e	%e	i	%i	p	%p	χ^2	P value	Total
Left	Medial	I	18	58.1	12	39.0	1	3.2	0	0.0	30.124	<0.001	31
		V	7	43.8	2	13.0	7	43.8	0	0.0			16
	Lateral	I	16	50.0	13	41.0	3	9.4	0	0.0	0.224	0.894	32
		V	7	53.8	5	39.0	1	7.7	0	0.0			13
Right	Medial	I	24	82.7	4	14.0	1	3.5	0	0.0	84.664	<0.001	29
		V	5	33.3	3	20.0	7	46.7	0	0.0			15
	Lateral	I	35	92.1	2	5.3	0	0.0	1	2.6	-	0.166*	38
		V	5	71.4	1	14.0	1	14.3	0	0.0			7
Total			117	64.6	42	23.0	21	11.6	1	0.6		$\leq 0.001^*$	181

Key: V=Visigothic, I=Islamic, a=absent, e=facet, i=imprint, p=pitting, χ^2 =chi squared value, * =Fishers exact test

The number of tibial modifications was statistically significantly greater in Visigothic females ($P<0.001$ $n=181$), suggesting greater knee hyperdorsiflexion in Visigothic females (table 7.3.52).

Left medial condyle: There was a significant difference in the type of modification on the left supracondylar surface between groups ($\chi^2=30.124$ $P<0.001$ 3df). Visigothic females had a greater prevalence of imprints, whereas Islamic females had a greater number of extensions. Imprints may reflect greater loading in Visigothic females as it is a more severe form of modification.

Left lateral condyle: There was no significant difference in the type of modification on the left lateral supracondylar surface between faith groups for females ($\chi^2=0.224$ $P=0.894$ 3df).

Right medial condyle: Visigothic females had significantly more tibial imprint modifications on the right medial supracondylar surface; specifically, more imprints were observed ($\chi^2=84.664$ $P<0.001$ 3df).

Right lateral condyle: There was no difference in the prevalence of tibial imprint modifications on the right lateral supracondylar surface ($P=0.166$ $n=45$).

Vastus notches on the patella

Table 7.3.53 Female vastus notches by faith group and type and chi-squared and Fisher's exact test results

Patella	a	%a	1	1%	2	2%	χ^2	P value	Total
Islamic left	18	52.9	11	32.3	5	14.7	1.648	0.439	34
Visigothic left	6	66.7	3	33.3	0	0.0			9
Islamic right	24	61.5	11	28.2	4	10.3	0.583	0.747	39
Visigothic right	4	57.1	2	28.6	1	14.3			7
Total	52	58.4	27	30.3	10	11.2		0.785*	89

Key: a=absent, 1=small, 2=large, χ^2 =chi squared value, * Fishers exact test result.

According to table 7.3.53, there was no difference in the overall prevalence of vastus notches between females ($P=0.785$ $n=89$).

Left: There was no difference in the size of vastus notches between Islamic and Visigothic females on the left patella ($\chi^2=1.648$ $P=0.439$ 2df).

Right: There was no difference in the size of vastus notches between Islamic and Visigothic females on the right patella ($\chi^2=0.583$ $P=0.747$ 2df).

Lateral tibial squatting facets

Table 7.3.54 Lateral tibial squatting facets by faith group and type and chi-squared and Fisher's exact test results

Tibia	a	%a	1	1%	2	2%	3	3%	χ^2	P value	Total
Islamic left	2	3.9	6	11.8	41	80.4	2	3.9	5.649	0.130	51
Visigothic left	2	16.7	1	8.3	9	75	0	0			12
Islamic right	3	6.1	6	12.2	38	77.6	2	4.1	-	0.423	49
Visigothic right	1	14.3	0	0	5	71.4	1	14.3			7
Total	8	26.2	13	19.1	93	52.4	5	2.3		0.115*	119

Key: a=absent, 1=small, 2=large, 3=extreme, χ^2 =chi squared value, *=Fisher's exact test

The overall prevalence of tibial squatting facets was not significantly different between Visigothic and Islamic females ($P=0.115$ $n=119$) (table 7.3.54).

Left: Although Visigothic females had fewer lateral tibial squatting facets, there was no statistical difference in the size of the squatting facet on the left tibia ($\chi^2=5.649$ $P=0.130$ 2df).

Right: It was not possible to examine whether prevalence differences in tibial squatting facet size existed for the right tibiae, as the sample size was too small. There was no difference in the overall prevalence of tibial squatting facets on the right tibia ($P=0.423$ $n=56$).

Talus squatting facets

Table 7.3.55 Female talus squatting facets by faith group and type and chi-squared test results

Talus	a	%a	c	%c	p	%p	χ^2	P value	Total
Islamic left	1	2.0	35	71.5	13	26.5	73.747	<0.001	49
Visigothic left	4	40.0	4	40.0	2	20.0			10
Islamic right	1	1.8	35	63.6	19	34.6	40.945	<0.001	55
Visigothic right	3	27.2	4	36.4	4	36.4			11
Total	9	7.2	78	62.4	38	30.4			125

Key: a=absent, c=congenital, p=pressure, χ^2 =chi squared value

According to table 7.3.55, Islamic females had significantly more talus squatting facets than Visigothic females ($P<0.001$ $n=125$), suggesting that Islamic females undertook significantly more ankle hyperdorsiflexion than Visigothic females.

Left: The left talus squatting facet was more prevalent in Islamic females. A greater prevalence of congenital and pressure facets were identified in Islamic females ($\chi^2=73.747$ P<0.001 2df).

Right: The right talus squatting facet was more prevalent in Islamic females who had a greater prevalence of congenital and pressure facets ($\chi^2=40.945$ P<0.001 2df).

Summary

Although the number of osteochondritis modifications and vastus notches was similar between faith groups, Visigothic females had a greater number of tibial imprints on the medial supracondylar surfaces than Islamic females. While this suggested a greater amount of knee hyperflexion in Visigothic females, the data for osteochondritic imprints and vastus notches does not support this. However, it could imply a greater force of hyperflexion in the Visigothic females where the tibial plateau is being forced in to the supracondylar surface in Visigothic females. While there was an equal prevalence of tibial squatting facets, Islamic females had significantly more congenital and pressure facets on both tali. This suggested a greater degree of ankle hyperdorsiflexion in Islamic females.

7.3.7 Comparison of Visigothic male and Islamic male non-pathological articular modifications: temporal changes in female gender ideology

Osteochondritis modifications on the femoral condyles

Table 7.3.56 Male osteochondritis modifications by faith group and type and Fisher's exact test results.

Side	Condyle	Group	A	%A	F	%F	I	%I	NBG	%NBG	P value	Total
Left	Medial	V	12	92.3	0	0.0	0	0.0	1	7.7	1.000	13
		I	47	92.2	0	0.0	4	7.8	0	0.0		51
	Lateral	V	8	72.7	1	9.1	0	0.0	2	18.2	0.358	11
		I	39	86.7	0	0.0	5	11.1	1	2.2		45
Right	Medial	V	17	100.0	0	0.0	0	0.0	0	0.0	0.551	17
		I	40	93.0	0	0.0	1	2.3	2	4.7		43
	Lateral	V	8	100.0	0	0.0	0	0.0	0	0.0	0.582	8
		I	51	86.4	3	5.1	3	5.1	2	3.4		59
Total			222	89.9	4	1.6	13	5.3	8	3.2	0.793	247

Key: V=Visigothic, I=Islamic, a=absent, f=facet, i=imprint, NBG=new bone growth,

There was no difference in the overall prevalence of osteochondritis modifications between Islamic and Visigothic males ($P=0.793$ $n=247$) (table 7.3.56). It was not possible to carry out chi-squared tests. There was also no difference in the number of modifications on each condyle between males (see table 7.3.56 for P values).

Tibial imprints.

Table 7.3.57 Male tibial imprints by faith group and type and chi-squared and Fisher's exact test score results.

Side	Condyle	Group	a	%a	e	%e	i	%i	P	%P	χ^2	P value	Total
Left	Medial	V	11	50.0	5	23.0	6	27.3	0	0.0	5.769	0.1234	22
		I	25	59.5	10	24.0	5	11.9	2	4.8			42
	Lateral	V	14	73.7	5	26.0	0	0.0	0	0.0	-	0.056	19
		I	22	44.9	22	45.0	4	8.2	1	2.0			49
Right	Medial	V	7	38.9	4	22.0	7	38.9	0	0.0	-	<0.001	18
		I	35	92.1	2	5.3	0	0.0	1	2.6			38
	Lateral	V	14	100	0	0.0	0	0.0	0	0.0	-	1.000	14
		I	55	93.2	3	5.1	1	1.7	0	0.0			59
Total			183	70.0	51	20.0	23	9.0	4	1.0			261

Key: V=Visigothic, I=Islamic, a=absent, e=extension, i=imprint, p=pitting, χ^2 =chi squared value

Due to the number of categories with 0 observations, it was not possible to carry out chi-squared tests to examine whether the prevalence of tibial imprint types varied between Visigothic and Islamic men for the left and right lateral condyles and the right medial condyle. According to table 7.3.57, there was no difference in the prevalence of tibial modifications between Islamic and Visigothic males ($P=0.133$ $n=261$).

Left medial condyle: There was no difference in the type of modification observed on the left medial supracondylar surface between Islamic and Visigothic males ($\chi^2=5.769$ $P=0.123$ 3df).

Left lateral condyle: There was a trend for the Islamic males to have more tibial imprints on the left lateral supracondylar surface than Visigothic males ($P=0.056$ $n=68$). In particular, there was a higher prevalence of extensions on the supracondylar surface in Islamic males.

Right medial condyle: Visigothic males had significantly more tibial imprint modifications than Islamic males ($P\leq 0.001$ $n=56$); this was particularly notable for the number of imprints.

Right lateral condyle: There was no difference in the prevalence of tibial imprint modifications on the right lateral supracondylar surface between faith groups ($P=1.000$ $n=73$).

Vastus notches on the patella

Table 7.3.58 Male vastus notches by faith group and size and chi-squared and Fisher's exact test score results

Patella	a	%a	1	1%	2	2%	χ^2	P value	Total
Visigothic left	7	50.0	4	28.6	3	21.4	24.461	0.001	14
Islamic left	22	42.3	5	9.6	25	48.1			52
Visigothic right	6	50.0	3	25.0	3	25.0	7.048	0.029	12
Islamic right	18	36.0	4	8.0	28	56.0			50
Total	53	41.4	16	12.5	59	46.1		0.375*	128

Key: a=absent, 1=small, 2=large, χ^2 =chi squared value, *=Fisher's exact test

Overall there was no difference in the prevalence of vastus notches between Islamic and Visigothic males ($P=0.375$ $n=128$) (table 7.3.58).

Left: Statistically, the Visigothic males had fewer and smaller vastus notches than the Islamic males on the left patellae ($\chi^2=24.461$ $P<0.001$ 2df).

Right: Statistically, the Visigothic males had fewer and smaller vastus notches than the Islamic males on the right patellae ($\chi^2=7.048$ $P=0.029$ 2df).

Lateral tibial squatting facets

Table 7.3.59 Lateral tibial squatting facets by faith group and size and chi-squared and Fisher's exact test score results

Tibia	a	%a	1	1%	2	2%	3	3%	χ^2	P value	Total
Visigothic left	3	30.0	3	30.0	4	10.0	0	0.0	11.416	0.001	10
Islamic left	3	5.9	12	23.5	35	68.6	1	2.0			51
Visigothic right	5	38.5	4	30.8	4	30.8	0	0.0	16.793	≤0.001	13
Islamic right	5	8.3	16	26.2	39	63.9	1	1.6			61
Total	16	11.8	35	25.9	82	60.7	2	1.6		≤0.001*	135

Key: a=absent, 1=small, 2=large, 3=extreme, χ^2 =chi squared value, *=Fisher's exact test

Table 7.3.59 indicated that Islamic males had a greater prevalence of tibial squatting facets than Visigothic individuals ($P\leq 0.001$ $n=135$), suggesting a greater adoption of ankle hyperdorsiflexion in Islamic males.

Left: Statistically, Islamic males had more, and larger, tibial squatting facets than the Visigothic males ($\chi^2=11.416$ $P=0.009$ 3df).

Right: Statistically, Islamic males had more, and larger, tibial squatting facets than the Visigothic males ($\chi^2=16.793$ $P<0.001$ 3df).

Talus squatting facets

Table 7.3.60 Talus squatting facets by faith group and size and chi-squared and Fisher's exact test score results

Talus	a	%a	c	%c	p	%p	χ^2	P value	Total
Visigothic left	4	44.4	3	33.3	2	22.3	38.532	<0.001	9
Islamic left	3	5.1	30	50.8	26	44.1			59
Visigothic right	2	13.3	2	13.3	11	73.4	53.014	<0.001	15
Islamic right	5	7.9	28	44.4	30	80.7			63
Total	14	9.6	63	43.2	69	51.1		0.013*	146

Key: a=absent, p=pressure, c=congenital. χ^2 =chi squared value, *=Fisher's exact test.

Statistically, and in line with the tibial squatting facet results, Islamic males had more talus squatting facets than the Visigothic males ($P=0.013$ $n=146$) (table 7.3.60).

Left: Statistically, Islamic males had more of both types of talus squatting facets than the Visigothic males ($\chi^2= 38.532$ $P<0.001$ 2df).

Right: Statistically Islamic males had more of both types of talus squatting facets than the Visigothic males ($\chi^2= 53.014$ $P<0.001$ 2df).

Summary

More differences emerged between the religious groups for the males than for the females. Osteochondritis modifications and tibial imprint modifications on the left medial and right lateral condyle did not differ between Islamic males and Visigothic males, whereas tibial imprints on the left lateral condyle and vastus notches were more prevalent in Islamic males. This may suggest a greater adoption of kneeling in Islamic males than Visigothic males. In addition, lateral tibial and talus squatting facets were more prevalent in Islamic individuals and may suggest greater adoption of ankle hyperdorsiflexion.

7.4 The results of osteoarthritis analysis

This section explores whether differences in osteoarthritis patterns, and hence loaded activity, exists between comparison groups as set out in section 6.3.1. To assess this, it was first necessary to determine the prevalence of osteoarthritis and skeletal patterns of osteoarthritis involvement in the Islamic and Visigothic groups. Accordingly, osteoarthritis data was split and analysed in the respective faith groups. The analysis commenced with the assessment of Islamic osteoarthritis data. Islamic female and males were examined first to establish the degree of sex difference in the osteoarthritis prevalence and pattern for Muslims. Following this, the osteoarthritis prevalence and pattern was compared by Islamic phase group to demonstrate whether a change in the degree or type of activity occurred over time. Subsequently, to show whether loaded activity patterns changed over time for one sex only, a comparison of early and late osteoarthritis patterns and prevalence by sex is presented. Finally, in the early and late Islamic groups, osteoarthritis scores were compared between the sexes to establish whether the sex differences in osteoarthritis patterns changed diachronically. Subsequently, intra-faith analysis of osteoarthritis patterns in the Visigothic males and females was established. This acted as a control serving to present the pre-Islamic osteoarthritis patterns and gender differences prior to the arrival of Islam. This then permitted the interfaith comparisons of osteoarthritis patterns between the Islamic females and Visigothic females, and between Islamic males and Visigothic males. This demonstrated whether the arrival of Islam altered patterns of osteoarthritis in Écija. Due to the low prevalence of osteoarthritis, it was deemed not possible to analyse osteoarthritis by side, as this would have not been testable statistically.

7.4.1 Overall population prevalence of osteoarthritis in the Islamic sample

Table 7.4.1 Summary data for osteoarthritis prevalence in the Islamic individuals.

Number of individuals	Number of affected individuals	Number of observable joints	Number of affected joints	Number of observable joint surface	Number of affected joint surfaces
152	37 (24%)	980	63 (6.4%)	3464	97 (2.8%)

152 Islamic individuals were examined for evidence of osteoarthritis in at least one extra spinal synovial joint in the skeleton. Table 7.4.1 displays the prevalence of

osteoarthritis in the sample. The total number of individuals with at least one joint surface affected by osteoarthritis in the Écija assemblage was 37/152 (24%). The total number of joints affected by osteoarthritis was 63/980 (6.4%). The total number of joint surfaces affected by osteoarthritis was 97/3464 (2.8%). Although the total number of joint surfaces and joints affected was low, the proportion of individuals affected by osteoarthritis was higher. The low prevalence is likely to be related to the exclusion of old individuals and hence more likely to reflect activity.

Table 7.4.2 Individual joint involvement for the Islamic sample.

Joint	Number observable	Number affected	% affected
Temporomandibular	77	3	3.9
Acromioclavicular	117	12	10.3
Glenohumeral	122	9	7.4
Elbow	147	10	6.8
Wrist	136	8	5.9
Hip	121	6	5.0
Knee	140	13	9.3
Ankle	129	2	1.6
Total	989	63	6.0

Table 7.4.3 Individual joint surface involvement for the Islamic population.

Joint surface	Number observable	Number affected	% affected
Temporal	97	1	1.0
Mandible	96	2	2.1
Acromion	127	7	5.5
Clavicle	146	9	6.2
Glenoid	174	11	6.3
Proximal humerus	214	1	0.5
Distal humerus	225	4	1.8
Proximal ulna	222	0	0.0
Proximal radius	224	10	4.5
Distal ulna	194	7	3.6
Distal radius	214	4	1.7
Acetabulum	104	7	6.7
Proximal femur	170	1	0.6
Distal femur	216	6	2.8
Proximal tibia	202	9	4.5
Patella	204	16	7.8
Distal tibia	209	1	0.5
Distal fibula	196	1	0.5
talus	230	0	0.0
Total	3464	97	2.8

Tables 7.4.2 and 7.4.3 display results for the joint analysis of the entire Islamic sample. The most affected joint was the acromioclavicular joint, with 10.3% affected by osteoarthritis. In terms of joint surfaces, the most affected was the patella, rather than either the acromion or the acromial end of the clavicle (table 7.4.2).

7.4.2 Analysis of sex differences in osteoarthritis prevalence in the Islamic group: analysis of Islamic gender division.

Seventy one females and 81 males were examined for osteoarthritis. The difference between the number of males and females was not statistically significant ($P=0.754$ $n=152$). There was a 3% prevalence difference in osteoarthritis between males and females. Sixteen (23%) females had osteoarthritis in at least one joint in the body, in comparison to 21 (26%) males. The difference between affected females and affected males was not significant ($P=0.706$, $n=152$).

Table 7.4.4 displays the number of joints observable and affected by osteoarthritis for Islamic males and females. Just 5% of female joints were affected with osteoarthritis in comparison with 7.6% of male joints. Although males had a higher prevalence of affected joints, the difference was not significant ($P=0.148$, $n=980$).

Table 7.4.4. Table comparing the total number of affected and unaffected joints by sex.

Joint	Female			Male			P value	N
	NO	NA	% affected	NO	NA	% affected		
TMJ	36	2	5.7	40	1	2.5	0.596	76
AC	51	5	10	66	7	10.6	1.000	117
GH	58	3	5.2	64	6	9.4	0.496	122
E	69	4	5.8	78	6	7.8	0.750	147
W	64	1	1.6	72	7	9.7	0.066	136
Hip	55	1	1.8	66	5	7.6	0.219	121
K	64	6	9.4	77	7	9.1	1.000	141
A	59	1	1.7	61	1	1.6	1.000	120
Total	456	23	5.0	524	40	7.6	0.148	980

Key: NO=number observable, NA=number affected, TMJ=Temporomandibular, AC=Acromioclavicular, GH=Glenohumeral, E=Elbow, W=wrist, K=Knee and A=Ankle.

Table 7.4.5 displays the prevalence of osteoarthritis at each joint surface for males and females. In terms of total joint surfaces, 36 (2.2%) of 1643 female joint surfaces were affected, in comparison with 62 (3.4%) of 1818 male joint surfaces. This difference was

statistically significant ($P=0.032$ $n=3461$), with males having more affected joint surfaces than females.

Table 7.4.5 Total number of joint surfaces observed and affected by side and sex in the Islamic individuals from Écija.

Joint surface	Female			Male			Total			P value
	NO	NA	% A	NO	NA	% A	NO	NA	% A	
Temporal	43	0	0.0	54	1	1.9	97	1	1.0	1.000
Mandible	43	2	4.6	53	0	0.0	96	2	2.1	0.198
Acromion	63	3	4.8	64	4	6.3	127	7	5.5	1.000
Clavicle	66	2	3.0	80	7	8.8	146	9	6.2	0.185
Glenoid	88	5	5.7	90	7	7.8	174	11	6.3	0.768
Prox Hum	102	0	0.0	112	1	0.9	214	1	0.5	1.000
Dist Hum	111	3	2.7	114	2	1.8	225	5	2.2	0.681
Prox Ulna	112	0	0.0	112	0	0.0	222	0	0.0	1.000
Prox Rad	114	4	3.5	110	6	5.5	224	10	4.5	0.533
Dist Ulna	95	2	2.1	99	5	5.1	194	7	3.6	0.445
Dist Rad	108	0	0.0	96	4	4.2	204	4	2.0	0.059
Acetabulum	43	1	2.3	62	6	9.7	105	7	6.7	0.236
Prox Fem	80	0	0.0	91	1	1.1	171	1	0.6	1.000
Dist Fem	98	3	3.1	118	3	2.5	216	6	2.8	1.000
Prox Tib	91	6	6.6	110	3	2.7	201	9	4.5	0.305
Patella	92	5	5.4	112	11	9.8	204	9	4.4	0.313
Dist Tib	98	0	0.0	111	1	0.9	209	1	0.5	1.000
Dist Fib	90	0	0.0	106	0	0.0	196	0	0.0	1.000
Talus	106	0	0.0	124	0	0.0	230	0	0.0	1.000
Total	1643	36	2.2	1818	62	3.4	3455	90	2.6	0.032

NO= number observable, NA = number affected, A= Affected, Prox= Proximal, Dist = Distal, Hum = Humerus, Rad= Radius, Fem= Femur, Tib= Tibia, Fib = Fibula.

The following paragraphs explore the prevalence of osteoarthritis at individual joints and joint surfaces by sex (table 7.4.4 and table 7.4.5). P values reflect the statistical significance of male female difference in OA prevalence.

Temporomandibular joint (TMJ)

Three TMJ joints (2.1%) had osteoarthritis, two (5.7%) females and one (2.5%) male. The prevalence difference was not statistically significant ($P=0.596$, $n=144$). There was no difference in the amount of TMJ osteoarthritis on joint surfaces between Islamic men and women (temporal $P=1.000$ $n=97$, mandible $P=0.192$ $n=96$).

Acromioclavicular joint

Twelve acromioclavicular joints (10.3%) had osteoarthritis; seven male (10.6%) and five (10%) female. The difference was not significant ($P=1.000$, $n=117$) (see table 7.4.5). In terms of joint surfaces, there was a trend for the clavicle to be affected more frequently in males (8.8% males, females 3.0%), but the difference was not statistically significant ($P=0.185$, $n=146$).

Glenohumeral joint

Nine (7.4%) glenohumeral joints had osteoarthritis. Three (5.2%) female joints were affected in comparison with six (9.4%) male joints. The difference was not significant ($P=0.496$, $n=122$). Only one male had glenohumeral osteoarthritis. The prevalence difference between the sexes was not significant ($P=1.000$ $n=214$). Five (5.7%) female glenoids had osteoarthritis in comparison to seven (7.8%) male glenoids. The difference was not significant ($P=0.768$ $n=174$).

Elbow joint

Ten (6.8%) elbows had osteoarthritis; six (7.8%) male and four (5.8%) female. This difference was not significant ($P=0.750$ $n=147$). Three (2.7%) female distal humeri had osteoarthritis compared with two (1.8%) male distal humeri, but the difference was not statistically significant ($P=0.681$, $n=225$). No proximal ulna osteoarthritis was identified in the sample. Four (3.5%) female radial heads had osteoarthritis in comparison with six (5.5%) male radial heads, but the difference was not significant ($P=0.533$ $n=224$).

Wrist joint

Eight (5.9%) wrists had osteoarthritis: one (1.6%) female joint was affected in comparison with seven (9.7%) male joints. The difference in the prevalence of wrist osteoarthritis was just outside statistical significance ($P=0.066$ $n=136$), but a trend can be inferred. When examining the joint surfaces separately, two (2.1%) female distal ulnae had osteoarthritis in comparison to five male (5.1%) distal ulnae. The difference was not statistically significant ($P=0.445$, $n=194$). No female distal radii had osteoarthritis but four male radii did (4.2%). The difference between males and females

for the distal radius was just outside statistical significance ($P=0.058$, $n=204$) demonstrating a trend for a higher prevalence of distal radii osteoarthritis in men.

Hip joint

Six (5.0%) hips had osteoarthritis; five (7.6%) male and one (1.8%) female. Despite the higher prevalence of hip osteoarthritis in males, the difference was not statistically significant ($P=0.219$, $n=122$). When observing joint surfaces, no difference in the prevalence of femoral head osteoarthritis existed between men and women ($P=1.000$ $n=161$), as only one male was affected. Although not significant statistically, the amount of acetabulum osteoarthritis differed between the sexes with one female acetabulum affected (2.3%) and six male acetabuli affected (9.7%) ($P=0.236$ $n=105$).

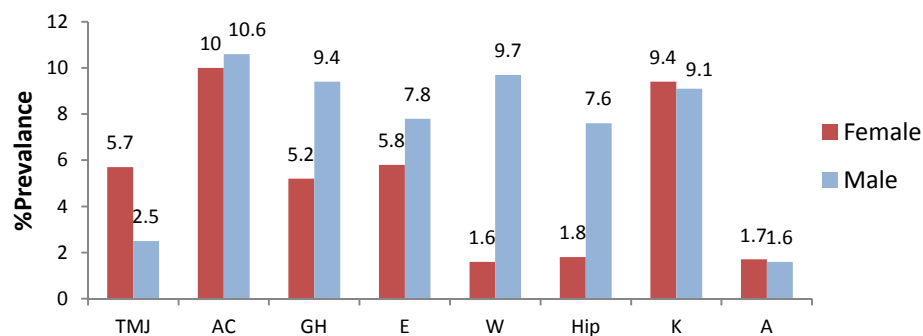
Knee joint

Thirteen (9.3%) knees had osteoarthritis. Six (9.4 %) female knees were affected in comparison with seven (9.1%) male knees. The difference between male and female knee osteoarthritis was not significant ($P=1.000$, $n=141$). There was no difference in the prevalence of osteoarthritis on the distal femur between men (2.5%) and women (3.1%), with three joint surfaces affected in each sex group ($P=1.000$, $n=216$). It was interesting to note that six female and three male proximal tibiae had osteoarthritis (6.6% and 2.7% respectively), but 11 male patellae had osteoarthritis in comparison to five female patella surfaces (5.4% and 9.8% respectively). Although there was no statistical difference in the prevalence of affected knee joint surfaces between males and females (tibia $P=0.303$ $n=201$; patella $P=0.313$ $n=204$), different trends in the affected joint surfaces of the knee were observed between sexes.

Ankle joint

As just two individuals (1.6%) had ankle osteoarthritis, one (1.6%) male and one (1.7%) female, no significant difference existed ($P=1.000$, $n=120$). In terms of joint surfaces, while the male was affected on the tibia, the female was affected on the fibula. The ankle joint surfaces were affected equally in men and women as the differences were not statistically significant (All: $P=1.000$, tibia $n=209$, fibula $n=196$, talus $n=230$).

Overall, with the exception of the TMJ, knee and ankle, males had higher osteoarthritis prevalence at all joints in comparison to women. It should be remembered, however, that for the TMJ, knee and ankle, the prevalence difference between the sexes was equal to, or less than, one individual, and could be considered a factor of sample size. It was possible that males were more affected by osteoarthritis than females, but this difference was not statistically significant except at the overall joint surface level and at the distal radii.



Key: TMJ=Temporomandibular, AC=Acromioclavicular, GH=Glenohumeral, E=Elbow, W=wrist, K=Knee and A=Ankle.

Figure 7.4.1 Male and female osteoarthritis % prevalence by joint.

When ranking the joints by prevalence rate for males and females, different patterns of skeletal involvement were observed between males and females (see figure 7.4.1 and table 7.4.4). When examining the joints as complete structures, in both sexes, the most affected joint was the acromioclavicular joint (10.6% men and 10% in women). However, the second most affected joint in males was the wrist (9.7%); this ranked lowest affected of all the female joints examined (1.6%). The second most affected female joint was the knee, which affected 9.4% of female individuals. While a similar percentage of males and females were affected at the knee, the glenohumeral joint was more affected in males (9.4%) relative to (5.2%) females. The difference in skeletal distribution of osteoarthritis between the sexes was not statistically significant ($P=0.275$, 7df, $\chi^2=8.694$).

When examining osteoarthritis by observable joint surface, the articular surface with the highest amount of OA in men was the patella, closely followed by the acetabulum. In women, the most frequently affected joint surface were the glenoid and the proximal

tibia (see table 7.4.5). This suggests that men and women were affected by osteoarthritis at different areas of the skeleton. This may be related to both genetic and activity differences.

7.4.3 Temporal differences in osteoarthritis prevalence between early and late Islamic individuals: analysis of changing social organisation

The following paragraphs explore whether any difference existed between the Islamic individuals in the early phase and the late phase. Seventy five early individuals and 83 late individuals were observable; no significant difference in the sample sizes existed (phase P=1.000 n=158).

There was very little difference in the number of individuals affected with osteoarthritis at least one joint surface between the early phase and the late phase. Nineteen individuals (25.3%) were affected in the early phase, in comparison with 18 (21.7%) in the late phase. This difference was not statistically significant (P=0.708, n=152).

Table 7.4.6 Total number of joints affected and unaffected by phase

Joint	Early			Late			P value	N
	NA	NO	% affected	NA	NO	% affected		
TMJ	1	40	2.5	2	38	5.3	0.610	78
AC	5	40	12.5	7	68	10.3	0.762	108
GH	5	50	10.0	4	69	5.8	0.490	119
E	3	60	5.0	7	78	9.0	0.513	138
W	4	54	7.4	4	74	5.4	0.721	128
H	1	44	2.3	5	74	6.8	0.409	118
K	7	58	12.1	6	74	8.1	0.560	132
AN	1	51	2.0	1	75	1.3	0.405	126
Total	27	397	6.8	35	550	6.4	0.792	947

Key: NA=Number affected, NO=Number observable, TMJ=temporomandibular joint, AC=Acromioclavicular joint, GH=Glenohumeral joint, E=Elbow, W=Wrist, H=hip, K=Knee, AN=Ankle.

Table 7.4.6 displays the number of joints observable and affected by osteoarthritis for early- and late-phase individuals. The total number of joints affected in the early phase was 27 (6.8 %) of 397 observable joints. In the late phase, 35 joints (6.4%) out of 550 observable joints were affected. This proved not to be statistically different (P=0.792, n=947).

Table 7.4.7 Total number of joint surfaces and affected joint surfaces by phase.

Joint surface	Early			Late			Total			P value
	NO	NA	% A	NO	NA	% A	NO	NA	% A	
Temporal	45	0	0.0	52	1	1.9	97	1	1.0	1.000
Mandible	45	1	2.2	51	1	1.9	96	1	1.0	0.497
Acromion	46	3	6.5	81	4	4.9	127	7	5.5	0.703
Clavicle	50	4	8.0	96	6	6.3	146	10	6.8	0.716
Glenoid	62	5	8.1	93	6	6.5	155	11	7.1	0.977
Prox Hum	59	0	0.0	96	1	1.0	155	1	0.6	1.000
Dist Hum	93	4	4.3	132	1	0.8	225	5	2.0	0.078
Prox Ulna	98	0	0.0	153	0	0.0	224	0	0.0	1.000
Prox Rad	96	3	3.1	128	7	5.5	224	10	4.5	0.519
Dist Ulna	82	3	3.7	112	4	3.5	194	7	3.6	0.701
Dist Rad	79	2	2.5	122	2	1.6	194	4	2.0	0.622
Acetabulum	36	1	2.8	68	6	8.8	104	7	6.7	0.417
Prox Fem	62	0	0.0	111	1	0.9	173	1	0.6	1.000
Dist Fem	88	4	4.5	126	2	1.6	214	6	2.8	0.220
Prox Tib	84	2	2.4	113	7	6.2	197	9	4.5	0.306
Patella	83	9	10.8	118	7	5.9	201	16	7.9	0.181
Dist Tib	99	1	1.0	131	0	0.0	220	1	0.5	1.000
Dist Fib	85	0	0.0	122	1	0.8	207	1	0.5	1.000
Talus	91	0	0.0	145	0	0.0	236	0	0.0	1.000
	1383	42	3.0	2050	57	2.8	3389	98	2.9	0.836

Key: NA=Number affected, NO=Number observable A=Affected, Prox=Proximal, Dist=Distal, Hum=Humerus, Rad=Radius, Fem=Femur, Tib=Tibia, Fib=Fibula.

The total number of affected joint surfaces per phase is presented in table 7.4.7. In terms of joint surfaces, 42 (3.0%) of 1383 early-phase surfaces were affected in comparison with 57 (2.9%) of 2050 late-phase surfaces. This difference was not statistically significant ($P=0.836$ $n=3389$).

The following paragraphs examine the joints separately to explore whether differences in osteoarthritis prevalence exist over time at any region in the skeleton (tables 7.4.6 and 7.4.7).

Temporomandibular joint

One early (2.5%) and two (5.3%) late TMJs were affected with osteoarthritis. The prevalence difference was not statistically significant ($P=0.610$ $n=78$). In terms of joint surfaces, as just one temporal was affected in the late phase (1.9%), there was no change in the prevalence of temporal osteoarthritis over time ($P=1.000$ $n=97$). One mandiblar

condyle was affected in each phase (early 2.2%, late 1.9%) and the prevalence difference was not significant ($P=0.497$ $n=96$).

Acromioclavicular joint

Five (12.5%) early and seven (10.3%) late acromioclavicular joints were affected with osteoarthritis. The prevalence difference, however, was not statistically significant. When examining the individual joint surfaces of the acromioclavicular joint separately, there was still no change in osteoarthritis prevalence over time, with three acromions affected (6.5%) in the early phase, and four (4.9%) in the late phase ($P=0.703$ $n=128$). The clavicle was affected in four (8%) cases in the early phase and 6 (6.3%) in the late phase ($P=0.716$ $n=146$). There was no change in the prevalence of acromioclavicular osteoarthritis over time.

Glenohumeral joint

Nine (7.6%) glenohumeral joints had osteoarthritis; four (5.8%) from the late phase and five (10%) from the early phase. A decrease in the prevalence of osteoarthritis at the glenohumeral joint was demonstrated, but it was not statistically significant ($P=0.490$ $n=119$). In terms of the joint surfaces affected, there was no difference in the prevalence of joint surfaces affected between phases. Although the percentage of affected glenoids decreased in the late phase (8% early, 6.5% late), the difference was not significant ($P=0.977$ $n=155$). Similarly, the only humeral head affected with osteoarthritis was in the late phase ($P=1.000$ $n=155$).

Elbow joint

Eleven elbows (8%) had osteoarthritis; three (5%) from the early phase and nine (9%) from the late phase. This demonstrated an increase in elbow osteoarthritis in the late phase, but was not statistically significant ($P=0.513$ $n=138$). In terms of joint surfaces, the prevalence of osteoarthritis on the distal humerus decreases over time (4.3% early to 0.76% late), whereas the amount of osteoarthritis on the proximal radius increases in the late phase (3.1% early to 5.4% late). These changes were not statistically significant (humerus $P=0.078$ $n=217$, radius $P=0.519$ $n=224$), but indicate trends whereby different areas of the elbow were affected in different phases. The ulna was not affected in either phase.

Wrist joint

Eight (6.3%) wrists had osteoarthritis; four (7.4%) in the early phase and four in the late phase (5.4%). The change in the prevalence of affected joints was not statistically significant ($P=0.720$ $n=128$). In terms of joint surfaces, the distal ulna was affected equally in the early and late phase (3.7% and 3.8% respectively) ($P=0.701$ $n=196$). A slight decrease in distal radii osteoarthritis prevalence was observed (2.5% early and 1.6% late), but the difference was not statistically significant ($P=0.622$ $n=165$).

Hip joint

Six hips had osteoarthritis; one early- (2.5%) and five late-phase hips (6.8%). The difference was not statistically significant ($P=0.409$ $n=118$). When observing the joint surfaces separately, the trend observed for increasing hip osteoarthritis appears to be due to an increase in acetabulum osteoarthritis, rather than the femoral head osteoarthritis, as the latter was only recognised once in the entire sample. The acetabulum was affected in one individual (2.7%) in the early phase and six individuals (8.8%) in the late phase. Although this was not statistically significant ($P=0.417$ $n=104$), this increase was noteworthy.

Knee joint

Fifteen (11.4%) knees had osteoarthritis; seven (9.5%) were affected in the late phase and eight (13.5%) in early phase. This difference was not significant ($P=0.560$ $n=132$). When examining the individual knee surfaces, there was an increase of proximal tibial osteoarthritis (2.4% early, 6.2 % in late). In an opposing trend, the amount of osteoarthritis on the patella decreased from 13% to 5.9%. Similarly the amount of distal femur osteoarthritis dropped from 4.5% to 1.6% in the late phase. This trend demonstrated that the knee joint surfaces affected by osteoarthritis changed over time (proximal tibia: $P=0.306$ $n=197$, patella: $P=0.181$ $n=193$, distal femur: $P=0.239$ $n=220$), but these individual changes were not statistically significant.

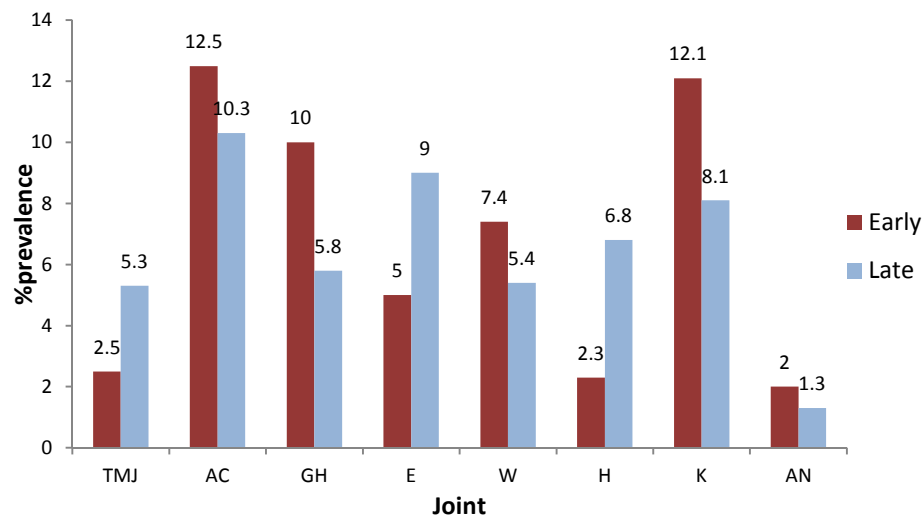
Ankle joint

Two individuals had ankle osteoarthritis (1.6%): one individual in each phase (2% early and 1.3% late). The difference in prevalence was not statistically significant ($P=0.405$

n=126). The early-phase individual was affected on the distal tibia whereas the late-phase individual was affected on the fibula. The prevalence difference in OA between early- and late-phase individuals at all joint surfaces was not statistically significant (All: $P=1.000$; tibia $n=208$, fibula $n=222$ and talus $n=236$).

Overall there were no statistically significant changes in the prevalence of osteoarthritis between phases for either joints or joint surfaces.

When ranking the joints in order of osteoarthritis prevalence by phase (see table 7.4.6), the acromioclavicular joint was the most affected joint (12.5% early phase, 10.3% late) in both phases. An increase from 5% in the early phase to 9% in the late phase means elbow osteoarthritis replaces knee osteoarthritis as the second most common form in the late phase. Similarly, an increase from 2.3 % in the early phase to 6.8% in the late phase, makes hip osteoarthritis the fourth most experienced osteoarthritis in the late phase, rather than the seventh in the earlier phase. A chi-squared test, however, indicated that the skeletal distribution of osteoarthritis was not statistically significantly different between phases ($P=0.506$, 7df, $\chi^2=6.289$).



Key: TMJ=Temporomandibular, AC=Acromioclavicular, GH=Glenohumeral, E=Elbow, W=wrist, H=Hip, K=Knee and AN=Ankle.

Figure 7.4.2. Early and late phase % of osteoarthritis per joint.

In terms of joint surfaces, the most affected joint surface in the early phase was the patella (11.4%), and in the late phase it was the acetabulum (12.1%). This coincides with the increase of hip osteoarthritis and decline in knee osteoarthritis in the late phase. The other notable difference included an increase in the amount of osteoarthritis on the

proximal tibia in the late phase. Due to the low numbers of observations for joint surfaces, it was not possible to carry out a chi-squared test.

7.4.4 Analysis of the temporal difference in osteoarthritis for Islamic males and females: changing Islamic identity

The following paragraphs analyse males and females OA data separately, and compares it by phase group to discern whether patterns of osteoarthritis changed temporally specifically for males or females. This identified whether gender roles changed over time. Firstly the overall prevalence of osteoarthritis was compared over time, and then a more detailed analysis of individual joints was presented. Small sample sizes prevented examination of joint surfaces.

Table 7.4.8 Summary results of individuals analysed for osteoarthritis

Sex	Early Islamic	Late Islamic	Total
Females	32	39	71
Males	37	44	81
Total	75	83	152

There was no significant difference between the number of males and females in each phase group (females: $P=0.314$ $n=71$. Males: $P=0.346$ $n=81$)

7.4.4.1 Analysis of temporal changes in female osteoarthritis prevalence: changing female Islamic identity

Eight females (25%) were affected with osteoarthritis in the early phase in comparison with 7 (17.9%) in the late phase. The difference was not statistically significant ($P=0.564$ $n=71$).

There was no difference in the number of joints affected by osteoarthritis between early phase women (4.7%) and the late phase women (5.5%) ($P=0.830$ $n=459$). Furthermore, there were no differences between the early and late women for the prevalence of osteoarthritis for any of the individual joints examined (see table 7.4.9 for P values). The early-phase and late-phase joints were equally affected for Islamic women.

Table 7.4.9. Table comparing the number of affected and unaffected joints between early and late phase females.

Joint	Early Female			Late Female			P value	N
	NA	NO	% affected	NA	NO	% affected		
TMJ	1	14	7.1	1	22	4.5	1.000	36
AC	1	18	5.6	3	33	9.1	1.000	51
GH	1	21	4.8	2	37	5.4	1.000	48
E	2	26	7.7	3	43	4.8	0.634	69
W	0	25	0.0	1	39	2.6	1.000	74
H	0	19	0.0	1	36	2.8	1.000	55
K	3	24	12.5	4	41	7.8	0.703	65
AN	0	22	0.0	1	39	2.6	1.000	61
Total Joints	8	169	4.7	16	290	5.5	0.821	459

Key: NA=Number affected, NO=Number observable, TMJ=temporomandibular joint, AC=Acromioclavicular joint, GH=Glenohumeral joint, E=Elbow, W=Wrist, H=hip, K=Knee, AN=Ankle.

7.4.4.2. Analysis of temporal changes in male osteoarthritis prevalence: changing male Islamic identity

Ten (27%) early-phase males had at least one joint with osteoarthritis, compared to 12 (27.3%) late-phase males. This increase in prevalence was not statistically significant ($P=1.000$ $n=81$).

Table 7.4.10 Table comparing the number of affected and unaffected joints between early and late phase males.

Joint	Early male			Late male			P value	N
	NA	NO	% affected	NA	NO	% affected		
TMJ	0	17	0.0	1	24	4.2	1.000	41
AC	4	30	13.3	4	36	11.1	1.000	66
GH	4	31	12.9	2	33	6.0	0.419	64
E	4	39	10.3	2	39	5.1	0.675	78
W	4	34	11.7	3	38	7.9	0.700	72
H	1	27	3.7	4	39	10.3	0.641	66
K	5	38	13.2	2	38	5.3	0.430	76
AN	1	29	3.4	0	36	0.0	1.000	65
Total joints	23	245	9.6	18	283	6.4	0.182	511

Key: NA=Number affected, NO=Number observable, TMJ=temporomandibular joint, AC=Acromioclavicular joint, GH=Glenohumeral joint, E=Elbow, W=Wrist, H=hip, K=Knee, AN=Ankle.

There was no difference ($P=0.182$ $n=511$) in the prevalence of joints affected by osteoarthritis between the early-phase men (9.6%) and the late-phase men (6.4%), although there was a trend for late-phase males to have a lower osteoarthritis prevalence. As so few males had osteoarthritis, it was not deemed valuable to analyse osteoarthritis by joint surface, as splitting the samples made the numbers too small for

statistical comparison. There were no statistically significant prevalence changes in osteoarthritis prevalence at any joint over time for males. Refer to table 7.4.10 for the amount of osteoarthritic joints per joint type and phase and P values.

7.4.5 Analysis of temporal changes in sex difference in non-pathological articular modifications: temporal analysis of changing gender ideology

There was no significant difference in the number of early males and early females ($P=0.865$ $n=150$), or the number of late females and late males ($P=0.877$ $n=166$) (see table 7.4.8 for individual numbers).

The difference in the number of affected females (25%) and males (27%) in the early phase was not statistically significant ($P=1.000$ $n=69$). This was the same for the late phase ($P=0.435$ $n=82$) with 17.9% of females and 27.3% of males being affected with osteoarthritis. There was no difference in the number of affected joints between early females (4.7%) and early males (9.6%) ($P=0.084$, $n=397$), but a strong trend for early males to have more joints affected than early females was identified. Comparing the number of affected joints between late females (5.5%) and late males (6.4%), the difference was not statistically significant ($P=0.764$, $n=573$). See tables 7.4.11 and 7.4.12 for the prevalence of osteoarthritis at each joint type.

Table 7.4.11 Comparison of number of affected joints between early males and females.

Joint	Early Female			Early Male			P value	N
	NA	NO	% affected	NA	NO	% affected		
TMJ	1	14	7.1	0	17	0.0	0.452	31
AC	1	18	5.6	4	30	13.3	0.637	48
GH	1	21	4.8	4	31	12.9	0.637	52
E	2	26	7.7	4	39	10.3	1.000	65
W	0	25	0.0	4	34	11.7	0.130	59
H	0	19	0.0	1	27	3.7	1.000	62
K	3	24	12.5	5	38	13.2	1.000	48
AN	0	22	0.0	1	29	3.4	1.000	51
Total Joints	8	169	4.7	22	228	9.6	0.084	397

Key: NA=number affected, NO=number observed, TMJ=temporomandibular joint, AC= acromioclavicular, GH=glenohumeral, E=elbow, W=wrist, H=hip, K=knee, AN=ankle

Table 7.4.12 Comparison of number of affected joints between late males and females.

Joint	Late female			Late male			P value	N
	NA	NO	% affected	NA	NO	% affected		
TMJ	1	22	4.5	1	24	4.2	1.000	48
AC	3	33	9.1	4	36	11.1	1.000	76
GH	2	37	5.4	2	33	6.0	1.000	74
E	3	43	4.8	2	39	5.1	1.000	82
W	1	39	2.6	3	38	7.9	0.616	81
H	1	36	2.8	4	39	10.3	0.366	80
K	4	41	7.8	2	38	5.3	0.679	85
AN	1	39	2.6	0	36	0.0	1.000	76
Total Joints	16	290	5.5	18	283	6.4	0.727	607

Key: NA=number affected, NO=number observed, TMJ=temporomandibular joint, AC= acromioclavicular, GH=glenohumeral, E=elbow, W=wrist, H=hip, K=knee, AN=ankle

Temporomandibular joint

Just one early female (7.1%) TMJ had osteoarthritis, making the difference in prevalence between the early sexes insignificant ($P=0.452$ $n=31$). In the late phase there was still no difference in the prevalence of TMJ osteoarthritis between late phases sexes, as only one male (4.2%) and one female (4.5%) had TMJ osteoarthritis ($P=1.000$ $n=48$).

Acromioclavicular joint

In the early phase, one female (5.6%) and four male joints (13.3%) had acromioclavicular osteoarthritis, but the difference was not statistically significant ($P=0.637$ $n=48$). In the late phase, three female (9.1%) and four male joints (11.1%) had acromioclavicular osteoarthritis, which was also not statistically significantly different ($P=1.000$ $n=76$).

Glenohumeral joint

In the early phase, just one female (4.8%) and four male glenohumeral joints (12.9%) had osteoarthritis. The difference in prevalence between the sexes was not statistically significant ($P=0.637$ $n=52$). In the late phase, two female glenohumeral joints (5.4%) and two male (6%) glenohumeral joints had osteoarthritis. Accordingly, there was no difference in the prevalence of glenohumeral osteoarthritis between the sexes ($P=1.000$ $n=74$).

Elbow joint

In the early phase, two female (7.7%) and four male (10.3%) elbows had osteoarthritis. The prevalence difference was not statistically significant ($P=1.000$ $n=65$). The late phase, three female (4.8%) and two males (5.1%) elbows had osteoarthritis. This difference was also not significant ($P=1.000$ $n=82$).

Wrist joint

In the early phase, no female wrists had osteoarthritis, whereas four male wrists were affected (11.7%). The difference in prevalence, however, was not statistically significant ($P=0.130$ $n=59$). In the late phase, one female (2.6%) and four male (7.9%) wrists had osteoarthritis. This difference was also not significant ($P=0.616$ $n=81$).

Hip joint

In the early phase, no females were affected with hip osteoarthritis, but one male (3.7%) hip was. The difference was not statistically significant ($P=1.000$ $n=62$). In the late phase, just one female (2.8%) hip and four male (10.3%) hips had osteoarthritis. This difference was also not statistically significant ($P=0.366$ $n=85$).

Knee joint

In the early phase, three female (12.5%) and five male (13.2%) knees had osteoarthritis, but the difference in prevalence was not significant ($P=1.000$ $n=48$). In the late phase, four female (7.8%) and two male (5.3%) knees had osteoarthritis, but the difference in prevalence was still not significant ($P=0.679$ $n=85$).

Ankle joint

In the early phase, only one male (3.4%) had ankle osteoarthritis. The difference in prevalence between sexes was not statistically significant ($P=1.000$ $n=51$). In the late phase, one female (2.6%) had osteoarthritis at the ankle, but no males were affected. Again there was no significant difference between the sexes for the prevalence of ankle osteoarthritis ($P=1.000$ $n=76$).

When examining for sex differences in the skeletal distribution of osteoarthritis, in the early phase, there was no difference between early females and early males ($\chi^2=7.010$, 6df, $P=0.320$). A sex difference, however, was observable between the late phase females and the late males ($\chi^2=13.495$, 6df, $P=0.036$). A gender difference was therefore observable in the late phase and, although the overall prevalence of osteoarthritis remains the same, males and females in the late phase were affected at different areas of the body.

7.4.6 Visigothic overall population prevalence of osteoarthritis

A total of 110 Visigothic individuals were examined for osteoarthritis in at least one synovial joint of the skeleton. Table 7.4.13 displays the prevalence of osteoarthritis in the population prior to dividing by sex. The total number of individuals with at least one joint surface affected by osteoarthritis in the Visigothic assemblage was 32 of 110 (29.1%). The total number of joints affected by osteoarthritis was 62 of 497 (12.5%). The total number of joint surfaces affected by osteoarthritis was 81 of 956 (8.5%). Although the total number of joint surfaces and joints affected was low, the number of individuals affected by osteoarthritis was higher.

Table 7.4.13 Summary of overall results for Visigothic individuals

Number of individuals	Number of affected individuals	Number of observable joints	Number of affected joints	Number of observable joint surface	Number of affected joint surfaces
110	32 (29.1%)	497	62 (12.5%)	956	81 (8.5%)

Tables 7.4.14 and 7.4.15 present the osteoarthritis results for the Visigothic population. The most prevalent osteoarthritis was glenohumeral, with 24.6% joints affected. The least affected joint was the ankle, with one individual (2.2%) affected (table 7.4.14 for joint prevalence). The most affected joint surface was the distal clavicle (22.2%) closely followed by the glenoid (21.3%). The least affected joint surfaces were the distal tibia and the talus, both of which were not affected.

Table 7.4.14 Total number of joint surfaces observed and affected for Visigothic individuals.

Joint	Total observable	Total affected	%affected
Temporomandibular	71	8	11.3
Acromioclavicular	22	4	18.2
Glenohumeral	57	14	24.6
Elbow	54	7	12.9
Wrist	38	3	8.6
Hip	78	15	19.2
Knee	69	10	14.5
Ankle	46	1	2.2
Total	435	62	14.3

Table 7.4.15 Total number of joints observed and affected for Visigothic individuals

Joint surface	Number observed	Number affected	%affected
Temporal	91	5	5.5
Mandibular condyle	56	4	7.1
Distal clavicle	18	4	22.2
Acromion	11	2	18.2
Proximal humerus	34	4	11.7
Glenoid	61	13	21.3
Distal humerus	41	3	7.3
Proximal radius	37	5	13.5
Proximal ulna	58	5	8.6
Distal radius	35	3	8.6
Distal ulna	31	3	9.7
Acetabulum	96	13	13.5
Proximal femur	98	3	3.1
Distal femur	62	5	8.1
Patella	59	3	5.1
Proximal tibia	44	5	11.4
Distal tibia	49	0	0.0
Talus	48	0	0.0
Distal fibula	27	1	3.7
Total	956	81	8.5

7.4.7 Analysis of sex differences in osteoarthritis between Visigothic female and Visigothic male: Analysis of Visigothic gender division in osteoarthritis

53 females and 57 males were examined. The difference in the number of males and females was not statistically significant ($P=0.893$ $n=220$). Six (11.3%) females had osteoarthritis in comparison to 26 (45.6%) males. This difference was highly statistically significant ($P\leq 0.001$ $n=110$), demonstrating a sex difference in the occurrence of osteoarthritis in Visigothic individuals.

Table 7.4.16 presents the Visigothic joint data by sex. Overall there was a statistically significant difference in the number of osteoarthritic joints between males and females ($P\leq 0.001$ $n=435$). Males were far more likely to have osteoarthritis than females, as just 3.5% of female joints were affected in comparison with 23.2% of male joints.

This difference was further demonstrated when examining the sexes at the joint surface level. Table 7.4.17 displays the prevalence of osteoarthritis at each joint surface. Just 2.8% of female joint surfaces had osteoarthritis in comparison to 14.1% of male surfaces ($P\leq 0.001$ $n=891$).

Table 7.4.16 Joints observed and affected by sex with Fisher's exact scores

Joint	Female			Male			P value	Total
	NA	NO	%affected	NA	NO	% affected		
Temporomandibular	0	41	0.0	8	30	26.7	≤ 0.001	71
Acromioclavicular	1	7	14.3	3	15	20.0	1.000	22
Glenohumeral	0	25	0.0	14	32	43.8	≤ 0.001	57
Elbow	1	24	4.2	6	30	20.0	0.117	54
Wrist	0	18	0.0	3	20	15.0	0.232	38
Hip	1	34	2.9	14	44	31.8	0.001	78
Knee	4	29	13.8	6	40	15.0	1.000	69
Ankle	0	20	0.0	1	26	3.8	1.000	46
Total	7	198	3.5	55	237	23.2	≤ 0.001	435

Key: NA=Number affected, NO=Number observable

Table 7.4.17 Total joint surfaces observed and affected by sex with Fisher's exact scores

Joint surface	Females			Males			P value	N
	NO	NA	%Affected	NO	NA	%Affected		
Temporal	33	0	0.0	37	5	13.5	0.053	70
Mandibular condyle	54	0	0.0	25	4	16.0	0.008	79
Clavicle	6	1	16.7	12	3	25.0	1.000	18
Acromion	5	1	20.0	6	1	16.7	1.000	11
Proximal humerus	11	0	0.0	23	4	17.4	0.280	34
Glenoid	28	0	0.0	33	13	39.4	≤0.001	61
Distal humerus	15	0	0.0	23	4	17.4	0.139	38
Proximal radius	13	1	7.7	26	3	11.5	1.000	39
Proximal ulna	28	0	0.0	30	5	16.7	0.053	58
Distal radius	15	0	0.0	10	3	30.0	0.052	25
Distal ulna	11	0	0.0	20	3	15.0	≤0.001	31
Acetabulum	39	0	0.0	57	13	22.8	≤0.001	96
Proximal femur	24	1	4.2	48	1	2.1	1.000	72
Distal femur	25	2	8.0	19	3	15.8	0.638	44
Patella	23	2	8.7	35	1	2.8	0.557	58
Proximal tibia	17	2	11.8	27	3	11.1	1.000	44
Distal tibia	23	0	0.0	26	0	0.0	1.000	49
Talus	7	0	0.0	30	0	0.0	1.000	37
Distal fibula	10	0	0.0	17	1	5.9	1.000	27
Total	387	11	2.8	504	71	14.1	≤0.001	891

Key: NA=Number affected, NO=Number observable A=Affected,

The following paragraphs explore the prevalence of osteoarthritis at individual joints and joint surfaces by sex for the Visigothic individuals (table 7.4.16 and 7.3.17) Tables 7.4.16 and 7.3.17 also contain the results of Fisher's tests demonstrating the statistical significance of any differences observed between males and females.

Temporomandibular joint

A total of eight of 71 TMJ (9.9%) had osteoarthritis. All were males. The prevalence difference between males and females was significant ($P \leq 0.001$ $n=71$). No female temporal or mandibular condyles had osteoarthritis, whereas in males, five temporals (13.5%) and four mandibular condyles (16%) were affected. The difference in the prevalence of temporal osteoarthritis between the sexes was just outside statistical significance ($P=0.053$ $n=70$), indicating a trend for males to be more affected than females. The prevalence of mandibular condyle osteoarthritis, however, was

significantly different between the sexes ($P=0.008$ $n=79$), as no females were affected in comparison to four males (16%).

Acromioclavicular joint

One female (14.3%) acromioclavicular joint had osteoarthritis in comparison to three male joints (20%). The difference in prevalence was not statistically significant ($P=1.000$ $n=22$). In terms of joint surfaces, one (16.7%) female clavicle was affected in comparison to three (25%) male clavicles. This difference was not statistically significant ($P=1.000$ $n=28$). One female (20%) and one (16.7%) male acromion had osteoarthritis, but statistically there was no significant difference in prevalence between the sexes ($P=1.000$ $n=11$).

Glenohumeral joint

Fifty seven glenohumeral joints were observable, and while 14 had evidence for osteoarthritis, only males were affected (43.8%). The sex difference observed in the prevalence of glenohumeral osteoarthritis was highly significant ($P\leq 0.001$ $n=57$). Of the humeral head, only four (17.4%) male surfaces were affected. but the difference in prevalence between the sexes was not statistically significant ($P=0.280$ $n=34$). The glenoid was affected on 13 occasions, but only in males (39.4%). This difference between sexes was significant ($P\leq 0.001$ $n=61$). Males therefore had more glenohumeral osteoarthritis and glenoid osteoarthritis than females.

Elbow joint

Seven of 54 elbows had osteoarthritis (12.3%); one female elbow (4.2%) and six male elbows (20%). This difference was not statistically significant ($P=0.117$ $n=54$). In terms of joint surfaces, no female distal humeri were affected in comparison to four male (17.4%) distal humeri. The difference between the sexes was not statistically significant ($P=0.139$ $n=38$). The proximal radius was affected on one female surface (7.7%) and on three male (11.5%) surfaces. This difference was also not statistically different ($P=1.000$ $n=39$). Finally, no female proximal ulnae were affected in comparison with five (16.7%) male surfaces. This prevalence difference was just outside statistical significance ($P=0.053$ $n=58$) suggesting a trend whereby males had more proximal ulna arthritis.

Wrist joint

Just three of 38 (7.9%) wrists had osteoarthritis. No female elbows were affected with osteoarthritis in comparison to three male elbows (15%). This difference, however, was not statistically significant ($P=0.232$ $n=38$). In reference to joint surfaces, the difference between males and females for distal radius osteoarthritis was just outside statistical significance ($P=0.052$ $n=25$), with no female distal radii and three (30%) male distal radii having osteoarthritis. This demonstrates a trend where males had more distal wrist osteoarthritis than females. No females and three males (15%) had distal ulna osteoarthritis; this was significantly different ($P\leq 0.001$ $n=31$), demonstrating that males had more distal ulna osteoarthritis than females.

Hip joint

Fifteen of 78 (19.2%) hips examined had osteoarthritis. Just one female hip (2.9%) had osteoarthritis whereas six male (20%) hips had osteoarthritis. This prevalence difference was statistically significant ($P=0.001$ $n=78$). In terms of joint surfaces, no female acetabuli were affected, whereas 13 (22.8%) male acetabuli were affected. This difference was statistically significant ($P\leq 0.001$ $n=96$). The proximal femur was affected in one (2.1%) male and one female (4.2%). The prevalence difference was not statistically different ($P=1.000$ $n=72$). Males had more hip osteoarthritis, and this resulted from males having more osteoarthritis in the acetabulum.

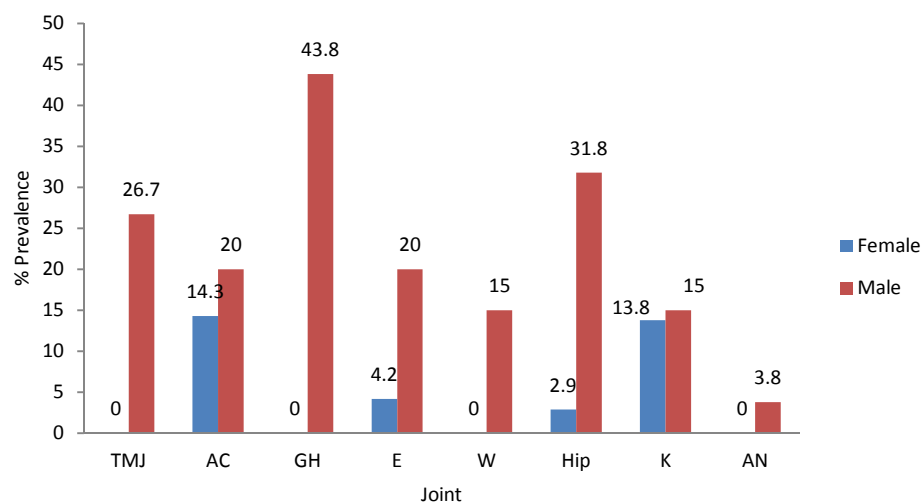
Knee joint

10 of 69 (14.5%) knees had osteoarthritis; four female knees (13.8%) and six male knees had osteoarthritis (15%). The difference in prevalence was not statistically significant ($P=1.000$ $n=69$). In terms of joint surfaces, two female distal femora (8%) and three male distal femora (15.8%) were affected, again the difference in prevalence was not statistically significant ($P=0.638$ $n=44$). Of the patellae, two female surfaces (8.7%) and one male surface (2.8%) were affected. The prevalence difference was not significant ($P=0.557$ $n=58$). Two female proximal tibiae (11.8%) and three male proximal tibiae (11.1 %) were affected with osteoarthritis. The prevalence difference between the sexes was not significant ($P=1.000$ $n=44$). Therefore there was no difference in the amount of knee, or knee joint surface osteoarthritis between sexes.

Ankle joint

One male ankle (2.2%) had osteoarthritis out of the 46 ankles examined. The difference in prevalence between the sexes was not statistically significant ($P=1.000$ $n=46$). The distal tibia and the talus were not affected in either sex and therefore the prevalence did not differ ($P=1.000$: tibia $n=49$, talus $n=37$). One male individual was affected on the fibula, but the difference between the sexes was not statistically significant ($P=1.000$ $n=27$). No difference in the prevalence of ankle osteoarthritis, or the prevalence of distal tibia, fibula or talus osteoarthritis existed between the sexes.

Males, in all cases, had a higher prevalence of osteoarthritis at all joints, and it was clear that males suffered far more from osteoarthritis than women (reinforced by the statistically significant results obtained from the overall prevalence of the disease at the joint and joint surface level). Higher osteoarthritis prevalence for females were observed at the acromion, proximal femur and the patella, however these differences occur by as a result of a single individual and were not statistically significant. Overall, there were some highly significant results between men and women, demonstrating a gender difference in the occurrence of osteoarthritis at the TMJ, glenohumeral and hip joints. Trends were also observed for the wrist and elbow.



Key: TMJ = Temporomandibular, AC = Acromioclavicular, GH = Glenohumeral, E = Elbow, W = wrist, K = Knee and A = Ankle.

Figure 7.4.3 Osteoarthritis by joint and sex for the Visigothic group

When ranking the joints in order of osteoarthritis prevalence by sex, the most affected male joint was the glenohumeral joint (43.8%) where as in females it was the acromioclavicular joint (14.3%). The second most affected male joint was the hip (31.8%) followed by the TMJ (26.7%). In females, the second and third most affected joints were the knee (13.8%) and the elbow (4.2%). Different areas were affected in Visigothic men and women.

In terms of joint surfaces, the most affected male joint surface was the glenoid (39.4%), where as in females, it was the acromion. The second and third most affected male joint surfaces were the distal radius (30%) and the acetabulum (22.8%). In females, the second and third most affected joints were the distal clavicle (16.7%) and the proximal tibia (11.8%). Due to the low prevalence of osteoarthritis in the Visigothic females, it was not possible to carry out a chi-squared test to compare the skeletal distribution pattern of osteoarthritis between sexes. However it is clear that the skeletal pattern was different between males and females, inferring very different patterns of joint loading.

7.4.8 Comparison of Visigothic female and Islamic female osteoarthritis prevalence: changes in female gender ideology

The low prevalence of osteoarthritis in females of both faith groups meant it was not possible to compare the groups in a meaningful way. The areas affected by osteoarthritis were similar between the two faith groups.

7.4.9 Comparison of Visigothic male and Islamic male osteoarthritis prevalence: changes in male gender ideology

Statistically, Visigothic males had more osteoarthritis at all joints than the Islamic males (see table 7.4.20) ($P < 0.001$ $n=761$). This difference was also evident when examining at a joint surface level ($P < 0.001$ $n=2322$).

Table 7.4.18 Osteoarthritis prevalence for Islamic and Visigothic male joints

Joint	Islamic male			Visigothic male			P value	Total
	NO	NA	%A	NO	NA	%A		
Temporomandibular	40	1	2.5	30	8	26.7	0.004	70
Acromioclavicular	66	7	10.6	15	3	20.0	0.383	81
Glenohumeral	64	6	9.4	32	14	43.8	≤0.001	96
Elbow	78	6	7.8	30	6	20.0	0.089	108
Wrist	72	7	9.7	20	3	15.0	0.449	92
Hip	66	5	7.6	44	14	31.8	0.002	110
Knee	77	7	9.1	40	6	15.0	0.363	117
Ankle	61	1	1.6	26	1	3.8	0.511	87
Total	524	40	7.6	237	55	23.2	<0.001	761

Key: NO= number observed, NA=number affected, A = affected.

Table 7.4.19 Total number of joint surfaces observed and affected by osteoarthritis in males

Joint surface	Islamic male			Visigothic males			P Value	Total
	NO	NA	%Affected	NO	NA	%Affected		
Temporal	54	1	1.9	37	5	13.5	0.038	91
Mandibular condyle	53	0	0.0	25	4	16.0	0.002	78
Clavicle	64	4	6.3	12	3	25.0	0.074	76
Acromion	80	7	8.8	6	1	16.7	0.267	86
Proximal humerus	90	7	7.8	33	13	39.4	<0.001	123
Glenoid	112	1	0.9	23	4	17.4	0.003	135
Distal humerus	114	2	1.8	23	4	17.4	0.007	137
Proximal radius	112	0	0.0	30	5	16.7	<0.001	142
Proximal ulna	110	6	5.5	26	3	11.5	0.373	136
Distal radius	99	5	5.1	20	3	15.0	0.131	119
Distal ulna	96	4	4.2	10	3	30.0	0.006	106
Acetabulum	62	6	9.7	57	13	22.8	0.078	119
Proximal femur	91	1	1.1	48	1	2.1	1.000	139
Distal femur	118	3	2.5	19	3	15.8	0.035	137
Patella	110	3	2.7	27	3	11.1	0.091	137
Proximal tibia	112	11	9.8	35	1	2.8	0.295	147
Distal tibia	111	1	0.9	26	0	0.0	1.000	137
Talus	106	0	0.0	17	1	5.9	0.145	123
Distal fibula	124	0	0.0	30	0	0.0	1.000	154
Total	1818	62	3.4	504	71	14.1	<0.001	2322

Key: NO= number observed, NA=number affected.

Temporomandibular joint

Statistically, Visigothic males had a greater prevalence of temporomandibular joint disease than Islamic males ($P=0.004$ $n=70$). Both temporomandibular joint surfaces had a significantly greater osteoarthritis prevalence in Visigothic individuals (temporal $P<0.038$ $n=91$, mandible condyle $P=0.002$ $n=78$). This suggests greater temporomandibular loading in Visigothic males. It is possible that Visigothic males were using the jaw in activity.

Acromioclavicular joint

There was no difference in the prevalence of acromioclavicular osteoarthritis between males of each faith group ($P=0.383$ $n=81$). There was no difference in the prevalence of osteoarthritis at either the acromion, or the clavicle (acromion $P=0.741$ $n=76$, clavicle $P=0.267$ $n=86$), suggesting no difference in the degree of stress at this joint between faith groups.

Glenohumeral joint

There was significantly more glenohumeral osteoarthritis in the Visigothic group ($P\leq 0.001$ $n=91$). Specifically, the glenoid and the humeral head had significantly more osteoarthritis in Visigoths (glenoid $P<0.001$ $n=123$, humerus $P=0.003$ $n=135$), suggesting a greater degree of loading at this joint in Visigothic males.

Elbow joint

There was no difference in the overall prevalence of elbow osteoarthritis between the males of each faith group ($P=0.089$ $n=108$), although it could be argued that a greater prevalence existed in Visigothic men (see table 7.4.22). When observing joint surfaces, Visigothic males had a greater prevalence of osteoarthritis at the distal humerus and the proximal ulna (humerus $P=0.007$ $n=137$, ulna $P\leq 0.001$ $n=142$), but not at the radial head ($P=0.373$ $n=136$). This suggests that Visigothic individuals undertook a greater amount of loaded elbow flexion, and demonstrates the importance of examining joint surfaces in addition to joints.

Wrist joint

There was no difference in the prevalence of wrist osteoarthritis between the Islamic and Visigothic males ($P=0.449$ $n=92$), suggesting a similar level of loading on these joints in the two faith groups. There was no difference in the prevalence of osteoarthritis on the distal ulna between groups ($P=0.131$ $n=119$) but a greater prevalence of distal radius osteoarthritis was observed in Visigothic males ($P=0.006$ $n=106$). This suggested greater distal radius and carpals loading in Visigoths.

Hip joint

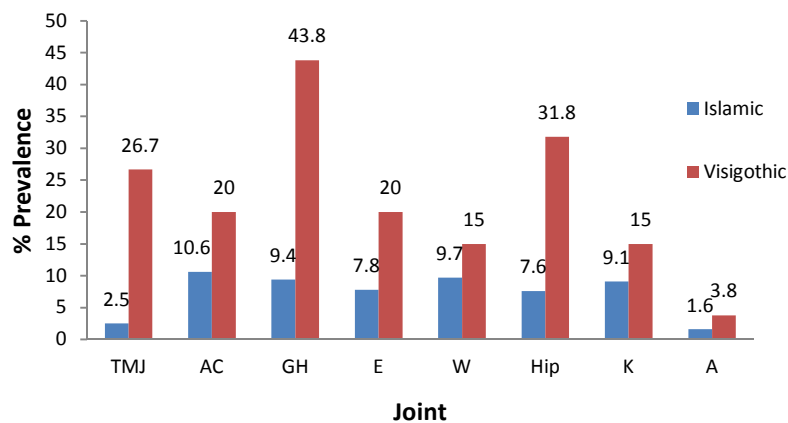
Significantly more hip osteoarthritis was identified in the Visigothic males ($P=0.002$ $n=110$), suggesting greater loading at the hip joint in Visigothic males. This is something that has been identified in rural populations (Thelin and Holmberg 2007) (section 4.6.1). Despite the distinct difference in the prevalence by joint, only the acetabulum exhibited a trend for greater osteoarthritis in Visigothic individuals ($P=0.078$ $n=119$). There was no difference in the amount of osteoarthritis present on the femoral head ($P=1.000$ $n=139$).

Knee joint

There was no difference in knee osteoarthritis prevalence between faith groups for males ($P=0.363$ $n=117$). This suggests similar use of the knee between faith groups and may reflect the idiopathic nature of the disease at this joint. There was more distal femoral osteoarthritis in the Visigothic group ($P=0.035$ $n=137$). The prevalence of patella and proximal tibial osteoarthritis was similar between groups (patella $P=0.091$ $n=137$, proximal tibia $P=0.295$ $n=147$).

Ankle joint

There was no difference in the prevalence of ankle osteoarthritis between Islamic and Visigothic males ($P=0.511$ $n=87$). There was no difference in the prevalence of osteoarthritis on any of the three joint surfaces of the ankle (distal tibia $P=1.000$ $n=137$, distal fibula $P=0.145$ $n=123$, talus $P=1.000$ $n=154$), suggesting similar degree of loading, and a lack of trauma to the ankle joint.



Key TMJ=temporomandibular, AC=acromioclavicular, GH=glenohumeral, E=elbow, W=wrist, K=knee, A=ankle.

Figure 7.3.5 The % prevalence of osteoarthritis for Visigothic and Islamic males.

The skeletal distribution of osteoarthritis was significantly different between the two faith groups. This indicates that the two groups of males had different activity patterns, with Visigothic males undertaking more loaded physical activity ($\chi^2=54.452$ $P<0.001$ 6df). A feature of the Visigothic group was the high prevalence of glenohumeral and hip osteoarthritis.

Summary

Visigothic males had significantly more osteoarthritis than Islamic males at both the joint and joint surface level. In particular Visigothic males may have been using the jaw in activities. A greater prevalence of osteoarthritis was seen at the glenohumeral and hip joints. These are joints commonly affected in farming practices (see section 4.6.1). At a joint surface level, differences in the prevalence of distal humeral, proximal ulna and distal radius osteoarthritis infers a different degree of elbow loading between groups, with a more loaded activity being undertaken in Visigothic men. This may include an activity that does not involve rotation at the proximal radioulnar joint.

7.5 Analysis of absolute long bone measurements and indices

This section explores whether differences in bone length and morphology, and therefore activity, exists between comparison groups set out in section 6.3.1. This was achieved through the analysis of differences in bone measurements and indices between the Islamic and Visigothic groups. The process by which the measurements and indices were selected and calculated is outlined in chapter 6.4.4. The analysis of absolute measurements was carried out prior to the analysis of indices. It was not possible to calculate indices for Visigothic individuals due to bone incompleteness.

Prior to interfaith comparison, intrafaith trends were examined as per section 6.3.1. This permitted a detailed analysis of the two samples and highlighted important changes that may cause interfaith variation. Islamic data are presented prior to Visigothic results.

7.5.1 Absolute bone measurements for the Islamic sample

One hundred and fifty Islamic individuals had at least one long bone available for measurement. The following paragraphs explore the absolute data for the Islamic sample which was analysed following the comparisons set out in section 6.3.1. For each absolute measurement asymmetry was examined to highlight left and right differences.

7.5.1.1 Analysis of sexual difference in absolute bone measurements for the Islamic sample: Analysis of sexual dimorphism

The following section explores absolute measurements by sex in order to ascertain the degree of sexual dimorphism in the Islamic sample as a whole. The dimorphism index (DI) is presented to demonstrate the size difference between males and females. Means and individual numbers are provided. Standard deviations highlight the degree of intra-sex variation for each measurement.

Clavicle

The results in table 7.5.1 indicate that for every clavicle measurement, males were larger than females. For all but the superior-inferior sternal diameter of the left clavicle and the anterior-posterior diameter of the right sternal end, this difference was highly statistically significant (table 7.5.1). The level of sexual dimorphism expressed for each measurement varied with the right acromial superior-inferior diameter proving to be least sexually dimorphic (1.04), and the left midshaft circumference proving to be the

most sexually dimorphic (1.23). The superior-inferior diameter of the sternal clavicle showed the greatest difference in sexual dimorphism between sides (left 1.05, right 1.18). The maximum length of the clavicle had the lowest variation in sexual dimorphism by side (1.09 left 1.08 right).

Table 7.5.1 Absolute clavicle measurements (mm), means, standard deviations and dimorphism index, & GLA results by sex

Measurement	Side	Female			Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
DsistC	L	23.91	31	3.94	25.19	26	2.56	0.158	1.05
	R	22.43	34	3.10	26.42	35	3.92	<0.001	1.18
DapstC	L	18.87	31	2.46	21.15	27	3.93	0.056 ⁺	1.12
	R	19.28	33	3.50	20.91	29	2.47	0.103	1.08
DsiacC	L	10.98	20	1.73	12.28	23	2.20	0.042	1.12
	R	11.98	30	2.17	12.46	36	3.42	0.059	1.04
DapacC	L	21.75	19	3.55	24.54	20	4.40	0.037	1.13
	R	22.00	30	3.41	25.27	34	3.62	0.030	1.15
XLC	L	137.50	16	9.46	150.67	18	8.57	<0.001	1.096
	R	134.00	18	8.98	145.11	18	8.72	0.001	1.08
CmC	L	33.50	14	6.93	41.11	18	5.66	0.030	1.23
	R	35.78	18	3.52	41.89	18	6.39	0.001	1.17
DsimC	L	9.73	15	0.95	11.05	18	1.56	0.014	1.14
	R	9.66	18	1.17	11.40	18	1.83	0.003⁺	1.18
DapmC	L	10.61	15	1.54	12.73	18	1.86	<0.001	1.2
	R	10.74	18	1.21	12.49	18	1.44	0.001	1.16

Key: DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number, DI = dimorphism index, + = Mann Whitney U tested, * = log transformed data.

To explore whether there were differences in the expression of asymmetry between males or females in the Islamic sample, a repeated measures (RPM) test was carried out (table 7.5.2). Only clavicle measurement to be statistically significantly different between sides in females was sternal anterior-posterior diameter. However, in males the superior-inferior diameter of the acromion and the maximum length of the clavicle were statistically significantly different between sides. Asymmetry in the length of the clavicle is thought to be a result of handedness (Mays *et al.* 1999), and could infer a greater expression of handedness in males. These results also demonstrated a difference in asymmetry between men and women for the clavicle.

Table 7.5.2 RPM test results examining asymmetry in male and female clavicle diameters

Measurement	Female			Male		
	P value	n Left	n Right	P value	n Left	n Right
DsistC	0.112	25	25	0.360	11	11
DapstC	0.005	24	24	0.854	15	15
DsiacC	0.090	18	18	0.017	17	17
DapacC	0.119	16	16	0.431	15	15
XLC	0.182	12	12	<0.001	12	12
CmC	0.282	10	10	0.431	8	8
DsimC	0.536	11	11	0.801	8	8
DapmC	0.795	11	11	0.828	8	8

Key: DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft, n = number.

Table 7.5.3 RPM test results for examining clavicle asymmetry differences between Islamic men and women

Clavicle measurement	P value	Female					Male				
		# of pairs	Left		Right		# of pairs	Left		Right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
DsistC	0.084	25	24.34	4.02	23.24	2.91	14	24.85	2.90	25.55	2.87
DapstC	0.165	24	18.76	2.64	19.91	3.37	17	20.43	3.98	20.56	2.16
DsiacC	0.743	18	11.15	1.68	11.89	1.48	15	11.85	2.29	12.77	2.68
DapacC	0.971	16	22.03	3.29	22.91	3.22	12	26.03	5.55	26.88	4.60
XLC	0.013	12	136.08	9.90	134.5	9.18	8	148.13	10.63	142.25	11.13
CmC	0.533	10	35.40	8.93	35.20	2.3	8	40.75	7.30	39.50	6.16
DsimC	0.909	11	9.38	0.83	9.47	1.04	8	11.18	2.26	11.33	2.33
DapmC	1.000	11	10.46	1.61	10.56	1.16	8	11.90	1.69	12.00	1.45

Key: DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, # = number.

When examining the differences in the degree of asymmetry between sexes, the maximum length of the left and right clavicles had a significantly different pattern of asymmetry between males and females ($P=0.013$ $n=20$) (table 7.5.3). Females on average had just 1.6mm difference between left and right clavicles, whereas male clavicles differ by some 5.9mm. This suggested that males are more asymmetric for this diameter than females, again indicative of greater expression of handedness in males. No other measurements had different patterns of asymmetry between the sexes. However, it was worth noting that the sternal superior-inferior diameter neared significance ($P=0.09$ $n=40$). Female left sternal clavicles were 1.1mm larger in the superior-inferior diameter than the right sternal clavicles. In males a reverse trend is evident, whereby male left sternal clavicles were 0.7mm shorter in the superior-inferior dimension than the right equivalent.

Humerus

Table 7.5.4 Absolute humerus measurements (mm), means, standard deviations and dimorphism index, & GLA results by sex

Measurement	Side	Female			Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	N	S.D		
XLH	L	301.58	12	18.66	317.47	15	19.85	0.044	1.053
	R	297.67	12	13.69	317.72	18	16.30	0.002	1.067
phH	L	296.63	8	15.28	314.70	10	19.70	0.056	1.061
	R	294.75	12	16.72	313.13	16	14.31	0.011⁺	1.062
YCH	L	58.24	33	5.71	64.92	38	3.95	<0.001	1.115
	R	59.00	36	4.77	67.87	44	4.34	<0.001⁺	1.151
CHH	L	12.68	12	0.81	13.84	8	0.69	0.004	1.092
	R	12.93	14	0.80	14.27	15	0.59	<0.001	1.104
XDmH	L	20.49	9	1.43	21.85	13	1.74	0.074	1.066
	R	20.63	10	1.42	22.70	21	1.68	0.074	1.100
YDmH	L	16.06	9	2.15	18.28	13	0.80	0.003	1.138
	R	16.19	10	3.01	19.11	21	3.27	<0.001	1.180
XDshH	L	38.71	11	1.71	43.00	9	0.92	<0.001	1.111
	R	39.65	12	5.50	43.09	13	5.15	0.001	1.087
XDtHH	L	40.44	13	2.27	44.07	10	2.26	0.010	1.090
	R	41.36	14	10.86	45.54	18	10.65	0.001	1.101
WPH	L	44.40	12	2.75	47.91	11	2.53	0.007	1.079
	R	46.13	14	9.34	51.81	18	19.70	0.007	1.123
WDH	L	55.48	26	4.35	63.35	25	3.85	<0.001*	1.142
	R	56.23	27	20.76	64.16	27	13.04	<0.001⁺	1.141

Key: XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. S.D = standard deviation, $\bar{x}$ = mean, n = number of individuals, DI = dimorphism index, + = Mann Whitney U tested, * = log transformed data.

Male humeri dimensions were all larger than female dimensions. This was statistically significant for all measurements except for the left and right maximum diameter of midshaft (XDmH), which was close to significance ($P=0.074$ $n=31$). The measurement with the biggest size difference between sexes was the right minimum diameter of the midshaft at 1.18mm. The smallest degree of sexual dimorphism was the maximum length of the left humerus (1.053).

The measurement with the greatest difference in sexual dimorphism between sides was the minimum diameter of the midshaft (1.18 right, 1.14 left). The measurement with the

least variation in sexual dimorphism between sides was the physiological length (1.061 left 1.062 right) and the distal epiphysis breadth (1.142 left and 1.141 right).

Table 7.5.5 RPM test results examining asymmetry in male and female humeral dimensions

Measurement	Female			Male		
	P value	n Left	n Right	P value	n Left	n Right
XLH	0.073	7	7	0.001	10	10
LphH	0.476	7	7	0.314	9	9
YCH	1.000	31	31	0.002	33	33
CHH	0.160	10	10	0.022	7	7
XDmH	0.941	7	7	0.013	14	14
YDmH	0.234	7	7	0.302	14	14
XDsHH	0.219	8	8	0.441	5	5
XDtHH	0.706	10	10	0.600	8	8
WPH	0.283	9	9	0.009	9	9
WDH	0.071	21	21	0.216	17	17

Key: XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CHH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. n = number.

According to RPM tests, no humeral dimensions were significantly different between sides for female individuals. Only the distal epiphysis ($P=0.071$ $n=41$) and the maximum length ($P=0.073$ $n=14$) were close to being statistically asymmetric (table 7.5.13). However in males, five measurements were statistically significantly different between sides: the maximum length, the minimum circumference of the diaphysis, the circumference of the humeral head, the maximum diameter of the midshaft and the width of the proximal epiphysis (table 7.5.5). This demonstrates that males had a marked asymmetry for humeri whereas females did not. These results match with those results obtained for the clavicle, and also the MSM scores (section 7.2.2.1) implying greater expression of handedness in males.

Table 7.5.6 RPM test results for examining humeral asymmetry differences between Islamic men and women

Humerus measurement	P value	Female					Male				
		# pairs	Left		Right		# pairs	Left		Right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
XLH	0.528	7	299.57	14.23	302.57	16.30	10	312.70	14.56	316.70	13.64
LphH	1.000^	7	296.00	18.05	297.57	19.71	9	299.67	17.69	301.10	15.59
YCH	0.060	31	58.80	5.76	58.80	5.09	33	66.55	4.38	67.88	4.97
CHH	0.775	10	12.60	0.57	12.76	0.80	7	13.49	0.73	13.69	0.79
XDmH	0.208	7	20.80	1.46	20.76	1.53	14	21.68	1.75	22.26	1.46
YDmH	0.944	7	16.14	1.71	16.37	1.40	14	17.94	1.16	18.14	1.62
XDsHH	0.712	8	38.11	1.09	39.10	1.90	5	40.96	2.19	41.54	2.99
XDtHH	0.573	10	40.80	2.86	40.59	3.30	8	43.18	2.14	43.35	2.18
WPH	0.855*	9	43.73	2.59	45.28	2.68	9	46.99	2.73	48.39	3.25
WDH	1.000^	21	55.46	4.80	56.02	4.47	17	63.25	3.67	64.07	4.06

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, f = female, m = male, # = number # = number, $\bar{x}$ = mean, * = log transformed data.

The only measurement where there was a trend for a different pattern of asymmetry between men and women was that of the minimum midshaft circumference ($P=0.060$ $n=64$ pairs). Female humeri did not differ at the minimum circumference of the shaft whereas right male humeri were on average 1.33mm larger than the left counterpart.

Radius

Table 7.5.7 Absolute radius measurements (mm), means, standard deviations and dimorphism index, & GLA results by sex

Radius measurement	Side	Female			Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLR	L	222.26	39	15.21	241.48	42	18.59	0.001	1.086
	R	225.54	46	13.29	245.44	63	15.95	<0.001*	1.088
DtmR	L	13.93	36	1.77	15.86	29	1.40	0.001	1.138
	R	14.20	39	1.49	16.22	54	1.38	<0.001	1.142
DapmR	L	10.81	36	1.09	12.33	12	0.74	0.001*	1.141
	R	10.82	39	0.95	12.71	54	1.17	<0.001*	1.175
DthR	L	19.76	41	1.71	23.03	37	2.33	<0.001*	1.165
	R	19.95	55	1.26	22.51	59	1.52	<0.001*	1.128
DXhR	L	20.32	22	1.91	23.35	22	1.82	<0.001*	1.149
	R	20.84	31	2.36	23.36	28	1.17	<0.001	1.121
XWdR	L	29.84	45	2.48	33.58	51	2.19	<0.001	1.125
	R	30.55	42	2.35	34.17	55	2.03	<0.001*	1.118

Key: L = left, R= right, XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number

Males had bigger radius dimensions than females. This was highly statistically significant for all measurements taken for both sides (table 7.5.7). The measurement with the greatest degree of sexual dimorphism was the right anterior-posterior diameter of the midshaft (1.175). The measurements with the smallest level of sexual dimorphism were the left and right maximum lengths of the radius (1.08).

In terms of differences in sexual dimorphism between sides, the measurement with the greatest difference was the transverse diameter of the radial head (1.165 left, 1.128 right) (table 7.5.7). The measurement with least difference in sexual dimorphism between sides was the maximum radius length (1.086 left and 1.088 right).

Table 7.5.8 RPM test results examining asymmetry in male and female radial dimensions

Measurement	Female			Male		
	P value	# Left	# Right	P value	# Left	# Right
XLR	<0.001	28	28	0.040	31	31
DtmR	0.169	25	25	0.103	21	21
DapmR	0.883	25	25	0.592	21	21
DthR	0.023	38	38	0.183	29	29
DXhR	0.050	16	16	0.302	10	10
XWdR	<0.001	35	35	0.017	35	35

Key: L = left, R= right, XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, # = number of pairs

Table 7.5.8 demonstrated that while males and females were both asymmetric for the maximum length of the radius and the radial distal epiphysis, two other measurements were statistically significantly asymmetric in females, the transverse head diameter and the maximum diameter of the radial head. This demonstrates greater asymmetry in the female radius.

Table 7.5.9 RPM test results for examining ulna asymmetry differences between Islamic men and women

Radius	P value	Female					Male				
		# pairs	Left		Right		# pairs	Left		Right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
XLR	0.161*	28	222.43	13.10	225.39	12.4	31	242.06	19.51	243.81	19.27
DtmR	1.000	25	13.81	1.99	14.21	1.45	21	15.88	1.62	16.28	1.52
DapmR	0.947^	16	10.83	1.14	10.74	0.81	7	12.53	0.77	12.6	0.91
DthR	0.080^	23	19.77	1.50	19.89	1.34	16	22.59	2.36	22.43	1.70
DXhR	0.523	16	20.00	1.70	20.28	1.74	10	23.52	1.12	23.7	1.09
XWdR	0.634	35	29.73	2.37	30.42	2.4	35	30.42	2.07	34.14	2.16

Key: L=left, R= right, XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, # = number, *long transformed data, ^ = Kruskal Wallis tested

Table 7.5.9 indicated that there were no statistically significant differences in the pattern of asymmetry experienced between males and females. The asymmetry at the radial head was outside statistical significance suggesting that females had greater asymmetry than males ($P=0.08$ $n=23$ pairs). This conformed to the greater forearm asymmetry observed in female MSMs in section 7.2.2.1. All other measurements had the same degree of asymmetry for both sexes.

Ulna

Table 7.5.10 Absolute ulna measurements (mm), means, standard deviations and dimorphism index, & GLA results by sex

Measurement	Side	Female			Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLU	L	242.25	28	16.24	265.74	34	19.62	<0.001	1.09
	R	245.14	29	13.64	266.84	44	13.04	<0.001	1.08
DapmU	L	14.54	26	1.42	17.04	26	1.76	<0.001	1.17
	R	14.59	27	1.34	17.13	38	1.97	<0.001	1.17
DtmU	L	11.06	25	1.04	13.91	26	1.23	<0.001⁺	1.25
	R	11.89	27	1.45	13.29	37	1.12	<0.001*	1.12

Key: XLU = maximum length of ulna, DapmU = anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, $\bar{x}$ = mean, S.D = standard deviation, n = number, DI = dimorphism index, + = Mann Whitney U tested, * = log transformed data.

Statistically males were larger than females for all diameters of left and right ulnae (table 7.5.10). The measurement which had the greatest difference between males and females was the left mediolateral midshaft diameter (1.25). The measurement with the least level of sexual dimorphism was the right ulna maximum length (1.08). In terms of difference between sides for the level of dimorphism, the mediolateral midshaft was substantially different with the left mediolateral midshaft being much more dimorphic than the right (1.25 and 1.12 respectively). The anterior-posterior diameter, however, did not differ between sides in sexual dimorphism.

Table 7.5.11 Results of a RPM test examining asymmetry in male and female ulna dimensions

Measurement	Female			Male		
	P value	n Left	n Right	P value	n Left	n Right
XLU	<0.001	15	15	0.012	16	16
DapmU	0.535	15	15	0.008	11	11
DtmU	0.028¹	15	15	0.124	11	11

Key: XLU = maximum length of ulna, DapmU = anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, $\bar{x}$ = mean, S.D = standard deviation, n = number, ¹ = Wilcoxon signed ranked test

Both males and females were asymmetric for maximum length of the ulna. In both sexes the right was longer than the left (table 7.5.11). In females the anterior-posterior midshaft diameters were symmetric between sides, whereas in males this was not the case; the right was significantly larger than the left ($P=0.008$ $n=22$). In females, the transverse midshaft diameter was statistically bigger on the right side (table 7.5.11) ($P=0.026$ $n=30$). In males, the transverse diameter was not significantly different between sides. This potentially demonstrates different loading on the ulnae between men and women. This difference may account for the difference in sexual dimorphism for the left and right mediolateral midshaft diameters presented in table 7.5.11.

Table 7.5.12 Ulna asymmetry measurements (mm) by sex

Ulna	P value	Female					Male				
		# pairs	Left		Right		# pairs	Left		Right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
XLU	0.476	15	243.93	13.79	248.07	13.50	16	261.19	15.16	264.31	13.48
DapmU	0.019	15	14.55	1.39	14.66	1.42	11	16.71	1.54	17.55	2.02
DtmU	0.696^	9	11.26	1.19	11.74	1.52	5	14.14	1.21	14.54	1.09

Key: XLU = maximum length of ulna, DapmU = anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, # = number, ^ = Kruskal Wallis tested

RPM tests indicated that the degree of asymmetry experienced by men and women only differed for the anterior-posterior midshaft diameters ($P=0.019$ $n=52$). In females, the right anterior-posterior dimension of the midshaft was 0.11 mm larger than the left counterpart. In males, however the right anterior-posterior dimension of the midshaft was 0.84 mm larger. This suggested that little asymmetry existed in the anterior-posterior diameter of the midshaft in females, but did exist in males.

Summary

As would be expected, males were bigger than females for all absolute measurements. This was statistically significant for all but five measurements (two sternal clavicle measurements and three humeral measurements). This demonstrated that MSM scores did need to be controlled for body size, as was carried out in section 7.2.1.1. In terms of lateral asymmetry, males had a greater degree of asymmetry than females. Seven female measurements were asymmetric, whereas 11 male measurements were asymmetric (five of which were humeral). Different patterns of asymmetry were found between males and females. Males expressed clearer handedness at the clavicle and humerus. Females, however, had greater asymmetry in the forearm. This suggested that males and females were carrying out different activities with the upper limbs and supports the MSM results in section 7.2.2.1.

7.5.1.2 Analysis of temporal difference in absolute measurements in Islamic group: changes in social organisation

The following paragraphs explore whether any differences in bone diameters existed between early and late Islamic individuals for absolute measurements. It also explores the degree of asymmetry expressed in each Islamic phase and compares patterns of asymmetry between phases. As there were different numbers of males and females in the early and late phases, the GLA test was controlled using a hierarchal analysis by using sex as a covariate.

Clavicle

Table 7.5.13 Absolute clavicle measurements (mm), means, standard deviations and GLA results for differences between Islamic phases

Measurement	Side	Early			Late			P value
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D	
DsistC	L	24.29	27	3.75	24.48	30	3.10	0.970
	R	24.10	25	4.02	24.35	34	3.46	0.316
DapstC	L	19.89	27	3.72	20.13	31	3.39	0.400 ⁺
	R	20.53	27	3.06	19.71	36	10.49	0.311
DsiacC	L	12.05	18	2.03	11.41	15	2.20	0.350
	R	12.45	30	1.77	12.17	37	2.54	0.391 ⁺
DapacC	L	23.06	16	4.40	23.32	24	4.27	0.809*
	R	24.12	31	3.07	23.44	34	4.56	0.641
XLC	L	145.21	14	14.33	143.95	20	9.95	0.583
	R	138.26	19	12.36	141.00	17	8.30	0.493
CmC	L	37.15	13	10.41	38.21	19	5.30	0.525*
	R	38.42	19	5.06	39.29	17	7.06	0.765
DsimC	L	10.30	14	1.72	10.56	19	1.49	0.768
	R	10.69	19	1.99	10.35	17	1.59	0.618*
DapmC	L	11.99	14	2.18	11.61	19	1.63	0.315
	R	11.21	19	1.48	12.07	17	1.69	0.098

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number, + = Mann Whitney U tested, * = log transformed data.

As table 7.5.13 indicates, while some variation in clavicle dimensions was observable, none differed significantly between phases, suggesting no temporal change in clavicle size.

According to table 7.5.14, three clavicle measurements were statistically asymmetric, one from the early phase and two from the late phase. The early phase right superior-inferior diameter of the clavicle was 0.39mm larger than the left counterpart ($P=0.048$ $n=9$ pairs). In the late phase, this degree of asymmetry was reduced to 0.21mm, and reversed, left side was larger than the right. Statistical significance was lost ($P=0.855$ $n=44$). The maximum length of the clavicle was asymmetric during the late phase, with the left side 2.95mm longer than the right ($P=0.008$ $n=20$). This suggests greater expression of handedness in late-phase individuals (Mays *et al.* 1999). The late-phase superior-inferior diameter of the sternal clavicle was asymmetric, with the left being

0.13mm larger than the right side ($P=0.048$ $n=40$). While still asymmetric in favour of the right side in the early phase, statistical significance was absent ($P=0.661$ $n=36$).

Table 7.5.14 RPM test results examining asymmetry in early and late clavicle dimensions

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
DsistC	0.661	18	18	0.048	20	20
DapstC	0.370	17	17	0.344	22	22
DsiacC	0.852	14	14	0.816	17	17
DapacC	0.567	12	12	0.813	14	14
XLC	0.110	9	9	0.008	10	10
CmC	0.557	8	8	0.492	9	9
DsimC	0.048	9	9	0.973	9	9
DapmC	0.343	9	9	0.994	9	9

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number

Table 7.5.15 RPM test results examining clavicle asymmetry differences between early and late Islamic individuals

Measurement	P value	Early					Late				
		n	left		Right		n	Left		right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
DsistC	0.128	18	24.97	4.04	23.68	3.51	22	24.17	3.26	24.46	2.71
DapstC	0.043	17	18.41	2.43	20.00	2.9	24	20.19	3.7	20.31	2.99
DsiacC	0.689	14	11.61	1.95	12.30	1.97	19	11.36	2.05	12.28	2.28
DapacC	0.741	12	23.02	4.99	23.68	4.28	16	24.29	4.66	25.31	4.29
XLC	0.421	9	139.33	13.17	135.22	12.35	11	142.18	10.66	139.55	8.78
CmC	0.756	8	37.38	11.77	37.00	5.13	10	38.10	6.24	37.20	4.85
DsimC	0.325	9	9.66	1.62	10.03	2.01	10	10.57	1.9	10.45	1.86
DapmC	0.302	9	10.97	10.97	10.76	10.76	10	11.16	11.16	11.54	11.54

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number of pairs, + = Mann Whitney U tested, * = log transformed data.

Statistically, the only measurement that showed a difference in asymmetry between phases was the sternal anterior-posterior diameter ($P=0.043$ $n=82$) (table 7.5.15). In the early phase, the right sternal end of the clavicle was 1.6mm larger. This difference was reduced to just 0.12mm in the late phase with the right sternal end still being larger.

Humerus

Table 7.5.16 Absolute humerus measurements (mm), means, standard deviations and GLA results for differences between Islamic phases

Measurement	Side	Early		Late				P value
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D	
XLH	L	308.17	12	18.73	312.20	15	22.45	0.743
	R	310.67	15	18.65	308.05	22	18.02	0.763
LphH	L	305.87	8	17.53	307.30	10	18.55	0.256 ⁺
	R	306.07	14	17.50	298.33	21	19.66	0.127
YCH	L	62.57	35	6.39	62.05	44	6.34	0.218
	R	63.63	40	6.09	63.38	47	6.65	0.389
CHH	L	13.22	11	0.59	13.06	14	1.12	0.109
	R	13.74	15	0.85	13.40	21	1.02	0.090
XDmH	L	21.04	11	1.43	21.47	16	1.86	0.903
	R	22.31	15	1.88	21.89	23	1.71	0.357
YDmH	L	17.11	11	2.12	17.24	16	1.57	0.288
	R	17.88	115	2.33	17.44	23	2.13	0.877
XDshH	L	39.61	12	2.38	40.77	14	2.52	0.683
	R	41.98	14	2.37	40.21	18	2.78	0.026
XDtHH	L	41.80	13	2.52	42.57	15	3.41	0.337
	R	44.10	18	3.92	43.01	21	3.65	0.361
WPH	L	45.66	11	3.79	46.07	17	3.18	0.376
	R	49.65	17	3.45	47.55	22	3.75	0.010*
WDH	L	58.32	26	5.76	59.70	31	5.44	0.343*
	R	59.89	30	5.43	60.41	32	5.73	0.678

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, n = number, SD = standard deviation, * = log transformed data, n = number of individuals, + = Mann Whitney U tested, * = log transformed data.

Table 7.5.16 indicates that, statistically, there were two differences between the early and late phase humeral dimensions, suggesting some temporal change in proximal humeral morphology over time. The right sagittal diameter of the head ($P=0.026$ $n=32$) and the right proximal epiphysis breadth ($P=0.01$ $n=39$), were smaller in the late phase.

Table 7.5.17 RPM test results examining asymmetry in early and late humeral dimensions

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
XLH	0.643	6	6	0.528	17	17
LphH	0.894	5	5	0.958	16	16
YCH	0.212	28	28	0.069	64	64
CHH	0.721	8	8	0.775	17	17
XDmH	0.496	7	7	0.208	21	21
YDmH	0.950	7	7	0.944	21	21
XDsHH	0.307	6	6	0.712	13	13
XDtHH	0.954	8	8	0.453	10	10
WPH	0.968	6	6	0.919	18	18
WDH	0.622	18	18	0.699	38	38

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, n = number, SD = standard deviation, * = log transformed data, n = number of individuals, + = Mann Whitney U tested, * = log transformed data.

There was no significant asymmetry for the dimensions of the early or late humeri (table 7.5.17) suggesting that the humerus was symmetric for all measurements in both phases.

Table 7.5.18 RPM test results examining humeral asymmetry differences between early and late Islamic individuals

Measurement	P value	Early					Late				
		n	left		right		n	Left		right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
XLH	0.028	6	310.17	15.33	315.83	16.52	11	305.73	16.07	308.18	15.81
LphH	0.233^	4	311.75	12.4	314.75	10.69	8	301.25	17.91	301.25	16.98
YCH	0.440	28	63.14	6.15	63.71	6.38	36	62.56	6.62	63.33	7.12
CCH	0.439	8	13.01	0.55	13.24	0.73	9	12.92	0.95	13.06	1.08
XDmH	0.892	7	21.6	1.14	21.87	1.31	14	21.28	1.92	21.71	1.80
XDmH	0.525	7	17.79	1.47	17.87	1.20	14	17.11	1.64	17.39	1.98
XDsHH	0.375	6	38.83	1.96	40.23	1.51	7	39.53	2.30	39.87	3.36
XDtHH	0.561	8	42.29	2.17	41.96	2.94	10	41.51	3.25	41.70	3.41
WPH	0.312^	6	43.87	3.26	46.67	2.24	18	46.11	2.82	46.92	3.81
WDH	0.425^	15	58.25	6.57	59.09	6.27	16	60.06	5.12	60.51	5.62

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n= number, ^ = Kruskal Wallis tested.

When examining changes in the degree of asymmetry experienced in each phase, the maximum length of the humerus is the only measurement with differences between phases ($P=0.028$ $n=34$). In the early phase, the right side was 5.8mm longer than the left counterpart. This trend was reduced in the late phase, where the right humerus was 1.8mm longer than the left. This demonstrates a loss of asymmetry over time. All other measurements demonstrate consistent asymmetry over time (see table 7.5.18).

Radius

Table 7.5.19 Absolute radial measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between Islamic phases

Measurement	Side	Early			Late			P value
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D	
XLR	L	234.29	24	23.17	231.35	57	17.90	0.521 ⁺
	R	237.15	40	17.81	236.99	69	17.94	0.859
DtmR	L	14.67	15	2.33	14.76	19	1.98	0.321*
	R	15.20	35	1.53	15.48	58	1.86	0.414
DapmR	L	11.35	15	1.44	11.40	19	1.09	0.103
	R	11.89	35	1.27	11.94	58	1.53	0.996*
DthR	L	21.38	21	2.84	21.30	26	2.07	0.111
	R	21.30	46	1.86	21.25	68	1.93	0.962 ⁺
DXhR	L	21.82	19	2.76	21.71	23	2.17	0.223
	R	21.79	34	1.71	22.37	35	2.15	0.936
XWdR	L	31.27	32	3.28	32.10	64	2.81	0.737
	R	32.06	38	2.81	32.95	59	2.79	0.077

Key: L = left, R = right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number, + = Mann Whitney U tested, * = log transformed data.

Table 7.5.19 demonstrated no significant differences between the early and late radii measurements. However, the distal end of the right radius was close to statistical significance ($P=0.077$ $n=97$) suggesting a trend for larger distal radii in the later phase.

Table 7.5.20 RPM test results examining asymmetry in early and late radial dimensions.

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
XLR	0.322	18	18	0.415	41	41
DtmR	0.753	14	14	0.901	32	32
DapmR	0.504	14	14	0.491	32	32
DthR	0.700	21	21	0.045	46	46
DXhR	0.455	12	12	0.525	14	14
XWdR	0.589	25	25	0.851	45	45

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number

According to RPM tests, neither early- nor late-phase individuals had asymmetric radial measurements, except for the transverse head diameter in late-phase individuals ($P=0.045$ $n=96$) (table 7.5.20). In early-phase individuals, the left transverse head measurement was 0.07mm larger than the right equivalent. The difference between the means was less than in the late phase (0.19mm) (table 7.5.21), however, the smaller sample number makes this difference less significant, but worthy of note.

Table 7.5.21 RPM test results examining radial asymmetry differences between early and late Islamic individuals

Measurement	P value	Early					Late				
		#	Left		right		#	left		right	
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD
XLR	0.974^	11	229.55	22.02	232.09	21.01	12	233.17	18.32	233.75	17.84
DtmR	0.163	14	14.85	2.48	14.86	1.58	32	14.72	1.94	15.23	1.90
DapmR	0.369*	14	11.64	1.43	11.55	1.28	32	11.50	1.21	11.59	1.16
DthR	0.895^	21	21.03	2.42	21.10	2.17	46	21.05	2.61	20.86	1.89
DXhR	0.148	12	20.783	2.17	21.19	2.10	14	21.84	2.34	21.95	2.41
XWdR	0.746	25	30.99	3.09	31.55	3.19	45	31.66	2.82	32.28	2.75

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, # = number of pairs, ^ = Kruskal Wallis tested, * log transformed data.

When assessing whether variation in asymmetry patterns occurred diachronically for any radial measurements, RPM tests for parametric and Kruskal-Wallis tests for non-parametric data were carried out. There was no change in asymmetry over time (table 7.5.21).

Ulna

Table 7.5.22 Absolute ulna measurements (mm), means, standard deviations and GLA results for differences between Islamic phases

Measurement	Side	Early			Late			P value
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D	
XLU	L	257.90	21	22.55	253.71	41	21.15	0.999
	R	254.42	31	15.05	259.55	42	18.34	0.267
DapmU	L	16.18	16	2.04	15.62	36	2.03	0.824
	R	15.79	27	1.89	16.28	38	2.03	0.172
DtmU	L	13.39	15	1.91	12.14	36	1.69	0.087*
	R	13.36	27	1.76	13.25	38	1.73	0.883 ⁺

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, n = number, + = Mann Whitney U tested, * = log transformed data.

Table 7.5.22 indicated that only the transverse midshaft of the left ulna changed in size over time ($P=0.087$ $n=51$), but the difference was not significant. Late right ulnae are 1.25mm smaller at the midshaft anterior-posterior plane than the early phase equivalent.

Table 7.5.23 RPM test results examining asymmetry in early and late ulna dimensions.

Measurement	Early			Late		
	P value with sex	n Left	n Right	P value with sex	n Left	n Right
XLU	0.032	9	9	0.955	22	22
DapmU	0.242	6	6	0.068	20	20
DtmU	0.851	6	6	0.348	20	20

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, n = number

Only the early maximum length of the ulna was statistically asymmetric ($P=0.032$ $n=18$), indicating that, although the left ulna was significantly longer than the right equivalent, little change in ulna dimensions occurred over time (table 7.5.23).

Table 7.5.24. RPM test results examining ulna asymmetry differences between early and late Islamic individuals

Measurement	P value	Early						Late					
		#	left		right		#	left		right			
			$\bar{x}$	SD	$\bar{x}$	SD		$\bar{x}$	SD	$\bar{x}$	SD		
XLU	0.727	9	252.90	16.34	256.90	14.22	22	252.80	17.29	256.20	16.48		
DapmU	0.662	6	15.73	1.98	16.28	2.44	20	15.39	1.78	15.77	2.20		
DtmU	0.831^	6	12.52	1.7	12.97	2.11	20	12.09	1.86	12.55	1.79		

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse midshaft diameter, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, # = number of pairs, ^ = Kruskal Wallis tested.

There were no significant size differences between the early and late ulnae (table 7.5.24 for P values). In both phases, for all three measurements, the right ulna was larger than the left. The mediolateral diameter of the ulna midshaft showed a non-significant decrease in size on both the left and the right sides.

Summary

Statistically there were no differences in the absolute measurements between phases. However, some differences in asymmetry could be observed particularly for the clavicle and the transverse diameter of the radial head. This suggests that diachronic changes in bone morphology may have been masked by pooling the sexes together.

7.5.1.3 Analysis of temporal difference in absolute measurements in Islamic females: changing female activity and identity

Clavicle

Table 7.5.25 Absolute clavicle measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic females.

Measurement	Side	Early female		Late female		P value
		n	$\bar{x}$	N	$\bar{x}$	
DsistC	L	15	23.52	16	25.71	0.603
	R	13	22.00	21	22.70	0.528
DapstC	L	15	18.57	16	19.16	0.418 ⁺
	R	14	19.69	19	18.97	0.587
DsiacC	L	8	11.30	12	10.77	0.509
	R	12	19.91	18	12.03	0.882
DapacC	L	8	22.39	11	21.28	0.450
	R	13	23.21	17	21.08	0.098
XLC	L	7	137.43	9	137.56	0.981
	R	10	132.10	8	136.38	0.362
CmC	L	6	31.17	8	35.25	0.370
	R	7	35.60	8	36.00	0.826
DsimC	L	7	9.20	8	10.19	0.050
	R	10	9.76	8	9.53	0.532 ⁺
DapmC	L	7	10.56	8	10.66	0.897
	R	10	10.37	8	11.21	0.168

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number + = Mann Whitney U tested, * = log transformed data.

According to table 7.5.25, only the size of left superior-inferior diameter of the clavicle midshaft differed between phases (9.2mm early, 10.2mm late) ($P=0.05$ $n=28$). The early females also tended to have wider acromial ends than late females (23.20 mm early, 21.08 mm late) ($P=0.09$ $n=30$).

Table 7.5.26 RPM test asymmetry results for left and right female clavicle measurements by phase.

Measurement	Early			Late		
	P value	# Left	# Right	P value	# Left	# Right
DsistC	0.137	11	11	0.241	12	12
DapstC	0.002	11	11	0.301	11	11
DsiacC	0.326	8	8	0.270	8	8
DapacC	0.284	8	8	0.781	6	6
XLC	0.118	7	7	0.889	4	4
CmC	0.475	6	6	0.580	3	3
DsimC	0.270	7	7	0.754	3	3
DapmC	0.867	7	7	0.504	3	3

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, # = number of pairs

According to table 7.5.26, only the early sternal clavicle end anterior-posterior diameter was statistically asymmetric ($P=0.002$ $n=22$). According to table 7.5.33 the left anterior-posterior sternal end diameter was 1.8mm smaller than the right. This difference was halved in late females and the statistical significance was lost ($P=0.301$ $n=16$).

Table 7.5.27 RPM test results examining clavicle asymmetry differences between early and late female Islamic individuals

Measurement	Early Female				Late female				# pairs	P value
	left		right		left		right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
DsistC	24.19	4.52	22.63	3.39	24.46	3.75	23.72	2.49	25	0.549
DapstC	18.37	2.72	20.17	3.43	19.08	2.64	19.69	3.45	24	0.109
DsiacC	11.30	1.66	11.93	1.49	11.03	1.77	11.86	1.55	18	0.813
DapacC	22.39	4.32	23.31	3.91	21.68	2.06	22.51	2.57	16	0.938
XLC	137.43	12.49	134.57	12.21	134.20	5.26	134.40	2.88	13	0.187
CmC	31.17	11.51	35.67	2.944	34.25	3.30	34.5	0.58	10	0.665^
DsimC	9.2	0.99	9.4	1.27	9.7	0.35	9.6	0.83	11	1.000^
DapmC	10.56	1.34	10.50	1.38	10.30	2.23	10.68	0.78	11	0.606

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, # = number. ^ = Kruskal Wallis tested.

Statistically, there was no difference in asymmetry experienced between early and late females (table 7.5.27).

Humerus

Table 7.5.28 Absolute humeral measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic females

Humerus	Side	Early female		Late female		P value
		n	$\bar{x}$	n	$\bar{x}$	
XLH	L	8	305.00	4	294.75	0.395
	R	6	301.67	10	296.60	0.513
phH	L	5	298.80	5	288.00	0.349
	R	7	296.71	9	288.22	0.184 ⁺
YCH	L	17	58.94	20	57.40	0.411
	R	20	59.65	20	58.10	0.170 ⁺
CHH	L	8	13.08	6	12.13	0.022
	R	8	13.20	10	12.73	0.389
XDmH	L	7	21.00	4	19.73	0.171
	R	5	21.32	9	20.63	0.414
YDmH	L	7	16.34	4	15.56	0.573
	R	5	15.98	9	15.59	0.926
XDshH	L	9	38.58	5	38.54	0.967
	R	7	40.56	9	38.60	0.156
XDtHH	L	10	41.38	5	39.08	0.108
	R	8	42.29	10	40.67	0.470
WPH	L	8	44.94	6	42.98	0.263
	R	8	47.66	10	44.93	0.070
WDH	L	17	55.99	13	54.72	0.630 ⁺
	R	17	56.58	14	55.89	0.857 ⁺

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number, ⁺ = Mann Whitney U tested.

The humeral dimensions, like those of the clavicle, varied little over time, and just two dimensions were statistically significantly different between early and late women (table 7.5.28). The minimum circumference of the left humeral head was larger in the early females (13.08mm) than in the late females (12.13mm) ($P=0.028$ $n=14$). Some caution was required, as only 14 humeral heads were observable across the two phases combined. While not statistically significant ($P=0.07$ $n=18$), the right proximal epiphysis breadth was also larger in early females (47.66mm) than late females

(44.93mm). As articular surfaces may be responsive to mechanical loading before puberty, this may suggest that early females were either undertaking more asymmetrical physical activity than late females, or were starting the activity earlier in life. Of further note was that in general, female humeral dimensions decreased over time, but not significantly.

Table 7.5.29 RPM test asymmetry results for left and right female humeral measurements by phase

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
XLH	0.026	3	3	0.572	4	4
LphH	0.408	3	3	1.000	4	4
YCH	0.827	15	15	0.588	16	16
CHH	0.203	6	6	0.622	4	4
XDmH	0.863	3	3	0.744	4	4
YDmH	0.840	3	3	0.007	4	4
XDsHH	0.125	5	5	0.420	3	3
XDtHH	0.754	6	6	0.834	4	4
WPH	0.286	5	5	0.911	4	4
WDH	0.103	12	12	0.464	9	9

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, # = number

Statistically, one measurement in each phase appeared to be asymmetric, the maximum length of the humerus in early females, and the minimum diaphysis diameter in late females (table 7.5.29). Otherwise, there was little difference in asymmetry between the early and late females. It should be remembered that the number of female humeri was small requiring caution when interpreting the results. However, the distal epiphysis and the minimum circumference of the shaft, where the sample numbers were higher, remain symmetric over time (early: YCH P=0.827 n=30, WDH P=0.103 n=24. Late: YCH P=0.588 n=32, WDH P=0.464 n=18).

Table 7.5.30 RPM test results examining humeral asymmetry differences between early and late female Islamic individuals

Measurement	Early Female				Late female				# pairs	P Value
	left		right		left		right			
	ȳ	SD	ȳ	SD	ȳ	SD	ȳ	SD		
XLH	306.00	20.81	311.33	21.94	294.75	6.65	296.00	8.72	14	0.208^
LphH	309.67	17.04	313.33	14.22	285.75	11.47	285.75	14.39	7	0.430
YCH	59.93	6.285	59.67	5.07	59.93	6.29	59.67	5.76	29	0.673^
CCH	12.85	0.45	13.05	0.73	12.23	0.57	12.33	0.79	10	0.668^
XDmH	22.23	0.78	21.97	0.65	19.73	0.51	19.85	0.65	7	0.761
YDmH	16.90	2.10	17.00	1.48	15.58	1.38	15.90	1.33	7	0.476^
XDsHH	38.10	0.88	39.96	1.51	38.13	1.63	37.67	1.78	8	0.130
XDtHH	42.18	2.51	41.88	3.45	38.73	2.14	38.65	2.10	10	0.286^
WPH	43.96	3.63	46.80	2.48	43.45	0.33	43.38	1.50	9	0.311
WDH	55.52	6.09	56.37	5.65	55.39	2.55	55.57	2.35	21	0.269

Key: XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, # = number, ^ = Kruskal wallis test

Statistically there was no difference in the degree of asymmetry for female humeral measurements over time (table 7.5.30).

Radius

Table 7.5.31 Absolute radial measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic females

Radius	Side	Early female		Late female		P value
		n	$\bar{x}$	n	$\bar{x}$	
XLR	L	12	226.00	27	220.74	0.963 ⁺
	R	16	226.00	30	225.53	0.994
DtmR	L	12	14.30	24	13.77	0.712 ⁺
	R	15	14.10	24	14.24	0.965 ⁺
DapmR	L	12	11.10	24	10.67	0.470 ⁺
	R	15	10.90	24	10.78	0.773 ⁺
DthR	L	15	20.50	26	19.36	0.049
	R	21	20.20	34	19.78	0.214
DXhR	L	12	20.80	10	19.77	0.322 ⁺
	R	17	20.80	14	20.14	0.207
XWdR	L	17	29.30	28	30.19	0.232
	R	17	30.00	25	30.93	0.214 ⁺

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number, + = Mann Whitney U tested,

Radial diameters changed little over time in Islamic females (table 7.5.31). The only diameter that was statistically significantly different was the left radial head transverse diameter (P=0.049 n=41). The early females had larger transverse head diameters than late females (early 20.45 mm, late 19.37mm).

Table 7.5.32 RPM test asymmetry results for left and right female radii measurements by phase

Measurement	Early			Late		
	P value	# Left	# Right	P value	# Left	# Right
XLR	0.025	10	10	<0.001	18	18
DtmR	0.870	10	10	0.009	15	15
DapmR	0.550	10	10	0.185	15	15
DthR	0.552	13	13	0.009	25	25
DXhR	0.006	10	10	1.000	6	6
XWdR	0.021	15	15	0.004	20	20

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, # = number

Changes in asymmetry were observed for female radii over time (table 7.5.32). In both phases the maximum length of the radius was statistically asymmetric (early $P=0.025$ $n=20$, late $P<0.001$ $n=18$). The distal epiphysis width was also asymmetric in both phases (early $P=0.021$ $n=30$, late $P=0.004$ $n=40$). The transverse midshaft diameter was not statistically asymmetric in the early females, but was in late females ($P=0.009$ $n=30$). The left radius was narrower in the transverse plane than the right equivalent (table 7.5.32) ($P=0.009$ $n=30$). The transverse radial head diameter was not asymmetric in the early phase ($P=0.552$ $n=26$), but was in the late phase ($P=0.009$ $n=50$) (table 7.5.32). Interestingly the maximum diameter of the head was statistically asymmetrical in the early phase ($P=0.006$ $n=20$), but not in the late phase ($P=1.000$ $n=12$). This result was confusing and difficult to comment upon but may reflect a change in the shape of the radius. Overall, the late females experience more asymmetry than early individuals. This was notably, a different pattern from the humerus.

Table 7.5.33 RPM test results examining radial asymmetry differences between early and late female Islamic individuals

Measurement	Early Female				Late female				# pairs	P Value
	left		right		Left		right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
XLR	225.40	15.11	228.40	13.83	220.78	11.99	223.72	11.60	28	0.971
DtmR	14.25	2.64	14.36	1.58	13.52	1.44	14.11	1.40	25	0.413
DapmR	11.14	1.32	10.96	0.83	10.60	0.99	10.75	0.81	25	0.231
DthR	20.10	2.18	20.23	1.81	19.34	0.95	19.62	1.00	38	0.473
DXhR	20.25	2.00	20.74	2.01	19.53	1.01	19.53	0.87	16	0.100
XWdR	29.07	2.16	29.76	21.74	30.23	2.46	30.92	2.49	35	0.996

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, # = number

Statistically, there was no difference in the degree of asymmetry experienced by early and late females for any of the radial dimensions (table 7.5.33).

Ulna

Table 7.5.34 Absolute ulna measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic females

Measurement	Side	Early female		Late female		P value
		n	$\bar{x}$	n	$\bar{x}$	
XLU	L	7	245.00	21	241.30	0.596
	R	12	246.00	17	244.71	0.843
DapmU	L	6	14.50	20	14.55	0.916
	R	11	14.30	15	14.81	0.348
DtmU	L	5	11.00	20	11.06	0.759 ⁺
	R	11	11.90	16	11.85	0.767 ⁺

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, $\bar{x}$ = mean, S.D = standard deviation, n = number, + = Mann Whitney U tested, L = left, R = right, ⁺ Man Whitney U tested.

There was no statistical difference between early and late females for the dimensions of the ulna (table 7.5.34).

Table 7.5.35 RPM test asymmetry results for left and right female ulna measurements by phase

Measurement	Early			Late		
	P value	# Left	# Right	P value	# Left	# Right
XLU	0.017	3	3	0.004	12	12
DapmU	0.924	3	3	0.496	12	12
DtmU	0.593 ¹	3	3	0.047¹	12	12

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, n = number, ¹ = Wilcoxon test

In both phases, the maximum length of the ulna was asymmetric in females (table 7.5.35) and, in both cases, the right was longer than the left. While the anterior-posterior diameter was symmetric in early and late females (table 7.5.35), the transverse midshaft diameter was asymmetric in late phase females only (P=0.047 n=24).

Table 7.5.36 RPM test results examining ulna asymmetry differences between early and late female Islamic individuals

Measurement	Early Female				Late female				# pairs	P value
	left		right		left		Right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
XLU	240.00	11.53	246.67	12.01	244.92	14.58	248.42	14.32	15	0.141
DapmU	14.47	0.50	14.53	1.56	14.58	1.56	14.69	1.47	15	0.91
DtmU	11.07	1.29	11.43	1.62	11.04	1.29	11.43	1.62	15	0.664^

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, $\bar{x}$ = mean, S.D = standard deviation, # = number. $\bar{x}$ = mean, # = number, ^ = Kruskal Wallis tested.

Statistically, there was no difference in the degree of ulna asymmetry experienced between early females and late females (table 7.5.36).

Summary

Some differences between early females and late females were observed. Just three left absolute measurements varied by phase, the superior-inferior midshaft diameter of the clavicle, the humeral head maximum circumference and the radial head transverse diameter. The former was larger in the late phase, while the latter two were larger in the early phase. This demonstrated little change in the size of female dimensions over time. However, there was no indication of a statistically significant change in maximum long-bone lengths, and therefore stature. In terms of asymmetry differences, six measurements were asymmetric in the early phase and seven in the late phase. Of these thirteen statistically asymmetric measurements, just six measurements were statistically significant in both phases; the maximum length of the ulna, the maximum length of the radius and the distal width of the radius. Different areas of the skeleton were asymmetric in each phase, particularly the ulnae and radii, suggesting a temporal change in the use of the forearm in females.

7.5.1.4 Analysis of temporal difference in absolute measurements in Islamic males: changing male activity and identity

Clavicle

Table 7.5.37 Absolute clavicle measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic males

Measurement	Side	Early male			Late male			P value
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
DsistC	L	12	25.74	2.60	14	24.74	2.42	0.339
	R	11	25.89	2.93	14	26.83	2.85	0.428
DapstC	L	12	21.20	4.58	15	21.09	3.92	0.804 ⁺
	R	12	21.46	2.51	17	20.53	2.10	0.288
DsiacC	L	10	12.65	2.17	13	12.00	2.40	0.510
	R	17	12.65	1.93	19	12.30	2.48	0.645
DapacC	L	8	23.73	4.65	13	25.04	4.84	0.548
	R	17	24.27	2.83	17	25.79	4.44	0.418
XLC	L	7	153.00	12.15	11	149.20	7.80	0.428
	R	9	145.10	9.37	9	145.11	8.28	1.000
CmC	L	7	42.30	6.29	11	40.36	5.07	0.485
	R	9	41.56	5.25	9	42.20	7.73	0.833
DsimC	L	7	11.40	1.61	11	10.83	1.83	0.508
	R	9	11.72	2.06	9	11.08	1.86	0.627 ⁺
DapmC	L	7	13.43	1.93	11	12.29	1.25	0.146
	R	9	12.14	1.26	9	12.83	1.68	0.340

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number, + = Mann Whitney U tested, * = log transformed data.

Statistically, there were no temporal changes in male clavicle diameters (table 7.5.37).

Table 7.5.38 RPM test asymmetry results for left and right male clavicle measurements by phase

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
DsistC	0.497	7	7	0.014	8	8
DapstC	0.016	6	6	0.660	11	11
DsiacC	0.209	6	6	0.060	9	9
DapacC	0.913	4	4	0.446	8	8
XLC	0.037	2	2	0.003	6	6
CmC	1.000	2	2	0.383	6	6
DsimC	0.126	2	2	0.864	6	6
DapmC	0.403	2	2	0.503	6	6

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number

In both phases, the maximum length of the clavicle was asymmetric (early $P=0.037$ $n=8$, late $P=0.003$ $n=12$), but in both cases the sample sizes were low (table 7.5.38). Statistically, in early males, the anterior-posterior diameter of the sternal clavicle end was asymmetric ($P=0.016$ $n=12$), which was not the case in late males ($P=0.660$ $n=22$). Interestingly, the superior-inferior diameter of the sternal clavicle end was statistically asymmetric in late males ($P=0.014$ $n=16$), but not in early males ($P=0.497$ $n=14$). This suggests that the arms may be being used in an asymmetrical task, but that that task or activity may have changed over time. Furthermore, although not statistically significant, asymmetry was noted in the acromial superior-inferior diameter in the late phase ($P=0.060$ $n=18$). This suggests a strong trend where asymmetry was experienced at the acromial end by late males and not early males.

Table 7.5.39 RPM test results examining clavicle asymmetry differences between early and late male Islamic individuals

Measurements	Early male				Late male				# pairs	P Value
	Left		right		left		right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
DsistC	26.20	3.06	25.33	3.23	23.66	2.33	25.75	2.74	15	0.043
DapstC	18.47	2.05	19.68	1.78	21.50	4.44	21.04	2.28	17	0.257
DsiacC	12.02	2.38	12.80	2.54	11.73	2.37	12.74	2.92	15	0.756
DapacC	24.28	6.68	24.40	5.51	26.91	5.16	28.11	3.87	12	0.646
XLC	146.00	18.39	137.50	17.68	148.83	9.39	143.83	9.95	8	0.087
CmC	41.00	12.73	41.00	9.89	40.67	6.62	39.00	5.69	8	0.652
DsimC	11.25	2.90	12.25	3.18	11.15	2.33	11.02	2.26	8	0.434
DapmC	12.40	3.25	11.65	2.47	11.73	1.33	12.12	1.29	8	0.303

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, # = number.

The RPM analysis suggests that the asymmetry experienced at the superior-inferior sternal end diameter of the clavicle was statistically different between phases (table 7.5.39). In early males, the left sternal superior-inferior diameter was larger than the corresponding right diameter by 0.87mm. In late males the right diameter was 2.9mm larger than the left, demonstrating a reversal in the pattern of asymmetry and change in activity patterns ($P=0.043$ $n=15$ pairs).

Humerus

Table 7.5.40 Absolute humerus measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic males

Humerus	Side	Early male			Late male			P value
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
XLH	L	4	314.50	8.27	11	318.55	22.94	0.741
	R	9	316.70	17.82	12	317.33	17.43	0.933
phH	L	4	311.30	8.26	8	306.38	29.80	0.760
	R	7	315.40	20.17	12	305.90	12.22	0.318 ⁺
YCH	L	17	66.47	3.57	24	65.92	12.93	0.342
	R	20	67.70	4.99	27	67.30	4.67	0.854 ⁺
CHH	L	3	13.60	0.53	8	13.76	0.77	0.749
	R	7	14.37	0.77	11	14.01	0.46	0.281
XDmH	L	4	21.13	1.21	12	22.05	1.79	0.357
	R	10	22.81	1.65	14	22.70	1.86	0.871
YDmH	L	4	18.45	1.22	12	17.80	0.10	0.316
	R	10	18.83	2.20	14	18.43	2.01	0.612
XDshH	L	3	42.70	2.16	9	42.01	0.17	0.605
	R	7	43.40	2.59	9	41.81	1.93	0.198
XDtHH	L	3	43.47	2.48	10	44.31	1.70	0.598
	R	10	45.55	2.59	11	45.14	3.99	0.779
WPH	L	3	47.57	3.67	11	47.76	2.47	0.917
	R	8	51.64	3.17	12	49.73	5.58	0.196
WDH	L	9	62.71	3.89	18	63.29	3.66	0.681 ⁺
	R	13	64.24	4.36	18	63.92	1.42	0.857 ⁺

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number, + = Mann Whitney U tested, L = left, R = right, $\bar{x}$ = mean

Unlike females, there were no differences in the dimensions of the humerus in males between phases (see table 7.5.40 for P values).

Table 7.5.41 RPM test asymmetry results for left and right male humeral measurements by phase

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
XLH	0.027	3	3	0.023	7	7
LphH	0.205	2	2	0.579	7	7
YCH	0.028	13	13	0.033	20	20
CHH	0.374	2	2	0.056	5	5
XDmH	0.263	4	4	0.039	10	10
YDmH	0.486	4	4	0.360	10	10
XDsHH	-	1	1	0.287	4	4
XDtHH	0.295	2	2	0.398	6	6
WPH	-	1	1	0.023	8	8
XLH	0.255	6	6	0.535	11	11

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CHH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number

Overall, greater humeral asymmetry was experienced by late-phase males than early-phase males (table 7.5.41). This may highlight a greater expression of handedness in late males. However, very few early male humeri were observable, and results may not truly represent reality for some measurements. Accordingly it was only worth mentioning that while the minimum circumference of the diaphysis was statistically asymmetric in both phases (early $P=0.028$ $n=26$, late $P=0.033$ $n=40$), the WDH was apparently statistically symmetric in both phases.

Table 7.5.42 RPM test results examining humeral asymmetry differences between early and late male Islamic individuals

Measurement	Early male				Late male				# pairs	P Value
	Left		right		left		right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
XLH	314.33	10.12	320.33	11.85	312.00	16.79	315.14	14.94	10	0.139
LphH	305.00	2.83	308.00	4.24	298.14	20.10	299.14	17.34	9	0.572
YCH	66.85	3.36	68.38	4.17	66.35	5.01	67.55	5.51	33	0.681
CHH	13.50	0.71	13.80	0.42	13.48	0.82	16.64	0.95	7	0.381
XDmH	21.13	1.22	21.80	1.30	21.90	1.94	22.15	1.55	14	0.795
YDmH	18.45	0.10	18.53	0.29	17.73	1.33	17.99	1.81	14	0.943^
XDsHH	42.50	0.00	41.60	0.00	40.58	2.32	41.53	3.46	5	0.342
XDtHH	42.60	1.13	42.20	0.85	43.36	2.45	43.73	2.41	8	0.335
WPH	43.40	0.00	46.00	0.00	47.44	2.53	48.68	3.34	9	0.333
XLH	63.82	3.14	65.17	1.11	62.95	4.05	63.47	4.97	17	0.553

Key: XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. L = left, R= right, S.D = standard deviation, $\bar{x}$ = mean, # = number, ^ = Kruskal Wallis tested.

There was no difference in the degree and direction of humeral asymmetry experienced between early males and late males (table 7.5.42). Like females, the sample sizes were small which may have impacted statistical testing.

Radius

Table 7.5.43 Absolute radius measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic males

Radius	Side	Early male			Late male			P value
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
XLR	L	12	242.90	22.28	30	240.90	17.30	0.755
	R	24	244.90	16.08	39	245.79	16.08	0.915 ⁺
DtmR	L	7	16.26	0.90	22	15.73	1.52	0.308 ⁺
	R	20	16.00	1.03	34	16.36	1.55	0.361 ⁺
DapmR	L	7	12.67	0.66	22	12.23	0.75	0.474 ⁺
	R	20	12.65	0.88	34	12.76	1.32	0.865 ⁺
DthR	L	10	23.32	2.56	27	22.92	2.28	0.648
	R	25	22.21	1.61	34	22.72	2.00	0.206
DXhR	L	7	23.60	2.62	13	23.21	1.32	0.905 ⁺
	R	17	22.74	0.94	21	23.86	1.14	0.002
XWdR	L	15	33.55	2.25	36	33.59	3.27	0.951
	R	21	33.74	2.03	34	34.44	2.02	0.08 ⁺

Key: L = left, R = right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number

Only the maximum head diameter of the right radius differed in size between early and late males (table 7.5.43). In the early-phase, the maximum radial head diameter was 22.74mm. In the late-phase this increased to 23.86mm. This may reflect an increase in mechanical loading at the elbow in childhood in males according to the research on epiphysis plasticity prior to fusion, as no significant increase in radial maximum length was identified (Hellier and Jeffery 2006).

Table 7.5.44 RPM test asymmetry results for left and right male radial measurements by phase

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
XLR	0.252	8	8	0.085	23	23
DtmR	0.711	4	4	0.039	17	17
DapmR	0.406	4	4	0.783	17	17
DthR	0.933	8	8	0.176	21	21
DXhR	0.874	2	2	0.260	8	8
XWdR	0.546	10	10	0.006	25	25

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number

No radial dimensions were statistically asymmetric in early males (table 7.5.44).

However in late males, the transverse midshaft diameter was asymmetric ($P=0.039$ $n=34$). This was also the case for the width of the distal radius ($P=0.006$ $n=50$). The asymmetry for the maximum length of the radius was also close to significance for late males ($P=0.085$ $n=46$). This suggests greater asymmetric use of the forearm in late males.

Table 7.5.45 RPM test results examining radial asymmetry differences between early and late male Islamic individuals

Measurement	Early male				Late male				# pairs	P Value
	left		Right		left		right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
XLR	245.1 3	25.24	246.50	24.85	241.00	17.65	242.87	17.50	31	0.795
DtmR	16.35	1.24	16.10	0.62	15.77	1.72	16.32	1.68	21	0.185
DapmR	12.86	0.84	13.03	0.96	12.30	0.73	12.33	0.88	21	0.719^
DthR	22.55	2.08	22.51	2.03	23.08	2.49	22.81	2.47	29	0.353^
DXhR	23.30	0.99	23.45	0.07	23.58	1.21	23.76	1.23	10	0.934
XWdR	33.86	1.71	34.23	2.53	33.47	2.23	34.10	2.05	35	0.605

= left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number, ^ = Kruskal Wallis tested.

Key: L

According to table 7.5.45, no difference in the patterns of asymmetry existed between phases for males, so even though the transverse diameter of the radial midshaft and the distal width of the radius were statistically asymmetric in the late phase, the difference between the phases was not substantial. In the case of the transverse diameter of the midshaft, while the left was larger than the right in the early phase and a reversed pattern was seen in the late phase, it did not reach a level of statistical significance. In the case of the distal radius width, the right was larger than the left in both phases.

Ulna

Table 7.5.46 Absolute ulna measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early and late Islamic males

Measurement	Side	Early male		Late male		P value
		n	$\bar{x}$	n	$\bar{x}$	
XLU	L	14	264.00	20	266.75	0.724
	R	19	263.00	25	269.64	0.103
DapmU	L	10	17.20	16	16.94	0.737
	R	16	16.80	22	17.35	0.348
DtmU	L	10	14.60	16	13.5	0.020⁺
	R	16	14.30	22	14.26	0.941 ⁺

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, $\bar{x}$ = mean, S.D = standard deviation, n = number + = Mann Whitney U tested, L = left, R = right

According to table 7.5.46, just one measurement changed temporally for Islamic males: the anterior-posterior dimension of the left ulna was statistically larger in early males (early =14.57mm, late =13.5mm) (P=0.020 n=26).

Table 7.5.47 RPM test asymmetry results for left and right male ulnae measurements by phase

Measurement	Early			Late		
	P value	n Left	n Right	P value	n Left	n Right
XLU	0.140	6	6	0.055	10	10
DapmU	0.093	3	3	0.054	8	8
DtmU	0.535	3	3	0.113	8	8

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, $\bar{x}$ = mean, S.D = standard deviation, n = number

Statistically, there were no asymmetric male measurements. However the early maximum ulna length and the anterior-posterior diameter of the late ulna midshaft were just outside significance, indicating a trend whereby these measurements did differ by side (table 7.5.47). In terms of the early male ulnae, sample numbers were too low to conjecture sensibly about asymmetry.

Table 7.5.48 RPM test results examining ulna asymmetry differences between early and late male Islamic individuals

Measurement	Early male				Late male				# pairs	P Value
	left		right		left		right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
XLU	259.33	14.9 9	262.00	13.10	262.30	15.9 6	265.70	14.2 1	16	0.757
DapmU	17.00	2.17	18.03	1.81	16.60	1.41	17.38	2.18	11	0.675
DtmU	13.97	0.15	14.50	1.23	13.66	1.43	13.93	1.09	11	0.575

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, $\bar{x}$ = mean, S.D = standard deviation, #=number.

There was no change in the degree of ulna asymmetry experienced by Islamic males (table 7.5.48). In both phases, the right ulna is longer than the left, whereas for the anterior-posterior and transverse diameters of the midshaft, the left bone is larger than the right.

Summary

The limited sample size for some measurements prevented detailed analysis of temporal variation in male measurements. Nevertheless, some temporal changes were observed. In terms of absolute measurements, the maximum head diameter of the right radius and the left transverse diameter of the ulna midshaft differed between phases. This demonstrated that overall male size did not vary over time. However, in terms of asymmetry, four measurements were asymmetric in the early phase, but nine were asymmetric in the late phase. A further four measurements neared significance in the late phase. Just three measurements were asymmetric in both phases; the maximum length of the humerus, the minimum circumference of the humeral diaphysis and the maximum length of the clavicle. All of these differences may be related to a greater expression of handedness in late males. Finally, just one measurement had a statistically significant different pattern of asymmetry between phases. The superior-inferior diameter of the clavicle sternal end in early males was larger on the left side. This was reversed for the late phase, suggesting a change in the use of the shoulder over time.

7.5.1.5 Analysis of temporal difference in sexual dimorphism in absolute bone measurements: temporal changes in gender division and social organisation

It was only possible to examine long-bone dimensions, as when the data was broken down into phase groups and by sex, there was not enough data to look at asymmetry.

Clavicle

Table 7.5.49 Absolute clavicle measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early Islamic females and males

Measurement	Side	Early Female			Early Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
DsistC	L	23.52	15	4.27	25.71	12	2.68	0.135	1.093
	R	22.00	13	3.55	25.89	11	2.93	0.008	1.177
DapstC	L	18.57	15	2.43	21.20	12	4.58	0.067	1.142
	R	19.69	14	3.45	21.46	12	2.51	0.154	1.090
DsiacC	L	11.30	8	1.66	12.65	10	2.17	0.167	1.119
	R	11.91	12	1.28	12.65	17	1.93	0.258	1.062
DapacC	L	22.39	8	4.35	23.73	8	4.66	0.561	1.060
	R	23.21	13	3.36	24.74	17	2.83	0.185	1.066
XLC	L	137.43	7	12.49	153.00	7	12.15	0.036	1.113
	R	132.10	10	11.76	145.11	9	9.37	0.017	1.098
CmC	L	3.12	6	1.15	4.23	7	0.63	0.045⁺	1.357
	R	3.50	10	0.28	4.16	9	0.53	0.006	1.167
DsimC	L	9.20	7	1.00	11.40	7	1.61	0.009⁺	1.239
	R	9.76	10	1.46	11.72	9	2.06	0.018	1.201
DapmC	L	10.56	7	1.34	13.43	7	1.93	0.007	1.272
	R	10.37	10	1.16	12.14	9	1.26	0.005	1.171

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number. ⁺ = Mann Whitney U tested

Table 7.5.50 Absolute clavicle measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between late Islamic females and males

Measurement	Side	Late Female			Late Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
DsistC	L	24.71	14	3.71	24.74	14	2.41	0.981	1.001
	R	22.62	19	2.90	26.83	14	2.85	<0.001	1.186
DapstC	L	19.24	14	2.75	21.20	15	3.92	0.155	1.102
	R	18.99	17	4.14	20.53	17	2.10	0.182	1.081
DsiacC	L	10.88	10	1.92	12.00	13	2.41	0.241	1.103
	R	12.10	16	2.77	12.30	19	2.48	0.518 ⁺	1.017
DapacC	L	21.01	9	2.43	25.04	13	4.84	0.033	1.192
	R	20.51	15	3.15	25.79	17	4.40	0.001	1.257
XLC	L	139.14	7	8.65	149.20	11	8.65	0.021	1.072
	R	136.14	7	6.15	145.11	9	8.28	0.031	1.066
CmC	L	3.70	6	0.329	4.04	11	0.507	0.166	1.092
	R	3.63	7	0.502	4.22	9	0.77	0.101	1.163
DsimC	L	10.27	6	0.929	10.83	11	1.83	0.497	1.055
	R	9.46	7	0.59	11.08	9	1.86	0.045	1.171
DapmC	L	11.33	6	1.27	12.29	11	1.24	0.153	1.085
	R	11.27	7	1.41	12.83	9	1.68	0.068	1.138

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number, ⁺ = Mann Whitney U tested

Tables 7.5.49 and 7.5.50 demonstrated that, for both late early and late groups, males were always larger than females. According to table 7.5.49, 9 out of 16 measurements were statistically significantly larger in early males than in early females. This was reduced to just five measurements for late females and late males (table 7.5.50). Apart from three measurements (the right sternal end superior-inferior diameter and the left and right anterior-posterior acromial diameter), sexual dimorphism was greater in early individuals, demonstrating a temporal loss of dimorphism. While the range of sexual dimorphism in the early phase (1.106 to 1.35) and late phase (1.001 – 1.25) were similar, the dimorphism has decreased over time, indicating that late male clavicles were not as big when compared with female clavicles.

Humerus

Table 7.5.51 Absolute humerus measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early Islamic females and males

Measurement	Side	Early Female			Early Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLH	L	305.00	8	22.09	314.5	4	8.27	0.434	1.031
	R	301.67	6	17.9	316.67	9	17.53	0.131	1.050
phH	L	298.80	5	20.29	311.25	4	8.26	0.291	1.042
	R	296.71	7	17.61	315.43	7	12.22	0.039	1.063
YCH	L	58.94	17	58.94	66.47	17	3.57	0.001⁺	1.128
	R	59.65	20	4.59	67.60	20	4.67	<0.001	1.133
CHH	L	13.08	8	0.58	13.60	3	0.52	0.206	1.040
	R	13.20	8	0.72	14.37	7	0.46	0.003	1.089
XDmH	L	21.00	7	1.64	21.13	4	1.63	0.898	1.006
	R	21.32	5	1.66	22.81	10	1.86	0.155	1.070
YDmH	L	16.34	7	2.37	18.45	4	0.10	0.251 ⁺	1.129
	R	15.98	5	1.80	18.83	10	2.01	0.019	1.178
XDsHH	L	38.58	9	1.74	42.70	3	0.17	0.012⁺	1.107
	R	40.56	7	1.93	43.40	7	1.94	0.017	1.070
XDtHH	L	41.38	10	2.59	43.47	10	1.70	0.223	1.051
	R	42.29	8	3.18	45.55	10	3.99	0.078	1.077
WPH	L	44.94	8	3.81	47.57	3	3.67	0.331	1.059
	R	47.66	8	2.74	51.64	8	3.01	0.015	1.084
WDH	L	55.99	17	5.35	62.71	9	3.66	0.003	1.120
	R	56.58	17	4.97	64.24	13	1.48	<0.001	1.135

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDsHH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number. ⁺ = Mann Whitney U tested

Table 7.5.52 Absolute humerus measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between late Islamic females and males

Measurement	Side	Late Female			Late Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLH	L	294.75	4	6.65	318.55	11	22.93	0.067	1.081
	R	296.90	10	10.79	317.33	12	17.82	0.005	1.069
phH	L	288.40	5	11.57	306.38	8	29.80	0.229	1.062
	R	288.22	9	14.32	305.92	12	20.17	0.038	1.061
YCH	L	57.40	20	4.73	65.92	24	4.71	<0.001⁺	1.148
	R	58.10	20	4.66	67.30	27	4.99	<0.001⁺	1.158
CHH	L	12.13	6	0.76	13.76	8	0.77	0.002	1.134
	R	12.73	10	0.84	14.01	11	0.77	0.002	1.101
XDmH	L	19.73	4	0.51	22.05	12	1.79	0.025	1.118
	R	20.63	9	1.34	22.70	14	1.43	0.002	1.100
YDmH	L	15.58	4	1.38	17.80	12	1.22	<0.001⁺	1.142
	R	15.89	9	1.69	18.43	14	1.79	0.003	1.160
XDshH	L	38.54	5	1.28	42.01	9	2.16	0.007	1.090
	R	38.60	9	1.97	41.81	9	2.59	0.009	1.083
XDtHH	L	39.08	5	2.02	44.31	10	2.48	0.001	1.134
	R	40.67	10	3.25	45.14	11	2.59	0.002	1.110
WPH	L	42.98	6	1.56	47.76	11	2.48	0.043	1.111
	R	44.93	10	2.26	49.73	12	3.17	0.001	1.107
WDH	L	54.72	13	2.47	63.30	18	3.90	<0.001⁺	1.157
	R	55.89	14	3.78	63.92	18	4.36	<0.001⁺	1.144

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number, + = Mann Whitney U tested

According to tables 7.5.51 and 7.5.52, in both phases, males were larger in all humeral dimensions than females. While this difference was statistically significant for 10 of 20 measurements in the early phase (table 7.5.51), 19 of 20 measurements were larger in males in the late phase (table 7.5.52), thereby demonstrating a greater degree of sexual dimorphism in the late phase. Furthermore the range of sexual dimorphism values was greater in the late phase (early 1.031–1.135, late 1.061–1.16). This could be due to the general, although not significant decrease in female humeral size over time. The only measurements to have greater sexual dimorphism in the early phase were the right physiological length of the humerus, the right minimum circumference of the midshaft and the left maximum sagittal diameter of the humeral head.

Radius

Table 7.5.53 Absolute radial measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early Islamic females and males

Radius	Side	Early Female			Early Male			P value	DI
		$\bar{x}$	#	S.D	$\bar{x}$	#	S.D		
XLR	L	225.67	12	21.53	251.25	4	17.75	0.05	1.113
	R	226.27	15	13.95	244.94	16	11.79	<0.001	1.083
DtmR	L	14.27	12	2.44	16.27	3	0.50	0.193	1.140
	R	14.14	15	1.41	15.90	16	1.13	0.001	1.124
DapmR	L	11.08	12	1.50	12.40	3	0.17	0.147	1.119
	R	10.87	15	0.96	12.54	16	0.85	<0.001	1.154
DthR	L	20.44	14	2.55	23.24	7	2.61	0.029	1.137
	R	20.22	21	1.55	22.04	21	1.44	<0.001	1.090
DXhR	L	20.77	12	2.35	23.60	7	2.62	0.027	1.136
	R	21.43	17	2.95	22.735	17	0.94	0.012	1.061
XWdR	L	29.27	17	2.69	33.25	11	2.29	0.001	1.136
	R	29.99	17	2.21	33.52	16	1.96	<0.001	1.118

Key: L = left, R= right, S.D = standard deviation, n = number, XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation.

Table 7.5.54 Absolute radial measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between late Islamic females and males

Radius	Side	Late Female			Late Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLR	L	221.00	10	11.62	242.00	10	21.96	0.016	1.095
	R	227.50	12	13.19	250.19	21	17.35	<0.001	1.100
DtmR	L	13.50	10	1.37	16.16	9	1.59	0.001	1.197
	R	14.03	12	1.80	16.57	22	1.65	<0.001	1.181
DapmR	L	10.60	10	0.634	12.27	9	0.75	<0.001	1.158
	R	10.64	12	1.15	13.01	22	1.41	<0.001	1.223
DthR	L	19.51	12	0.98	22.83	14	1.39	<0.001	1.170
	R	19.68	17	1.14	22.98	22	1.36	<0.001	1.168
DXhR	L	19.78	10	1.06	23.21	13	1.31	<0.001	1.173
	R	20.14	14	1.06	23.86	21	1.14	<0.001	1.185
XWdR	L	29.45	12	2.72	33.63	20	1.92	<0.001	1.142
	R	30.70	11	2.83	34.78	22	1.86	<0.001	1.133

Key: L = left, R= right, S.D = standard deviation, n = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation.

In both phases, males were significantly larger than females for all measurements (see table 7.5.53 and 7.5.54). The statistical significance was far stronger in the late phase than in the early phase. The range of dimorphism for the early phase was 1.061-1.154 in

comparison to 1.095-1.223 in the late phase. This demonstrated that for the radius, there was greater dimorphism in the late phase than in the early phase. Like the humerus, this may relate to the general non-significant reduction in size of female radii overtime, but also that some male radii diameters were larger in the late phase.

Ulna

Table 7.5.55 Absolute ulna measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between early Islamic females and males

Measurement	Side	Early Female			Early Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLU	L	245.10	7	23.12	264.30	14	20.09	0.065	1.078
	R	245.75	12	13.25	263.16	19	12.10	0.001	1.071
DapmU	L	14.48	6	1.78	17.19	10	1.46	0.005	1.187
	R	14.26	11	1.25	16.83	16	1.51	<0.001	1.180
DtmU	L	11.04	5	0.695	14.57	10	0.93	<0.001	1.320
	R	11.94	11	1.34	14.33	16	1.30	<0.001	1.200

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, n = number

Table 7.5.56 Absolute ulna measurements (mm), means, standard deviations and GLA and Mann Whitney U results for differences between late Islamic females and males

Measurement	Side	Late Female			Late Male			P value	DI
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D		
XLU	L	241.29	21	13.85	266.75	20	19.74	<0.001⁺	1.106
	R	244.71	17	14.31	269.60	25	13.26	<0.001	1.102
DapmU	L	14.56	20	1.35	16.94	16	1.97	<0.001	1.163
	R	14.81	22	1.39	17.35	22	1.73	<0.001	1.172
DtmU	L	11.06	20	1.12	13.50	16	1.25	<0.001⁺	1.221
	R	11.85	16	1.56	14.26	22	0.99	<0.001⁺	1.203

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, n = number, ⁺ = Mann whitney U tested

According to tables 7.5.55 and 7.5.56, males were significantly larger than females for all ulna diameters in both phases, with the exception of the left maximum length in the early phase. For the left and right maximum length of the ulna and the mediolateral diameter of the midshaft, the degree of sexual dimorphism was greater in late individuals. The range of dimorphism in the early phase was greater (1.071–1.32) than in the late phase (1.102–1.221).

Summary

With the exception of the clavicle, there was a temporal trend for increasing sexual dimorphism. While, this may be due to a general decrease in female bone size, the difference in long-bone lengths was not significant. The ulna retained similar dimorphism levels between time periods. This demonstrated that more than one factor may be influencing the dimorphism in this population, or that the clavicle is affected differently by changes in social circumstance. This could be related to the fact that the clavicle is formed via intramembraneous ossification rather than endochondrial ossification, like the humerus, radius and ulna.

In terms of side asymmetry, in the early phase, six female measurements and four male measurements were asymmetric. In the late phase, seven female measurements and nine male measurements (with a further three extremely close to statistical significance) were statistically asymmetric. This demonstrates that early males were less asymmetric than females but the reverse was apparent in the late phase. Taking this into consideration, it suggests that greater changes take place to males over time than to females.

7.5.2 Analysis of sexual difference in absolute bone measurements for the Visigothic sample: Analysis of sexual dimorphism

38 Visigothic individuals had at least one long bone available for measurement.

Table 7.5.57 Numbers of Visigothic males and females.

Age	Female	Male
Young	9	5
Middle	6	17
Total	15	22

The following paragraphs explore the absolute data for the Visigothic group. The preservation of the Visigothic material sometimes prevented measurement of bones and many parts were fragmented and, although over 300 individuals existed, in reality very few were measurable. Nevertheless, some analysis was possible. The limited sample size prevented the analysis of asymmetry.

Clavicle

Table 7.5.58 Clavicle measurement (mm) means, GLA results and dimorphism index by sex for Visigothic individuals

Measurement	Side	Female			Male			P value	DI
		#	$\bar{x}$	SD	#	$\bar{x}$	SD		
DsistC	L	7	20.23	2.43	6	27.72	0.97	≤0.001	1.37
	R	4	19.48	2.00	6	25.82	7.23	0.131	1.33
DapstC	L	8	16.73	1.47	7	20.32	3.01	0.001	1.33
	R	4	18.65	1.46	6	19.45	3.19	0.655	1.04
DsiacC	L	4	9.13	0.72	5	11.44	1.85	0.052	1.25
	R	2	10.05	0.49	2	20.40	11.88	0.343	2.03
DapacC	L	4	23.35	5.1	3	24.33	1.29	0.762	1.04
	R	2	20.80	2.4	2	27.25	0.07	0.063	1.31
XLC	L	5	137.60	8.02	5	150.20	3.7	0.013	1.09
	R	3	130.00	2.65	2	155.00	4.24	0.004	1.19
CmC	L	5	34.40	1.82	4	43.00	7.12	0.033	1.25
	R	3	34.33	2.52	1	48.00	-	0.042	1.40
DsimC	L	4	8.98	0.28	4	10.83	0.44	≤0.001	1.21
	R	2	8.25	0.78	2	11.85	0.21	0.024	1.44
DapmC	L	2	10.20	1.8	2	13.50	2.95	0.009	1.19
	R	2	11.43	0.42	2	13.65	0.14	0.024	1.32

Key: F=female, M=male, L=left, R=right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, # = number, + = Mann Whitney U tested, * = log transformed data. DI = dimorphism index.

Table 7.5.58 demonstrated that a number of clavicle measurements differed between Visigothic males and females, and of these, 10 were statistically different. However, caution was required as some of the sample sizes were small. Interestingly, while the left superior-inferior dimension of the sternal clavicle was significantly different between males and females, the right equivalent did not differ between the sexes. The measurement with the greatest level of dimorphism was the superior inferior acromial diameter of the right clavicle. Given that just four acromions were available for this measurement, the result should be considered cautiously. The measurement with the least dimorphism was the left acromion anterior-posterior diameter. Again, however, the sample size was small.

The acromion had the greatest difference in sexual dimorphism between sides. This was created by asymmetry in female acromial measurements. The measurement with the least difference in dimorphism between sides was the maximum length of the clavicle.

Humerus

Table 7.5.59 Humerus measurement (mm) means, GLA results and dimorphism index by sex for Visigothic individuals

Humerus	Side	Female			Male			P value	DI
		#	$\bar{x}$	SD	#	$\bar{x}$	SD		
XLH	L	3	298.00	7.00	6	315.5	22.07	0.234	1.06
	R	1	315.00	-	4	325.75	10.18	0.414	1.03
phH	L	1	297.00	-	4	317.5	21.70	0.460	1.07
	R	0	-	-	4	321.75	9.50	-	-
YCH	L	3	56.67	3.51	6	66.17	4.45	0.015	1.17
	R	1	58.00	-	4	70.00	1.41	0.005	1.21
CHH	L	0	-	-	0	-	-	-	-
	R	0	-	-	0	-	-	-	-
XDmH	L	1	21.30	-	6	22.67	1.71	0.493	1.06
	R	0	-	-	4	23.45	0.14		-
YDmH	L	1	16.90	-	6	18.40	1.01	0.228	1.09
	R	0	-	-	4	19.45	0.45	-	-
XDshH	L	1	36.50	-	0	-	-	-	-
	R	0	-	-	2	40.3	1.98	-	-
XDtHH	L	2	40.45	1.20	1	47.3	-	0.135	1.17
	R	0	-	-	4	47.4	3.23	-	-
WPH	L	3	45.17	3.10	1	49.1	-	0.387	1.09
	R	0	-	-	3	50.83	3.66	-	-
WDH	L	4	53.48	0.98	6	64.12	4.42	0.002	1.2
	R	2	55.05	2.76	6	62.82	4.96	0.088	1.14

Key: F=female, M=male, XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minimum circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, # = number, DI = dimorphism index.

The humeri were extremely fragmented, particularly the head. This prevented data collection for many measurements. Statistically the left and right minimum circumference of the humeral shaft and the distal epiphysis breadth were significantly different between males and females. All other measurements failed to reach a level of statistical significance (table 7.5.59). The low sample number however made it difficult to comment on this trend. The least amount of dimorphism existed for the maximum length of the left humeri. The greatest dimorphism was observed for the right minimum circumference of the shaft. It was not possible to compare the level of dimorphism between sides due to low sample numbers.

Radius

Table 7.5.60 Radius measurement (mm) means, GLA results and dimorphism index by sex for Visigothic individuals

Measurement	Side	Female			Male			P value	DI
		#	$\bar{x}$	SD	#	$\bar{x}$	SD		
XLR	L	5	221.2	20.47	8	249.63	10.18	0.006	1.11
	R	4	227.5	10.66	8	254.25	7.21	≤0.001	1.12
DtmR	L	6	14.07	1.040	5	15.80	0.90	0.017	1.12
	R	4	15.08	2.070	7	17.34	2.15	0.122	1.15
DapmR	L	6	10.68	0.96	5	12.76	0.82	0.004	1.19
	R	4	10.75	0.70	7	13.47	0.92	0.001	1.25
DthR	L	1	20.40	-	1	21.50	-	-	1.05
	R	1	19.90	-	1	23.60	-	-	1.19
DXhR	L	0	-	-	0	-	-	-	-
	R	0	-	-	1	23.70	-	-	-
XWdR	L	3	31.20	2.89	5	34.28	0.98	0.075	1.12
	R	3	30.53	0.87	5	34.26	2.32	0.033	1.10

Key: L = left, R = right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, # = number, DI = dimorphism index.

The radius significantly differed between the sexes for 6 of 8 measurements (table 7.5.60). In terms of dimorphism, the right sagittal midshaft diameter was most dimorphic (1.25). The head transverse diameter was the least dimorphic measurement, but as only two measurements were taken, it was unlikely to be representative. Dimorphism ranged from 1.10 – 1.19. In terms of differences in dimorphism by side, the measurement with the greatest variation was the sagittal midshaft of the radius (0.06 difference). All other dimorphism indices varied little by side.

Ulna

Table 7.5.61 Ulna measurement (mm) means, GLA results and dimorphism index by sex for Visigothic individuals

Measurement	Side	Female			Male			P value	DI
		#	$\bar{x}$	SD	#	$\bar{x}$	SD		
XLU	L	2	239.50	6.36	5	260.40	17.53	0.178	1.09
	R	4	230.25	19.41	2	265.50	2.12	0.073	1.15
DapmU	L	2	14.25	0.78	5	16.88	1.16	0.035	1.18
	R	2	13.85	1.91	2	16.60	0.42	0.185	1.2
DtmU	L	2	11.2	0.28	5	13.20	1.08	0.058	1.18
	R	2	11.7	0.71	2	13.30	0.71	0.152	1.14

Key: F=female, M=male, XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R = right, $\bar{x}$ = mean, S.D = standard deviation, # = number, DI = dimorphism index

Very few ulnae were suitable for measurement in the Visigothic sample (table 7.5.61). Just one measurement returned as being sexually dimorphic, the anterior-posterior midshaft diameter of the left ulnae. The right maximum length and the left mediolateral midshaft diameter were close to statistical significance inferring some dimorphism.

7.5.3 Analysis of interfaith differences in female absolute bone measurements: changing female activity and identity with the emergence of Islam

Clavicle

Table 7.5.62 Female clavicle means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Measurement	Side	Visigothic Female			Islamic Female			Female P value
		$\bar{x}$	#	S.D	$\bar{x}$	#	S.D	
DsistC	L	20.23	7	2.43	23.91	31	3.94	0.023
	R	19.48	4	2.00	22.43	34	3.10	0.071
DapstC	L	16.73	8	1.47	18.87	31	2.46	0.026
	R	18.65	4	1.46	19.28	33	3.50	0.740
DsiacC	L	9.13	4	0.72	10.98	20	1.73	0.047
	R	10.05	2	0.50	11.98	30	2.17	0.229
DapacC	L	23.35	4	5.10	21.75	19	3.55	0.424
	R	20.80	2	2.40	22.00	30	3.41	0.637
XLC	L	137.60	5	8.02	137.50	16	9.46	0.984
	R	130.00	3	2.65	134.00	18	8.98	0.489
CmC	L	34.40	5	1.82	33.50	14	6.93	0.811
	R	34.33	3	2.52	35.78	18	3.52	0.524
DsimC	L	8.98	4	0.28	9.73	15	0.95	0.164
	R	8.25	2	0.78	9.66	18	1.17	0.108
DapmC	L	10.20	2	1.80	10.61	15	1.54	0.363
	R	11.43	2	0.42	10.74	18	1.21	0.562

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, # = number

According to table 7.5.62, the left sternal end of the clavicle was smaller in female Visigoths. Specifically, the superior-inferior dimension and the anterior-posterior dimension of the sternal end of the clavicle, were shorter in Visigothic females ($P=0.022$ $n=38$ and $P=0.026$ $n=39$ respectively). The superior-inferior dimension of the left acromion also differed statistically between Visigothic and Islamic women ($P=0.047$ $n=24$). In general, all other measurements were similar between the two faith groups suggesting similarity between Visigoths and Muslims in bone size. This may

infer that either the two populations had similar body size, or that there was no change in female size associated with the emergence of Islam.

Humerus

Table 7.5.63 Female humeral means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Humerus	Side	Visigothic Female		SD	Islamic Female			Female P value
		$\bar{x}$	n		$\bar{x}$	n	S.D	
XLH	L	298.00	3	7	301.58	12	18.66	0.754
	R	315.00	1	-	297.67	12	13.69	0.259
phH	L	297.00	1	-	296.63	8	15.28	0.849
	R	-	-	-	294.75	12	16.72	
YCH	L	56.67	3	3.51	58.24	33	5.71	0.665
	R	58.00	1	-	59.00	36	4.77	0.853
CHH	L	-	0	-	12.67	12	0.81	
	R	-	0	-	12.93	14	0.80	
XDmH	L	21.30	1	-	20.49	9	1.43	0.625
	R	-	0	-	20.63	10	1.42	
YDmH	L	16.90	1	-	16.06	9	2.15	0.701
	R	-	0	-	16.19	10	3.01	
XDshH	L	36.50	1	-	38.71	11	1.71	0.218
	R	-	0	-	39.65	12	5.50	
XDtHH	L	40.45	2	1.2	40.44	13	2.27	0.933
	R	-	0	-	41.36	14	10.86	
WPH	L	45.17	3	3.1	44.40	12	2.75	0.599
	R	-	0	-	46.13	14	9.34	
WDH	L	53.48	4	0.98	55.48	26	4.35	0.378
	R	55.05	2	2.76	56.23	27	20.76	0.705

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDtHH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number

The number of observable Visigothic female humeri was low, as reflected by the results in table 7.5.63. Despite this, all Visigothic female measurements fell within the range of Islamic female humeri.

Radius

Table 7.5.64 Female radial means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Radius	Side	Visigothic Female		SD	Islamic Female			Female P value
		$\bar{x}$	n		$\bar{x}$	n	S.D	
XLR	L	221.20	5	20.47	222.26	39	15.21	0.889
	R	227.50	4	10.66	225.54	46	13.29	0.777
DtmR	L	14.07	6	1.04	13.93	36	1.77	0.860
	R	15.08	4	2.07	14.20	39	1.49	0.285
DapmR	L	10.68	6	0.96	10.81	36	1.09	0.793
	R	10.75	4	0.70	10.82	39	0.95	0.891
DthR	L	20.40	1	-	19.76	41	1.71	0.715
	R	19.90	1	-	19.95	55	1.265	0.905
DXhR	L	-	0	-	20.32	22	1.91	-
	R	-	0	-	20.84	31	2.36	-
XWdR	L	31.20	3	2.89	29.84	45	2.48	0.643
	R	30.53	3	0.87	30.55	42	2.35	0.642

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number

Statistically no differences in radial dimensions existed between the faith groups for females, but the sample size for Visigothic females was extremely low (see table 7.5.64).

Ulna

Table 7.5.65 Female ulna means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Measurement	Side	Visigothic Female			Islamic Female			Female P value
		$\bar{x}$	n	SD	$\bar{x}$	n	S.D	
XLU	L	239.50	2	6.36	242.25	28	16.24	0.816
	R	230.25	4	19.41	245.14	29	13.64	0.060
DapmU	L	14.25	2	0.78	14.54	26	1.42	0.781
	R	13.85	2	1.91	14.59	27	1.34	0.469
DtmU	L	11.20	2	0.28	11.06	25	1.04	0.849
	R	11.70	2	0.71	11.89	27	1.45	0.816

Key: XLU=maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L= left, R= right, $\bar{x}$ = mean, S.D = standard deviation, n = number

With so few female Visigothic ulnae, it was difficult to ascertain whether any similarity or differences existed between the two groups of females. One difference highlighted by a GLA analysis ($P=0.06$ $n=33$) was for the maximum length of the right ulna (table

7.5.65). Visigothic females have shorter ulnae than the Islamic females, but the greater standard deviation in the Visigothic group may suggest that an outlier might have impacted on the result. The clavicle, which has more data, demonstrated differences in the mediolateral movement of the shoulder, which was supported by the MSM results in section 7.2.3.1.

7.5.4 Analysis of interfaith differences in male absolute bone measurements: changing male activity and identity with the emergence of Islam

Clavicle

Table 7.5.66 Male clavicle means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Measurement	Side	Visigothic Male			Islamic Male			Male P value
		$\bar{x}$	n	S.D	$\bar{x}$	n	S.D	
DsistC	L	27.72	6	0.97	25.19	26	2.56	0.024
	R	25.82	6	7.23	26.42	35	3.92	0.743
DapstC	L	20.32	7	3.01	21.15	27	3.93	0.516
	R	19.45	6	3.19	20.91	29	2.47	0.190
DsiacC	L	11.44	5	1.85	12.28	23	2.2	0.448
	R	20.40	2	11.88	12.46	36	3.42	0.001
DapacC	L	24.33	3	1.29	24.54	20	4.4	0.942
	R	27.25	2	0.07	25.27	34	3.62	0.459
XLC	L	150.20	5	3.7	150.67	18	8.57	0.917
	R	155.00	2	4.24	145.11	18	8.72	0.132
CmC	L	43.00	4	7.12	41.11	18	5.66	0.559
	R	48.00	1	-	41.89	18	6.39	0.367
DsimC	L	10.83	4	0.44	11.05	18	1.56	0.802
	R	11.85	2	0.21	11.4	18	1.83	0.751
DapmC	L	13.65	2	0.14	12.73	18	1.86	0.385
	R	13.50	4	2.95	12.49	18	1.44	0.359

Key: L = left, R = right, DsistC = superior-inferior diameter of the sternal clavicle, DapstC = anterior-posterior diameter of the sternal clavicle, DsiacC = superior-inferior diameter of the acromion, DapacC = anterior-posterior diameter of the acromion, XLC = maximum length of the clavicle, CmC = circumference of midshaft, DsimC = superior-inferior diameter of the clavicle midshaft, DapmC = anterior-posterior diameter of the clavicle midshaft. $\bar{x}$ = mean, S.D = standard deviation, n = number

The only clavicle dimension to appear statistically significantly different between the males of each faith groups was the left superior-inferior sternal end diameter (table 7.5.66). While the right superior-inferior diameter of the acromion appeared significantly different, with only two Visigothic measurements, it was unwise to comment further, especially as the standard deviation was much larger in the Visigothic sample.

Humerus

Table 7.5.67 Male humeral means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Humerus	Side	Visigothic Male			Islamic Male			Male P value
		$\bar{x}$	n	SD	$\bar{x}$	n	S.D	
XLH	L	315.50	6	22.07	317.47	15	19.85	0.844
	R	325.75	4	10.18	317.72	18	16.30	0.344
phH	L	317.50	4	21.70	314.70	10	19.71	0.500
	R	321.75	4	9.50	313.13	16	14.31	0.201
YCH	L	66.17	6	4.45	64.92	38	3.95	0.723
	R	70.00	4	1.41	67.89	44	4.34	0.295
CHH	L	-	0	-	13.84	8	0.69	-
	R	-	0	-	14.27	15	0.59	-
XDmH	L	22.67	6	1.71	21.85	13	1.74	0.306
	R	23.45	4	0.14	22.70	21	1.68	0.344
YDmH	L	18.40	6	1.01	18.28	13	0.80	0.402
	R	19.45	4	0.45	19.11	21	3.27	0.529
XDshH	L	-	0	-	42.99	9	0.92	-
	R	40.30	2	1.98	43.09	13	5.15	0.232
XDthH	L	47.30	1	-	44.07	10	2.26	0.205
	R	47.40	4	3.23	45.54	18	10.65	0.256
WPH	L	49.10	1	-	47.91	11	2.53	0.616
	R	50.83	3	3.66	51.81	18	19.70	0.886
WDH	L	64.12	6	4.42	63.35	25	3.85	0.565
	R	62.82	6	4.96	64.16	27	13.04	0.487

Key XLH = maximum length of humerus, LphH = physiological length of humerus, YCH = minim circumference of shaft, CCH = circumference of head, XDmH = maximum midshaft diameter, YDmH = minimum diameter of midshaft, XDshH = sagittal head diameter, XDthH = transverse head diameter, WPH = width of proximal epiphysis, WDH = width of distal epiphysis. $\bar{x}$ = mean, SD = standard deviation, n = number

Excluding measurements which had less than four individuals in the Visigothic sample, there were no statistically significant differences in humeral size between the Islamic and Visigothic males (table 7.5.67).

Radius

Table 7.5.68 Male radial means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Radius	Side	Visigothic Male			Islamic Male			Male P value
		$\bar{x}$	n	SD	$\bar{x}$	n	S.D	
XLR	L	249.63	8	10.18	241.48	42	18.59	0.236
	R	254.25	8	7.21	245.44	63	15.95	0.130
DtmR	L	15.80	5	0.90	15.86	29	1.40	0.929
	R	17.34	7	2.15	16.22	54	1.38	0.060
DapmR	L	12.76	5	0.82	12.33	12	0.74	0.248
	R	13.47	7	0.92	12.71	54	1.17	0.107
DthR	L	21.50	1	-	23.03	37	2.33	0.522
	R	23.60	1	-	22.51	59	1.52	0.626
DXhR	L	-	0	-	23.36	22	1.82	-
	R	23.70	1	-	23.36	28	1.17	-
XWdR	L	34.28	5	0.98	33.58	51	2.19	0.431
	R	34.26	5	2.32	34.17	55	2.03	0.908

Key: L = left, R= right, S.D = standard deviation, N = number XLR = maximum length of radius, DtmR = Transverse midshaft diameter, DapmR = Anterior-posterior midshaft diameter, DthR = Transverse diameter of head, DXhR = Maximum head diameter, XWdR = maximum distal breadth, $\bar{x}$ = mean, SD = standard deviation, n = number

There were no statistically significant differences in radial dimensions between the Islamic and Visigothic males. However, the right transverse diameter of the radius midshaft was extremely close to statistical significance ($P=0.060$ $n=61$). Visigothic males were 1.12mm larger for the radial midshaft anterior-posterior dimension than Islamic individuals (table 7.5.68).

Ulna

Table 7.5.69 Male ulna means, standard deviation, number and GLA analysis results for Islamic and Visigothic comparison

Measurement	Side	Visigothic Male			Islamic Male			Male P value
		$\bar{x}$	n	SD	$\bar{x}$	n	S.D	
XLU	L	260.4	5	17.53	265.74	34	19.62	0.569
	R	265.5	2	2.12	266.84	44	13.04	0.886
DapmU	L	16.88	5	1.16	17.04	26	1.763	0.849
	R	16.6	2	0.42	17.13	38	1.97	0.656
DtmU	L	13.2	5	1.08	13.91	26	1.23	0.240
	R	13.3	2	0.71	13.29	37	1.12	0.225

Key: XLU = maximum length of ulna, DapmU – anterior-posterior diameter of midshaft, DtmU = transverse diameter of midshaft, L = left, R= right, $\bar{x}$ = mean, S.D = standard deviation, n = number

No statistically significant differences were observed between the Islamic and Visigothic males for ulna dimensions (table 7.5.69). Caution was required, however, as only two right ulnae were measurable for Visigothic males.

7.5.5 Results of the analysis of long-bone and clavicle indices for the Islamic group

The following paragraphs explore whether indices calculated for long-bone midshafts, in addition to the sternal and acromial ends of the clavicle, vary between Islamic comparison groups in 6.3.1. Differences in cross-sectional indices demonstrate whether loading on bones may have differed between groups (sex and or phase groups).

7.5.5.1 Analysis of sexual difference in long bone indices for the Islamic sample:

Analysis of sexual dimorphism

Table 7.5.70 indicated that three indices differed between the sexes. The right acromial end of the clavicle was significantly different in shape between the sexes ($P=0.024$ $n=63$), with the clavicle appearing less round in males. The right humerus midshaft was statistically rounder in males than in females ($P=0.042$ $n=38$). The left ulna was rounder in cross section in females than in males ($P=0.036$ $n=51$). This difference did not exist for the left equivalent bone. This demonstrates that different patterns of loading existed between males and females for these bones. As flatter bones have greater bending strength, it would appear that females have greater right humerus and left ulna bending strength than males.

Table 7.5.70 Upper limb indices calculated from absolute measurements (mm) for males and females.

Index	Side	Female			Male			P value
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
Clavicle sternal	Left	30	0.80	0.11	25	0.85	0.20	0.310*
	Right	31	0.87	0.18	25	0.80	0.12	0.211*
Clavicle acromial	Left	19	0.52	0.08	21	0.51	0.11	0.878
	Right	29	0.56	0.12	34	0.50	0.09	0.024
Clavicle midshaft	Left	15	0.93	0.17	18	0.87	0.13	0.259
	Right	18	0.91	0.17	18	0.92	0.16	0.895
Humerus midshaft	Left	11	0.78	0.08	16	0.83	0.06	0.114
	Right	14	0.77	0.09	24	0.82	0.06	0.042
Radial midshaft	Left	36	0.78	0.06	29	0.78	0.57	0.943
	Right	39	0.77	0.06	54	0.79	0.06	0.099
Ulna midshaft	Left	25	0.77	0.08	26	0.82	0.10	0.036
	Right	27	0.82	0.09	38	0.84	0.08	0.294

Key: L = left, R = right, * = log transformed data, SD = standard deviation, n=number

Table 7.5.71 Analysis of difference in asymmetry between Islamic males and females.

Index	Female				Male				# pairs	P value
	Left		Right		Left		Right			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
Sternal clavicle	0.79	0.1	0.86	0.09	0.85	0.12	0.8	0.09	40	0.019
Acromial clavicle	0.51	0.08	0.53	0.09	0.46	0.11	0.47	0.08	28	0.819
Clavicle midshaft	0.92	0.19	0.93	0.16	0.93	0.12	0.98	0.12	23	0.085
Humerus midshaft	0.77	0.07	0.79	0.09	0.83	0.06	0.82	0.05	21	0.172
Radius midshaft	0.79	0.06	0.77	0.05	0.79	0.06	0.77	0.07	46	0.714
Ulna midshaft	0.76	0.06	0.79	0.07	0.83	0.1	0.81	0.09	26	0.039

Key: # = number, $\bar{x}$ = mean, SD = standard deviation

Table 7.5.71 demonstrated that males and females had different patterns of asymmetry for two indices. The sternal clavicle ends were more asymmetric in females than males. Regarding the ulna, a similar degree of asymmetry was observed between the sexes, yet the side with the roundest midshaft differed. Males had greater bending strength at the right ulna, whereas the left ulna had greater bending strength in females. This supports the gendered pattern of arm usage highlighted in both absolute measurements and MSMs.

7.5.5.2 Analysis of temporal difference in indices in Islamic group: changes in social organisation

Table 7.5.72 demonstrated that there were no differences between early-phase and late-phase indices. However the difference in the right clavicle midshaft index was just outside the level of statistical significance ($P=0.054$ $n=35$), and implies a trend where early clavicles tend to have rounder midshafts than the equivalent late-phase bone. This supports general MSM results that demonstrated a change in clavicle scores overtime. Similarly, the left ulna midshaft was somewhat rounder in the early-phase, although just outside the level of statistical significance ($P=0.060$ $n=51$). Both indices indicated an increase in bending strength over time. This demonstrates that there were some changes in the patterns of loading between the early- and late-phase individuals, suggesting some reorganisation of activity.

Table 7.5.72 Upper limb indices calculated from absolute measurements (mm) for early and late individuals

Index	Side	Early			Late			P value
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
Clavicle sternal	Left	26	0.78	0.10	29	0.79	0.09	0.934*
	Right	24	0.82	0.09	33	0.78	0.11	0.330*
Clavicle acromial	Left	16	0.53	0.09	24	0.50	0.10	0.468
	Right	29	0.52	0.08	34	0.53	0.13	0.787
Clavicle midshaft	Left	14	0.87	0.15	17	0.92	0.13	0.304
	Right	19	0.96	0.19	17	0.86	0.11	0.058
Humerus midshaft	Left	11	0.81	0.08	16	0.80	0.06	0.790
	Right	15	0.80	0.09	23	0.80	0.07	0.815
Radial midshaft	Left	19	0.78	0.06	46	0.78	0.06	0.899
	Right	35	0.78	0.05	58	0.77	0.06	0.433
Ulna midshaft	Left	15	0.88	0.08	36	0.78	0.09	0.060
	Right	27	0.85	0.09	38	0.82	0.08	0.129

Key: L = left, R = right, * = log transformed data. * =Mann Whitney U tested, n=number, SD = standard deviation

Table 7.5.73 Indices of long bone dimensions by phase and side

Index	P value	Early					Late			
		# pairs	left		right		left		right	
			$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Sternal clavicle	0.220	23	0.76	0.76	0.84	0.10	0.86	0.10	0.84	0.08
Acromial clavicle	0.963	28	0.50	0.09	0.52	0.10	0.48	0.11	0.49	0.10
Clavicle midshaft	0.050	19	0.89	0.89	0.94	0.18	0.96	0.18	0.91	0.11
Humerus midshaft	0.901	21	0.83	0.08	0.82	0.09	0.81	0.07	0.80	0.05
Radius midshaft	0.435	46	0.79	0.06	0.78	0.06	0.79	0.06	0.76	0.07
Ulna midshaft	0.762	26	0.80	0.09	0.80	0.07	0.79	0.09	0.80	0.09

Key: # = number, $\bar{x}$ = mean. SD = standard deviation

The clavicle midshaft demonstrated a changing pattern of asymmetry over time (see table 7.5.73). In the early phase, the right clavicle midshaft presented with greater bending strength, whereas in the late phase, the left midshaft had greater bending strength. It was difficult to comment on the potential causes of this, and the trend does not appear to correlate with any of the changes in MSM in section 7.2.2.2, with the exception of the latissimus dorsi, which does not attach to the clavicle. It does however demonstrate change in physical activity and loading on the upper arm.

7.5.5.3 Analysis of temporal difference in indices of Islamic females: changing female activity and identity

Table 7.5.74 Temporal difference in indices between Islamic females and results of Mann Whitney-U tests

Index	Side	Female						P value
		early			Late			
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
Clavicle sternal	Left	15	0.81	0.13	15	0.79	0.09	0.895
	Right	12	0.89	0.16	14	0.77	0.10	0.790
Clavicle acromial	Left	8	0.51	0.09	11	0.52	0.08	0.934
	Right	17	0.48	0.11	17	0.60	0.13	0.232
Clavicle midshaft	Left	11	0.89	0.18	6	0.91	0.11	0.203
	Right	10	0.96	0.20	8	0.85	0.11	0.491
Humerus midshaft	Left	7	0.78	0.08	4	0.79	0.09	0.705
	Right	5	0.75	0.10	9	0.77	0.09	0.463
Radial midshaft	Left	12	0.78	0.07	24	0.78	0.06	0.867*
	Right	15	0.77	0.07	24	0.76	0.05	0.436*
Ulna midshaft	Left	5	0.80	0.07	20	0.76	0.08	0.377
	Right	11	0.84	0.10	16	0.80	0.08	0.430

Key: L = left, R = right, * = log transformed data. † = Mann Whitney U tested, n=number, SD = standard deviation

There was no change in the long-bone and clavicle indices of women over time (see table 7.5.74). There was also no change in the degree of asymmetry for any of the indices examined (see table 7.5.75). For mean values see table 7.5.74.

Table 7.5.75 Results of Kruskals Wallis analysis of temporal changes in index asymmetry in Islamic females

Index	P value	Number
Sternal clavicle	0.323	56
Acromial clavicle	0.600	53
Clavicle midshaft	1.000	33
Humerus midshaft	1.000	25
Radius midshaft	0.824	75
Ulna midshaft	0.885	52

7.5.5.4 Analysis of temporal difference in indices in Islamic males: changing male activity and identity

Table 7.5.76 Temporal difference in indices between Islamic males and results of Mann Whitney-U tests

Index	Side	Male						P value
		Early			Late			
		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
Clavicle sternal	Left	11	0.85	0.22	14	0.86	0.2	0.870
	Right	11	0.84	0.15	12	0.89	0.16	0.895
Clavicle acromial	Left	8	0.54	0.11	13	0.49	0.12	0.395
	Right	17	0.51	0.07	12	0.53	0.1	0.399
Clavicle midshaft	Left	7	0.86	0.12	11	0.89	0.15	0.497
	Right	9	0.97	0.18	9	0.87	0.12	0.622
Humerus midshaft	Left	4	0.88	0.05	12	0.81	0.06	0.050
	Right	10	0.85	0.08	14	0.80	0.05	0.412
Radial midshaft	Left	7	0.78	0.04	22	0.78	0.06	0.799
	Right	20	0.79	0.04	34	0.78	0.07	0.531
Ulna midshaft	Left	10	0.85	0.08	16	0.81	0.10	0.155
	Right	16	0.86	0.08	22	0.83	0.08	0.214

Key: L = left, R = right, SI = superior-inferior, AP = anterior-posterior, * = log transformed data. † = Mann Whitney U tested, n=number, SD = standard deviation

The only index that was statistically significantly different over time in Islamic men was the left humerus midshaft, which had less bending strength in the late phase (table 7.5.76). Although there was also a temporal decrease in the bending strength of the right humerus midshaft, its change was not as dramatic as the left counterpart. It is possible that an increase in dominance of the right had created a significant drop in left humeral strength, this is something that would be supported by an increase in MSM asymmetry in late phase males (section 7.2.2.3.2)

Table 7.5.77 Results of Kruskals Wallis analysis of temporal change in index asymmetry in Islamic males

Index	P value	N
Sternal clavicle	0.366	48
Acromial clavicle	0.734	50
Clavicle midshaft	0.884	36
Humerus midshaft	0.777	40
Radius midshaft	0.420	83
Ulna midshaft	1.000	64

There was no difference in the degree of asymmetry between early and late Islamic males (see table 7.5.77).

7.5.5.5 Analysis of temporal difference in sexual dimorphism in indices: temporal changes in gender division and social organisation

In the early phase only the left humeral shaft was close to being significantly different in shape between men and women ($P=0.089$ $n=26$) (table 7.5.78). Females exhibited greater left humerus bending strength than males. This difference was nearly completely lost in the late phase. However, we need to consider that the sample size was small, and that the standard deviation in the male group was large. The difference therefore may be the product of an outlier. In the late phase, there was a significant sex difference in the right acromial index ($P=0.024$ $n=103$). This suggests variation in the loading of this joint.

Table 7.5.78 Upper limb indices calculated from absolute measurements (mm) and change sexual dimorphism time.

Index	Side	Early						P value	Late						P value
		Female			Male				Female			Male			
		n	$\bar{x}$	SD	n	$\bar{x}$	SD		n	$\bar{x}$	SD	n	$\bar{x}$	SD	
Clavicle sternal	Left	15	0.81	0.13	11	0.85	0.22	0.659	15	0.79	0.09	14	0.86	0.20	0.844*
	Right	12	0.89	0.16	11	0.84	0.15	0.242	14	0.77	0.10	12	0.89	0.16	0.291*
Clavicle acromial	Left	8	0.51	0.09	8	0.54	0.11	0.600	11	0.52	0.08	13	0.49	0.12	0.839
	Right	17	0.48	0.11	17	0.51	0.07	0.894	17	0.60	0.13	12	0.53	0.10	0.024
Clavicle midshaft	Left	11	0.89	0.18	7	0.86	0.12	0.655	6	0.91	0.11	11	0.89	0.15	0.509
	Right	10	0.96	0.20	9	0.97	0.18	0.800	8	0.85	0.11	9	0.87	0.12	0.847
Humerus midshaft	Left	7	0.78	0.08	4	0.88	0.05	0.089	4	0.79	0.09	12	0.81	0.06	0.716
	Right	5	0.75	0.10	10	0.83	0.08	0.178	9	0.77	0.09	14	0.81	0.05	0.345
Radial midshaft	Left	12	0.78	0.07	7	0.78	0.04	0.564	24	0.78	0.06	22	0.78	0.06	0.220
	Right	15	0.77	0.07	20	0.79	0.04	0.477	24	0.76	0.05	34	0.78	0.07	0.214
Ulna midshaft	Left	5	0.80	0.07	10	0.85	0.08	0.178	20	0.76	0.08	16	0.81	0.10	0.171
	Right	11	0.84	0.10	16	0.86	0.08	0.622	16	0.80	0.08	22	0.83	0.08	0.532

Key: L = left, R = right, * = log transformed data. † =Mann Whitney U tested, n=number SD = standard deviation

Table 7.5.79 Indices of long-bone dimensions by phase, sex and side.

Index	P value	Early				Late			
		Female		Male		Female		Male	
		L	R	L	R	L	R	L	R
Sternal clavicle	0.221	0.79	0.89	0.71	0.75	0.78	0.84	0.96	0.83
Acromial clavicle	0.616	0.53	0.51	0.51	0.48	0.54	0.51	0.45	0.45
Clavicle midshaft	0.530	0.89	0.91	0.91	1.05	0.98	0.91	0.95	0.91
Humerus midshaft	0.630	0.76	0.78	0.88	0.85	0.79	0.80	0.81	0.80
Radius midshaft	0.144	0.55	0.54	0.56	0.57	0.55	0.54	0.54	0.58
Ulna midshaft	0.909	0.76	0.79	0.83	0.81	0.76	0.79	0.83	0.81

Key: L=left, R= right.

There was no change in sex difference in asymmetry over time (table 7.5.79). This suggests that any change experienced over time was equally experienced by men and women, or did not impact significantly on cross sections.

Chapter 8: Discussion

The primary objective of this research was to demonstrate how archaeology could contribute to discussions and debates on religion by viewing it as a social construct influenced by historic and political factors. By analysing the body as an indicator of religious identity, and therefore religion, it was possible to demonstrate the constructed nature of religion. Key to this was viewing Islam as a strong life-structuring tradition (Insoll 1999), or as tradition placed on a pre-existing system (Asad 1986, Eickelmen 1982). Accordingly, this was how it was viewed in the archaeological record. The examination of changing Islamic identity from ARSMs needed consideration of pre-existing structures and external influences in Iberia. This informed about Islam, its role in shaping identity and religion more broadly. This chapter discusses the results of the case study prior to evaluating religion in archaeology.

8.1 Écija Islamic Identity: Islam as a life-structuring principle: The example of gender

A key aim was to assess whether Islam actually transcended and structured other identities in Écija, using gender as an example. It did this through examination of sex differences in ARSM, placed in context with historic and religious ideas on gender and gender roles in the region.

Gendered divisions of labour and gender roles are identified in many societies (Bitel 2002) and are a strong feature of Islamic societies (Ruthven 2000). The results suggested that the sample from Islamic Écija was no exception, as clear sex differences existed in the prevalence and patterns of all the ARSMs, thereby suggesting gender-specific activity patterns. After controlling for age and body size, males appeared to have undertaken more mechanically demanding and high-impact activities than females, as evidenced through higher male enthesal scores and OA prevalence (section 7.2.2.1 and 7.4.2). Critically, as outlined below, males did not outscore females at all enthesal sites, an important indicator of activity difference (Weiss 2004).

A more detailed examination of ARSMs by sex implied differences in upper body use between males and females, inferring both sex-specific activities and differences in the degree of loading. In the Écija sample, females outscored males at a number of entheses, especially the scapular elevators. This was statistically significant for the trapezius and

deltoid attachments, and may signify an activity where females raised the arms above head level (section 7.2.2.1 page 166). Such a motion could be related to the use of the loom in females which required such an upward movement of the shoulder. Horizontal looms, originating in Europe, and vertical looms, originating in Africa and Asia, were common in Iberia and North Africa by the 12th century and earlier (Pacey 1991). Greater costoclavicular ligament and humeral enthesal scores in males suggest greater mediolateral movement of the arms in men. In addition, enthesal asymmetry were noted (section 7.2.2.1:page 166). Males had more asymmetry than females at the costoclavicular ligament attachment, latissimus dorsi and pectoralis major. This trend was also observed in long-bone measurements, where males had greater asymmetry at the superior-inferior diameter of the acromial end and the maximum length of the clavicle, as well as five humeral measurements (maximum length, minimum diaphysis circumference, circumference of the humeral head, maximum diameter of the midshaft and the width of the proximal humerus) (section 7.5.5.1:page 410). This suggested a greater expression of handedness in males, following trends identified in Mays *et al.* (1999) and Steele (2000), and therefore different use of the upper limbs.

Forearm (ulna and radius) use varied between the sexes. Females outscored males at the supinator brevis and flexor pollicis longus attachments of the radius, as well as the ulna pronator quadratus attachment (section 7.2.2.1:page 166). Males had greater ulna supinator and pronator teres scores. While these enthesal differences were not statistically significant, absolute bone measurement results indicated a significant sexual dimorphism in the midshaft diameters of the radius and ulna, and the radial head. The left ulna midshaft cross-sectional shape was rounder in males, and the right radius exhibited a similar (albeit non-significant) pattern. The results implied greater medio-lateral bending strength in female left ulnae and right radii (section 7.5.5.1:page 410).

Unlike the humerus, greater enthesal and absolute measurement asymmetry was observed in females at the forearm (sections 7.2.2.1, 7.5.5.1 and 7.5.6.1). With the exception of the flexor pollicis longus and pronator teres muscles, which are involved heavily in hand movement, the other forearm entheses were more asymmetric in females. The radius and ulna midshaft indices and the radial head diameter were significantly more asymmetric in females. With respect to the radial head, articular surfaces are more responsive to loading in the growth phase of life (i.e. prior to fusion) (Hellier and Jeffery 2006, Plochocki 2004). This may signify a trend whereby females

were undertaking an asymmetric gendered activity early in life, such as before, or around puberty. This could be loom work or another activity carried out by women. This certainly fits well with passages in the Qur'an, that suggest that girls and boys both become responsible for their actions in the eyes of Allah at the time of puberty (Hewer 2006).

The greater female forearm enthesal asymmetry was an important finding because, in general, archaeological studies have identified this as a feature of male enthesal scores (Weiss 2003a), which has led to the assumption that it might be a natural difference between the sexes (Groves 2005). It would, however, be uncertain as to why the trend for greater male asymmetry would only apply to the humerus. The differences here, with enthesal scores and bone absolute measurements, suggest that activity was likely to be the cause, and highlights the importance of using multiple indicators of activity.

The general sex differences identified in the data probably originate from strong gender ideology found in the history and nature of Islam as a predominantly patriarchal society. While men and women are seen as spiritually equal in the Qur'an (43:70), they are considered as complementary to each other (Lindsay 2005, Ruthven 2000, Shatzmiller 1994 and Waines 1995). Hussain (2003) argues that despite attempts by Muhammad, early jurists formulating *shari'a*, used verse 34 of the Sura al-Nisa' to subordinate women. Females are regarded as needing protection in Islamic tradition and are often limited to child bearing and domestic tasks (Hussain 2003). The easiest way to protect women is to prevent them from entering situations where they might come into physical and moral danger. Jewell (2007:134) cites a number of cases from Seville, Spain where legislation was created for the protection of women. This included prohibiting women from taking on occupations that might put them at risk of being alone with men (Jewell 2007). It was therefore unsurprising that male and female activity markers differed in relation to muscle development and joint loading, as well as the reduced female mobility as identified by other researchers (Pomeroy and Zakrzewski 2009, Robles 1997). However, it should be remembered that just because there were activity differences between men and women, does not mean that females were oppressed (see section 8.1.5.1). We cannot observe this from the data.

While it was difficult to be specific about tasks attributable to each sex, the ARSM results do not conflict with historic and religious sources. In a survey of economic

resources in al-Andalus, Shatzmiller (1994:348) found no examples of females working in areas requiring heavy labour (e.g. mining). This fits well with the general results of lower female OA and enthesal scores in this sample. The same economic research by Shatzmiller (1994), and historic sources identified by other scholars (Bitel 2002, Hillenbrand 1992, Lindsay 2005), suggest that weaving and cottage industries, such as pottery (Peacock 1982), dominated female work. Greater or equal forearm pronator and supinator enthesal scores, and asymmetry in forearm measurements in females, could support a hypothesis suggesting a female focus on light activity, particularly weaving, spinning and food processing. Similar enthesal sex differences have been observed elsewhere by other authors (Hawkey and Merbs 1995, Ponce 2010, Wilczak 1998), and have been related to female occupation in intricate, repetitive unloaded activities, such as small line fishing (Ponce 2010) or hide manipulation (Hawkey and Merbs 1995). While the greater prevalence of wrist OA in men initially appears to conflict with this notion, research on master weavers by Mays (2002) demonstrated that weavers were not at an increased risk of OA prevalence. Wrist OA in men was probably caused by male engagement in a loaded activity, or was secondary to injury (West 1997).

A further important observation was the considerable difference in humeral laterality identified between the sexes (sections 7.2.2.1, 7.5.5.1 and 7.5.6.1). Males have significantly more asymmetric humeri than females for metrics and enthesal scores. Humeral enthesal laterality was investigated in a study of known-occupation white-collar workers and blue-collar workers (Doyling 2010). It was demonstrated that the more specialised white collar workers had greater enthesal asymmetry. In addition, archaeological enthesal studies have identified that men involved in specialist activities also have pronounced enthesal asymmetry (e.g. spear throwing (Peterson 1998)). Indeed, Iberian Islamic men were recorded as working in trade, crafts, law and religious positions (Shatzmiller 1994). Such involvement explained why males outscored females at many entheses, and had different metric properties, with the exception of the forearm, which may represent specialist female involvement in domestic craft production and weaving.

Non-pathological articular modifications offered an additional perspective on the differences between the sexes, providing information on posture adoption rather than loading or muscle use. Sex differences were noted, with a greater prevalence of congenital squatting facets in females (section 7.3.1: 258). As there is no known

evidence for a relationship between the appearance of the squatting facet and sex, this meant that females were hyperdorsiflexing the ankle more frequently and earlier than males. Females also had a greater prevalence of metatarsal extensions than males, implying greater toe hyperdorsiflexion (section 7.3.2). It was, however, not possible to say whether females were undertaking prayer more than males. The differences in modification patterns could also be caused by different activities being undertaken by women, but again represent a clear gender division.

Écija was not the only Islamic site from Spain to present with a clear gender division. enthesal research from La Torrecilla (al-Oumaoui *et al.* 2004) and bone geometry studies and osteoarthritis patterns from San Nicolas, Murcia (Robles 1997), suggest that the results from Écija fit with a general trend of Islamic sites from southern Spain. It may be useful to outline here that in al-Oumaoui *et al.*'s. (2004) and Robles' (1997) data, and the results obtained from this research, the gender division was more evident in the Islamic samples than the comparative Christian groups, suggesting increased gender division in the Islamic groups. This study indicated that religion (Islam) was important in structuring gender roles in Southern Iberia and possibly did transcend other aspects of identity when it came to dictating the activities of men and women.

8.1.2 Islam as a malleable entity (Early and late phase comparisons of ARSM)

An additional aim of this research was to explore the temporal malleability of religious identity. Although Islam is an important social constructor, it is not rigid and inflexible, and is influenced by the people practicing the faith. Specifically this aspect focused on the development of Islamic identity over time. In order to gauge this, it was necessary to investigate whether ARSMs, and therefore activity patterns, changed diachronically by comparing individuals from the early and late phases of the Écija cemetery (see sections 7.2.2.2, 7.3.3, 7.4.3 and 7.5.1.2), and how variations may relate to local circumstances.

Neither Islamic temporal phase had consistently higher enthesal scores or OA prevalence, inferring similar levels of mechanical demand. This was supported by a lack of difference in absolute measurements and midshaft indices between early-and late-phase individuals. However, changes in the amount of medio-lateral arm movement could be suggested, and subtle asymmetry changes were observed in enthesal scores. While the pattern of clavicle muscle involvement did not differ between phases, a decrease in costoclavicular ligament laterality was observed in the late phase. By

contrast, the sternal clavicle superior-inferior diameter and the maximum clavicle length become more asymmetric in the late phase (section 7.5.1.2). As the costoclavicular ligament score becomes less asymmetric in the late phase, whereas the sternal clavicle superior-inferior diameter becomes more asymmetrical, it suggests no positive relationship between the costoclavicular ligament score and sternal dimensions.

Although the data suggested some differences which could be linked to changes in social organisation, these were minimal. This result initially seemed discouraging, but subsequent temporal analysis of the individual sexes indicated that these rather negative, and conflicting results, were caused by combining male and female data into general early and late groups. Significant trends were masked by the pooling of sexes.

8.1.3 Temporal analysis of female and male ARSM – Changing gender roles and Islamic identity

Given the strong relationship between gender identity and religious ideology, assessment was made of any ARSM changes that occurred over time specifically for males and females. This explored whether Islam remained a structuring principle for male and female gender identity in Iberia, and what other factors that may have influenced this.

8.1.3.1 The diachronic analysis of female ARSM and Islamic identity

Even though some early and late Islamic female ARSM patterns varied, there was no change in OA prevalence, implying that a low amount of high-impact stress remained a constant feature of Islamic female identity (section 7.4.4.1: page 320). There was, however, a clear trend for early females to have greater enthesal scores than late Islamic females, especially for muscles associated with medio-lateral movement of the humerus (see section 7.2.2.3.1: page 190) (with the exception of right forearm flexors and extensors [as discussed below] and the costoclavicular ligament score). This possibly infers a reduction in muscular demand over time, as maximum long-bone lengths do not indicate a statistically significant temporal decline in body size for Islamic females (section 7.5.1.3: page 368). A similar diachronic change was identified by Munson Chapman (1997) where female deltoid score increased diachronically with an intensification of maize processing in Pueblo Indians.

Temporal changes in forearm laterality were observed. In terms of radial enthesal scores, a significant increase in asymmetry for the supinator brevis and the pronator teres scores was identified (section 7.2.2.3.1: page 187). Other changes in asymmetry were recorded in the absolute bone size diameters: the minimum humeral shaft diameter, the transverse radial midshaft diameter, the transverse radial head diameter and the ulna transverse midshaft diameter (page 375) were all statistically asymmetrical in the late phase, and larger on the right side. Unlike the entheses for the humerus, most right ulna and radial enthesal scores are greater in the late phase, (see table 7.2.1.10: page 188). This showed a change in the use of the muscles involved in supination and pronation of the right forearm in the late phase.

Differences in forearm asymmetry reinforce the idea that a two-handed food processing system was replaced by a single-handed system (Antonio Ugalde *pers comm.*). However, a greater amount of research on the types and chronology of food processing technology is required before this can be verified, especially as there could be regional variation in technology usage. In addition, there was a significant change in the type of loom during the course of the Islamic period in Iberia (Pacey 1991). While these changes are not related to something directly written into Islamic scripture, the change had to be either acceptable or neutral under Islamic law to be incorporated into daily-life cycles. In this case, a single-handed food processing system may fit in line with ideology regarding the polluted left hand. Probably more likely, however, was that the decline in other enthesal scores infers that women became more specialised to specific roles, and may demonstrate a clearer gender identity when it came to work.

Subtle temporal differences were observed in the non-pathological articular modifications (section 7.3.3.1: page 273). In terms of kneeling modifications, the prevalence, type and size of osteochondritic imprints, tibial imprints and the left vastus notch remained constant over time. The vastus notch pattern becomes asymmetric in the late phase because the prevalence of right vastus notch decreased. In terms of ankle hyperdorsiflexion, the prevalence of medial tibial squatting facets did not differ between phases. The late-phase females had a greater prevalence of lateral tibial squatting facets, and larger lateral tibial facets than early females. Although the prevalence of talus squatting facets remained constant over time, the prevalence of left talus congenital facets significantly increased. A similar trend was also observed on the right talus. As congenital facets are thought to represent continual adoption of ankle hyperdorsiflexion

from childhood (Boulle 2001a), this implied that late Islamic females were undertaking either new activities, or that ankle hyperdorsiflexion activities were adopted earlier in life. While the prevalence of phalangeal wedging remains constant over time, a greater prevalence of metatarsal extensions was identified in late-phase females, but no toe was particularly affected. This data signifies that there was a temporal trend for more, and earlier hyperdorsiflexion of the ankle and metatarsophalangeal joints in females, which may be related to greater adoption of prayer, or earlier adoption of gendered activities.

Prayer is mentioned in *qadi* judgements of Córdoba as early as the 8th century, and repeatedly in the 9th century (Marin 1992), suggesting that it immediately made up part of life in al-Andalus, and could be a feasible cause of the alterations observed. Prayer is important for a number of reasons. Prayer acts to bring the community (usually males) together (Berkley 2003). It is a social process that acts to reinforce identity and social ties (Henkel 2005, Insoll 1999:28). It is stated in the Qur'an and in the *Muwattah* text (Book 8, *hadith* 1), that congregational prayer is far more powerful than individual prayer. As absence from prayer would be noted by the wider community, it is therefore important in identity maintenance. As prayer is a symmetric activity, more symmetrical patterning of articular modifications might be expected if prayer was a major causative factor of modifications in females. A temporal increase in ankle and metatarsal modifications could suggest that there was an increase in prayer activity in the late females, but the asymmetric nature of the vastus notch modifications probably meant that females were engaging in other kneeling activities, which affected skeletal morphology instead of, or as well as, prayer.

In addition to the changes in female activity patterns over time, a reduction in female mobility during the Islamic period in Iberia, identified by Pomeroy and Zakrzewski (2009), supported ideas that females became more restricted in their movements in comparison to males. This was in keeping with Islamic notions of restricting female movement to prevent danger (Insoll 1999). However, unique patterns of forearm activity markers infer that female may have undertaken specialist craft activities in the domestic sphere. This tied with legal and economic sources, which suggest that women were economically important in al-Andalus, dominating the textile industry, earning a wage and owning businesses and properties (Shatzmiller 1994). Therefore, despite possible gender segregation, women could exert considerable influence in other ways.

This calls into question contemporary popular stereotypes of Islamic women as always being oppressed and subjugated.

What could be gleaned was that changes in female activity patterns may not have necessarily revolved around overt Islamic ritual practices, which are often the exploit of men (Edwards 2005), but could be influenced by Islam indirectly. Hays-Gilpin (2008:247) notes that female activities are often seen as profane because they are not overt religious practices. Nonetheless, recognition that many domestic activities are influenced by religion is visible in archaeology, for example, pottery production for ritual activities, or shrouds for burial. Certainly, the production of this type of material would be a key way in which Islamic identity could be reproduced. This requires further research, but has been argued to be a cause of Islamic identity variation in other places (Edwards 2005, Halevi 2007, Morris 2006).

8.1.3.2 The diachronic analysis of male ARSM and Islamic identity

In terms of physical loading, increased enthesal scores were observed for most of the clavicle, humerus and right ulna entheses in late males (see section 7.2.2.3.2). While this increase may, in part, be related to body size, as identified by Weiss (2004), no significant difference was observed for the absolute bone size measurements between early and late males (see section 7.5.1.4). Age, as a compounding factor, was controlled in both the selection of individuals, and in the statistical analysis, limiting its effect on scores. This suggested that there may have been greater muscle recruitment in later males. An explanation may lie with the possibility that Écija was settled by Arabs who, in the early phase may represent an elite. Shatzmiller (1994:336) identified that in al-Andalus, Arabs tended to work in the service sector rather than extraction or manufacturing due to their proficiency in Arabic. Increases in enthesal scores may therefore reflect growing numbers of converts in the population, undertaking more physical roles, possibly as the link between being Arab and being Muslim was lost, and individuals of all status were incorporated into the Islamic population. This change in link was, however, difficult to identify from osteoarchaeology alone, for in accordance with Islamic tradition, funerary architecture in Écija had such similarity between individuals, that it was of little use in identifying status (Romo Salas n.d.). The presence of an Arab elite, however, could be inferred from historic documentation and of persistent early (8th - and 9th-century) unrest in the region where converts and Berbers

were unhappy about being treated as second-class citizens in comparison to Arabs (Garcia Baena 2006, Melville and Ubaydli 1992). Alternatively, as there were no significant differences in the overall prevalence or distribution of OA, suggesting no change in the amount of high-impact or traumatic activity, this may imply that the enthesal score increases may represent greater conformity of men to male roles. This was important in terms of developing gender divisions.

Significant temporal differences in asymmetry were observed. Four entheses demonstrated statistically significant asymmetry differences between phases: pectoralis major, brachioradialis extensor, quadratus and the ulna pronator quadratus attachment, and a further two (costoclavicular ligament and humeral deltoid attachment) were just outside statistical significance (section 7.2.2.3.2). The two entheses involved in moving the humerus were more asymmetric in the late phase, whereas the two forearm entheses were less asymmetric in the late phase. This difference was also observed in absolute bone measurements, where the superior-inferior sternal diameter of the clavicle, circumference of the humeral head, the maximum humeral head diameter and the width of the distal humerus appear asymmetrical in the late phase (section 7.5.1.4).

The data suggested that there was an increase in laterality, which inferred greater expression of handedness in late males. Turning again to the examples of Doyling (2010) and Stirland (1993) for entheses, and Steele (2000) and Mays *et al.* (1999) for absolute measurements, this result may support historic evidence which indicated that Muslims should avoid heavy labour, as well as economic research by Shatzmiller (1994) suggesting that males were involved more in fiscal, religious or trading work rather than mining or extractive work. Increasing asymmetry may imply the emergence of specialised asymmetric male activities (e.g. Peterson's (1998) study of male throwing patterns). This was supported by the increase in what Shatzmiller (1994) described as tertiary activities (those not involving manufacture, farming or extraction) in 11th-century Iberia. No difference in the humeral, radial or ulna midshaft indices, i.e. measures of bending strength, between the early and late males, supported OA data for no change in high-impact physical labour.

As discussed earlier, increasing laterality also conforms to Islamic ideology where the left hand is least preferred (Tan 1998). A high degree of laterality was also noted in the Écija population by Pomeroy and Zakrzewski (2009) and Cashmore (2008). This study

moved forward in identifying that this was more apparent in the late-phase males. There are Qur'anic references to the left and right hands (Nydell 2006, Tan 1998). The left is generally associated with bad attributes while the right is seen as good. Ritual purity and cleanliness is an important factor in Islam (Safran 2001, Insoll 1999). As the least preferred hand, the left hand is traditionally used for personal hygiene and similar related activities (Lindenbaum 1968). For example, in the *Muwattah*, a *hadith* exists that prohibits eating with the left hand (book 49, *hadith* 5) as the left is considered unclean. The right hand is used for other tasks including eating, greeting, exchange etc. Accordingly, being left-handed is problematic in some Islamic societies and can be actively discouraged (Fagard and Dahmen 2004, Payne 1987). While these tasks are unlikely to directly cause the laterality seen in the Islamic group, it could reinforce right hand preference as a correct practice, and thereby impact on procedures in other tasks, creating a greater uniformity in handedness in the Écija population.

Greater temporal differences in non-pathological articular modifications were observed in between phases in males, implying greater diachronic changes in posture than in females (see section 7.3.4.2). While there was no difference in the prevalence or type of tibial imprints, vastus notches were more prevalent and showed no side bias in late males, suggesting that late males undertook a greater amount of symmetric kneeling. Lateral tibial squatting facets were also more prevalent in the late phase, but the prevalence of talus squatting facets remained high (over 90%) and constant. There was, however, an increase in pressure facets on the talus; this was statistically significant on the right side. This suggested an increase in ankle hyperdorsiflexion, but also that ankle hyperdorsiflexion may have been undertaken in later life for late phase males. This was a different pattern to that observed for females. There was a trend for an increase in metatarsal extensions in males, implying greater toe hyperdorsiflexion. This was only statistically significant for the 5th left metatarsal, and it is difficult to understand why only this toe would be affected. During prayer, according to the *Muwattah*, the left foot is placed under the body while the right remains hyperdorsiflexed at the ankle (book 3, *hadith* 54). This could potentially place pressure on the 5th left metatarsal, but it was difficult to cite this as a cause because the toe may actually be positioned in the opposite direction, and no rule governs its direction. Interestingly, there was no change in the prevalence of wedged phalanges between phases. Overall, increased evidence for kneeling and hyperdorsiflexion of the ankle may signify increasing conformity to the

religious rite of Islamic prayer, especially given the symmetry of the non-pathological modifications.

Admittedly, these modifications could be caused by other factors. Males were known to squat and kneel for craft production in al-Andulas (see Robles 1997). Walking in mountainous terrain can also induce squatting modifications as there may be extreme flexion of the ankle when walking on harsh, uneven terrain. This was perhaps evidenced by individuals in St Stephens, Jerusalem (Ullinger *et al.* 2004), but Écija, however, is in a valley and the nearest mountains are 80km away. The high prevalence of the modifications is highly indicative of something undertaken *en masse* by the population, of which prayer would be a reasonable inference, and historic sources (Marin 1992) indicate that prayer was practiced by the population. As prayer at mosque is male activity, it also makes sense for males to demonstrate non-pathological articular modifications more consistent with prayer than females.

As highlighted previously, the most important temporal feature identified in section 7.2 was the greater change in male skeletal data than in the female data. The emergence of Islam may have had different implications for male and female activities, impacting more on the former, as the patterns observed in male data can be more confidently related to increasing conformity to Islamic tradition over time. In order to understand this pattern, it was important to further consider gender practices and ideology in Islam for each sex (as outlined in chapter 2).

Men and women have separate Islamic identities. This is because Islam outlines specific behaviour required of men and women in order to be a good Muslim (Marranci 2008). Female Islamic identity is strongly influenced by ideas of chastity and protection of paternity. In males, it is about providing and protecting family honour through adherence to Islamic practices. As such, the protection of paternity has resulted in the division of public and private space as male and female. As males operate in the public realm, and need to visibly display their Islamic identity, it was not surprising that greater differences in male activity patterns were observed. An ethnographic example of such a male-dominated situation was noted by Morris (2006:83) in the Islamic Zar cultures of Somalia. Here Islam is seen as a public cult, so it is therefore dominated by men; women are not allowed in mosques and few of them ever make *hajj* (Morris 2006). This, however, does not mean that women were areligious or unobservant, but supports

the idea that the religious tasks of women differed from those of men, as has been highlighted in other past populations by Hays-Gilpin (2008). This is why diachronic changes were visible in female activity patterns from Écija, but differ from male changes.

In terms of the increasing conformity to Islamic traditions over time in males, it might be important to consider the emergence of Islam in al-Andalus and its nature as an orthopraxy. Men need to demonstrate their Islamic identity in public by undertaking specific rituals. This may be particularly important in the region later when, as Kennedy (1996) and Hillenbrand (1992) argue, tax breaks and better employment options were available to Muslims. If we consider public expression of Islamic identity to be important, it is noteworthy that Pomeroy and Zakrzewski (2009) identified from lower limb-bone cross sections that Écijan Islamic females were far less mobile than Islamic males. Robles (1997) also noted the same trend, but further identified that Islamic female mobility was lower than pre-Islamic and contemporary Christian females. This suggested that gender segregation, and restriction on female mobility, may have been enforced. The public expression of Islam was therefore critical in Écija. This is certainly not surprising in that in order for identities to exist, one has to demonstrate what one is not by conforming to ideology i.e. identity is relational (Schöpflin 2001).

8.1.4 Comparison of ARSM sex differences by phase: changes in gender division

To ascertain whether the degree of gender division in the early and late phases changed over time, and thus Islamic ideology changed, sex differences in ARSM were compared between phase groups (early and late).

The first important finding was the diachronic increase in sexual dimorphism for bone lengths and indices in the late Islamic group (section 7.5.1.5). Variation in sexual dimorphism has been linked to many different factors. Low sexual dimorphism has been linked to monogamy, low fertility, social equality and similar physical activities (see section 4.5.3.1). While isolating the exact cause of the increase in sexual dimorphism is problematic (Pomeroy *et al.* forthcoming), it can be related to a number of these factors. Of particular note was that polygamy is permitted under Islamic law (Insoll 1999). To what extent this was practiced by the general Islamic population in Écija during this period is unknown. Perhaps more significantly, Holden and Mace (1999) demonstrated that the degree of sexual dimorphism was related to the contribution and access that

females had to food, with high dimorphism found in situations where this was limited. This, again, may infer the greater presence of gender segregation in the late phase, but teasing this out from other factors was problematic. Regardless, what was probably most significant was that a change in sexual dimorphism indicated a significant social change in the Ėcija population rather than a signification change in population. Stable isotope and non-metric traits suggest that the majority of the population from the Ėcija population were in fact local (Inskip 2013, Zakrzewski 2010).

While there was no change in the sex differences for the prevalence or distribution of osteoarthritis, inferring that little high-impact loading remained a feature of Islamic identity, different areas of the body were affected (section 7.5.4) in each phase. This is supported by a change in the sex difference in enthesal scores, indicating that the muscles used by men and women changed over time (section 7.2.2.4). In the early phase, six entheses statistically correlated with sex; the left subclavius, humeral deltoids, the right pectoralis major and both ulna pronator quadratus. Only the pronator quadratus were larger in females, the remainder were larger in males. The left costoclavicular ligament score was also larger in men. Scapular elevation, elbow flexion and extension appeared to be a feature of early female activity. There was no difference in asymmetry for the early entheses. In the late phase, six different entheses statistically correlated with sex; the left trapezium, the costoclavicular ligaments, the left pronator teres, and both supinator crests. Importantly, a further four were close to significance ($P \leq 0.09$); the right trapezium, brachioradialis extensor, pronator teres the left supinator brevis. The pectoralis major differed in asymmetry, being more asymmetrical in men. While scapular elevation appeared to remain an important part of female movement, the difference between men and women was reduced in the late phase. Medio-lateral arm movement, especially for the right arm, became an even stronger feature of male upper-body movement. The only index to display a statistically significant sex difference was the acromial end of the clavicle in the late phase, which could be related to the two very different movements being undertaken by men and women.

In terms of the non-pathological articular modifications, in the early phase, there was no difference in the prevalence of tibial imprints, but a significant difference for the prevalence of right vastus notch (this was more common in females) (section 7.3.4) existed. In the late phase, however, more sex differences were observed. The prevalence of tibial imprints on the left lateral femoral condyle increased in men, and vastus

notches were now both statistically significantly more common in men. With regard to ankle hyperdorsiflexion, there was no difference in the prevalence or type of lateral tibial or talus squatting facets between the early sexes. In the late phase, however, there was sexual dimorphism in the type of squatting facet observed, with females having a higher prevalence of congenital facets and males having more pressure facets. This demonstrates a significant sex difference in the timing of the first adoption of ankle hyperdorsiflexion. There was, however, no difference in the sex differences for toe hyperdorsiflexion modifications between phases.

Sex differences in ARSM were observable in both phases. Two important features were observed. Firstly, sex specific tasks may have changed over time because the entheses that statistically correlated with sex changed over time. This supports Marranci's (2008) observation that gender division always exists in Islam, but it may take different forms over time, as, for example, economic and technical situations change. This demonstrates Islamic traditions ability to adapt to different situations. The persistence of a clear gender division highlights the importance of Islamic gender ideology in structuring male and female activity patterns and therefore identity. A second important feature of this research was that data appears to suggest that greater adherence to a gender division in the late phase. This was especially noteworthy as females outscore males at more entheses and have greater differences in non-pathological articular modifications. Increasing gender division may confirm that Islamic ideology became more influential over the activities of men and women in the late phase when Islamic law was more consolidated and established (Payne 1973).

8.1.5 Religion as a key constructor of society: Comparison of Islamic and Visigothic individuals

To assess whether Islam was an important structuring tradition in the construction of medieval Iberian society, it was necessary to assess whether activity patterns changed with the arrival of Islam. Accordingly, ARSM were compared between pre-Islamic (Visigothic) and Islamic individuals. This demonstrated significant differences in ARSMs between the groups. In general, Visigothic individuals appeared to have had far more physically demanding lives than the Islamic group. This was particularly evident in the OA data (section 7.4.8). While OA has been shown to be strongly related to age (Waldron 1997, Roberts and Manchester 2005), by controlling for the impact of

senescence through selecting the youngest adult members of the population, and by controlling for imbalances in the numbers of middle and young individuals, it was hoped that the results obtained reflect true activity differences rather than age disparity.

Secondly, sex differences in ARSMs were more statistically significant in the Islamic groups than in the Visigothic group (with the exception of OA). This general comparison suggests that a stricter gendered division existed in the Islamic group. This might be expected from literature and documentary sources on Islamic gender ideology outlined in chapter 2.

Finally, the differences in ARSMs between the Islamic and Visigothic individuals were not the same for males and females, suggesting that the arrival of Islam had different repercussions for male and female activities and lives. This may mean that men and women may have had different Islamic identities or had roles when it came to constructing Islamic identity. Accordingly, the discussion below discusses this in more detail and outlines differences between faith groups by sex, and discusses why such differences may have occurred.

8.1.5.1 Changing female identity in early Medieval Iberia: Interfaith analysis of female ARSM

While sometimes there was no dissimilarity between Islamic and Visigothic females, subtle variations were observed. There was no difference in the prevalence or distribution of OA between Islamic and Visigothic females inferring no substantial changes in mechanically demanding tasks (section 7.4.8). However, the dimensions of the clavicle and enthesal scores of clavicle and upper humerus differed significantly between Islamic and Visigothic females (sections 7.3.2.1 and 7.5.3). Greater trapezius, costoclavicular ligament, humeral deltoid, teres major and latissimus dorsi scores infer greater mediolateral arm movement or loading in Visigothic females. This movement was suggested because, although these muscles are all involved in arm extension, the triceps brachii scores were actually greater in Islamic females. Visigothic females were more asymmetric at the subclavius, whereas the Islamic females were more asymmetric at the costoclavicular ligament. Despite Visigothic females having greater costoclavicular ligament scores, interestingly, Islamic females had larger sternal clavicle dimensions, especially on the left. Although the Visigothic sample size was small, the standard deviation suggests no extreme outliers in the sample. Higher scores for

muscles involved in pronation of the forearm, and movement of the thumb, were observed in Islamic females. This included the common extensor tendon, flexor pollicis longus, supinator brevis, quadratus, pronator quadratus and tricep brachii. Islamic females also had larger radial midshaft transverse diameters than Visigothic females.

In terms of non-pathological articular modifications, differences in female knee hyperdorsiflexion were inferred by the data. While there was equal prevalence of osteochondritic imprints and vastus notches, Visigothic females had a higher prevalence of tibial imprints. It was problematic to say that Visigothic females undertook more kneeling because of the equal prevalence of osteochondritic modifications and vastus notches, but knee flexion in a different activity may be responsible, as osteoarthritis prevalence suggests no dissimilarity in high-impact knee loading. For example, the knee could be flexed as part of squatting or as part of kneeling, but also through general movement such as walking or running. Significant differences were observed for the lateral tibial and talus squatting facets, which suggested greater adoption of ankle hyperdorsiflexion in Islamic females. This evidence implies Islamic and Visigothic females may have adopted different postures routinely, which may have included prayer in the Islamic females.

One area of particular debate that has surrounded female Islamic identity in Iberia is the idea that Muslim women were more liberated than in other parts of the *dar al-Islam* (see discussions in Imamuddin 1981, Mourtada-Sabbah and Gully 2003, Viguera 1992). However, Hambly (1999) argues that status may have been an important factor in the division of activity, and labour may have been divided in women as well as men. Guichard (1992) argued that this perceived liberation may have been limited to high-status women, and that Iberian women of normal status would have been subject to the same laws as other women in the east. In fact Ibn Rushd laments the lack of opportunity for Iberian women in the 12th century (Bitel 2002, Hillenbrand 1992). Furthermore, Guichard (1992) also suggests some liberation for women where the security of the family and paternity were not an issue, e.g. those that worked as concubines or the very rich. However, as Andalusian Islamic law records Muslim women being hauled before the court for failing to observe Islamic law (Fierro 2005, Melville and Ubaydli 1992), women did need to change their practices. Such a change was supported by the data here, and the supplementary information of reduced female mobility from Pomeroy and Zakrzewski (2009) and Robles (1997). Unfortunately it is not possible to resolve this

issue further by looking at status from burial rites, as great uniformity in burial practice was observed at Écija.

The lack of ARSM differences between Visigothic and Islamic females means that some activities for women have been the same whereas men may have had generally different activities. This may also support suggestions that Muslim men married local women rather than bringing significant numbers of their own families. This is something supported by preliminary isotope analysis (Inskip 2013). It is arguable that domestic roles were clearly the mainstay of women's work in both populations and these old roles did not clash with new and forming Islamic law (see Bitel 2002). For example, weaving may have been a particularly important female role in both societies. Morris (2006) demonstrates, from ethnographic work, that in many Islamic societies, women are important actors in syncretism; it is often the case that females carry on with traditional roles/practices and rituals which lead to variations that are observed in Islamic identity. Edwards (2005) certainly notes that females are largely involved in the practice of non-religious Islamic traditions. This is important in the emergence of Islamic folk traditions, which are responsible for many differences observed globally. Such retention could have potential to occur because females are operating in the private sphere. While syncretism is not clearly visible from this data, only in that similarity between the two faith groups exists, it is supported by documentary evidence. Safran (2001), in a study of acculturation and intermarriage, suggests that deviation from perceived norms of Islam was a concern for some individuals in the region, especially in the early period. There are also a number of cases where women continued with old traditions in al-Andalus, including the celebration of Christian festivals (Fierro 2005, Melville and Ubaydli 1992). The existence of such documentation infers that syncretism may have been a real possibility in al-Andalus. This needs to be researched further and could benefit from the analysis of domestic ceramic ware as this was largely produced by women (Hambly 1999).

8.1.5.2 Changing male identity in early Medieval Iberia: Interfaith analysis of male ARSM

The most striking difference between Islamic and Visigothic men was related to the unusually high prevalence of osteoarthritis in Visigoths (section 7.4.9). It is important to consider that the two samples may have a different genetic predisposition to osteoarthritis. However, it should be noted that isotope and non-metric traits suggest that the majority of the population from the Écija population were in fact local rather than immigrants (Inskip 2013, Zakrzewski 2010) and probably had a similar biological ancestry to the Visigothic population. It should be remembered, that due significant population movement during the Roman period, the population of Iberia already contained individuals with African and Eastern Mediterranean backgrounds.

In terms of the upper limb, the high prevalence of Visigothic glenohumeral osteoarthritis was startling, inferring greater arm loading in Visigoths. This was supported by enthesal scores (section 7.2.3.2). While Visigothic males did not systematically outscore the Islamic males at all entheses, they did outscore Islamic males for the large muscles involved in shoulder and upper arm movement and flexion. This included all humeral entheses except the common extensor tendon, an attachment involved in the hand and wrist extension. Visigothic males also substantially outscore Islamic males at the trapezius, which is involved in the superior movement of the glenoid. Finally, the high costoclavicular ligament (which serves as an anchor for medio-lateral and superior-inferior movement of the arm) attachment scores supported greater/more strenuous use of the arm in Visigothic men. Islamic males outscored Visigothic males at the flexor and extensors of the wrist and hand, with the exception of the pronator teres which is also involved in flexing the arm. While Visigothic individuals had more wrist osteoarthritis, the difference was not significant.

Visigothic males had significantly more temporomandibular osteoarthritis than the Islamic males. As age was controlled for in the selection of individuals, it seems unlikely that tooth loss was the cause of such difference. Two possibilities can be suggested; first, Visigothic males were using the jaw as a third hand in activity, but it is not possible to state what this could be. Second, Visigothic males had a different diet to Islamic males which could have involved a coarser diet, or increased tooth decay and loss. Without further investigation of the dentition, it is not possible at present to speculate which of the two factors could be the cause.

Patterns of asymmetry differ for three entheses in males. The subclavius and the flexor pollicis longus scores had greater asymmetry in Visigothic males, whereas the costoclavicular ligament attachment scores were far more asymmetrical in Islamic males. It is difficult to say much about handedness as so few absolute bone measurements were available for the Visigothic group.

Significant differences were also observed in the prevalence of hip and the distal femur osteoarthritis, which were much higher in the Visigothic males. The patella also demonstrated a trend for greater OA in the Visigothic group. The Visigothic individuals therefore appear to have undertaken significantly more loaded activity at the lower body than Islamic individuals.

While both populations are documented as being largely agricultural, data suggests Visigothic individuals were undertaking significantly more loaded upper arm activities than Islamic males, who have greater expression of the hand and wrist flexors. This difference between faith groups was also identified in enthesal scores by al-Oumaoui *et al.* (2004) in different Iberian Islamic (La Torrecilla) and Christian groups (Villanueva de Soportilla and San Baudelio de Berlanga). Islam prizes knowledge. Mohammed stated that Muslims should seek knowledge and it is accordingly encouraged in the Qur'an (Abu-Hamdiyyah 2000, Lindsay 2005:196, Insoll 1999). As mentioned previously, Islamic males in al-Andalus were supposed to avoid heavy labour (Shatzmiller 1994) and 12th-century Al-Shayzari suggests that boys should not be subjected to demeaning tasks including moving manure or stones (Lindsay 2005:195). The more elite status of Muslim men, especially in the early phases, may mean that physically demanding tasks were undertaken primarily by non-Muslims. Heavy agricultural tasks may have fallen to other individuals (Ibero-Romans) or to rural individuals not included in the Écija cemetery population. An additional important factor may which may have restricted activities was the ability to speak Arabic, although Arabic was always the language of bureaucracy (as indicated by Arabic-only coins minted in al-Andalus from AD 721 onwards (Guichard 1992)) and was popularly spoken from the 9th century (Lapidus 2002). As such, Islamic males probably dominated religious, law and trading positions. This stratification of society was mentioned by Hillenbrand (1992:125) and a number of other scholars (Chenje 1974, Imamuddin 1981, Glick 1979) and could explain the low levels of osteoarthritis and some low enthesal

scores in Islamic males in comparison to Visigothic males. Future comparison of Islamic data to a contemporaneous Christian population would help test this argument.

Variation in kneeling and squatting non-pathological articular modifications imply differences in posture adoption between Islamic and Visigothic males (section 7.3.7). While there was no difference in the overall prevalence of kneeling modifications between the two groups, the pattern of knee involvement differed. The prevalence of tibial imprints on the left medial and right lateral femoral condyles did not differ statistically between faith groups, but tibial imprints on the left lateral supracondylar surface and vastus notches were more prevalent in Islamic individuals. Visigothic osteochondritic modifications were asymmetric on the left condyles and symmetric on the right condyles. There was no difference in prevalence of osteochondritis modifications between left and right condyles in the Islamic individuals, with the medial condyle affected on both sides. In addition, Islamic individuals had a symmetric patterning of tibial imprints on the medial and lateral condyles, whereas the Visigothic males were affected more on the lateral condyles. This implied differences in knee use between the two groups. This result, combined with the higher prevalence of knee osteoarthritis in Visigothic men, suggested that knee flexion in Islamic individuals was symmetric and not severely loaded. In addition, lateral tibial and talus squatting facets were statistically more prevalent in Islamic individuals, thereby suggesting greater adoption of ankle hyperdorsiflexion in Muslims. These results also support the conjecture that prayer may have been involved in creating these modifications.

8.1.6 Iberian Islamic Identity: The emergence and development of Iberian Islam

Comparison of Islamic and Visigothic skeletal data demonstrates clear differences in activity patterns between the groups. As preliminary isotope (Inskip 2013), non-metric and craniometric data (Zakrzewski 2010) from the region does not clearly support that the population were significantly genetically different from the pre-Islamic group, activity appears to be the more significant factor in dictating this difference. The arrival of Arab conquerors and the emergence of Islam directly and indirectly impacted on the physical activities of the population. Importantly, some of the observed differences could be related to religious ideology. The ARSM data was not the only material culture to demonstrate this trend. Cemetery data from Écija indicated that key practices in Islamic burial rites were followed from the first phase of use at the cemetery. Nearly all

interments were facing Mecca, and the individuals were buried on their right side. There were very few grave-goods: those that were present were personal items such as jewellery (Romo Salas n.d.). There was little coffin evidence and, in most graves, people were buried in shrouds and placed directly in the ground, as would be expected in Islamic burial customs (Halevi 2007, Insoll 1999). This marks a distinct break from Visigothic customs where individuals were buried supine with ceramic vessels. The latter was seen at Écija, in a small Visigothic cemetery, which was too fragmentary to be used in this project (Romo Salas n.d.). This demonstrated that Islam left a traditional imprint on the identities of the local population. It was possible to conjecture that Islam is an important social structuring agent in Écija.

In terms of exploring developing Islamic identity over time, it was interesting to observe that features typically associated with Islam, especially the gendered division of labour and possibly the changes in the amount of loaded activity, handedness and the appearance of prayer-related modifications, were more clearly identified in the later Islamic phase. Cemetery data from Écija also exhibited the trend of increasing adherence to gender division. Separate areas of burial for men and women were observed in the late phases of the cemetery (Romo Salas n.d.). While there was variation in the form of burials (e.g. stone-lined graves, the use of tiles etc), which may infer external influences on burial rites, it is stated in *hadith* tradition that in order to prevent disturbance to the grave e.g. by dogs, material can be used to protect the deceased. This was important as the body is needed at final judgement (Halevi 2007). Here it was possible to see where local circumstance permits a deviation from normal practice, but how it was made acceptable through law because the integrity of the body is a more important aspect of Islamic ideology. In order to investigate the possible mechanisms behind this apparent increase in adherence to Islamic tradition, it was necessary to explore the literature highlighted in chapters 2 and 3 on the spread of Islam and the history of the region.

Islam itself was only formed in AD 622, less than 100 years prior to arrival in Iberia. While some key behaviour was set very early in the faith's history, including prayer, other law was only formed when an issue arose (see chapter 2) which led to some regionalisation in law. As such, Islam itself was still being shaped when it arrived in Iberia, and a typical pattern of Islam, as we know it today, did not exist at that point. With increasing law formation and consolidation of Islamic identity globally, traditions

and practices will have had a chance to spread to Écija and other parts of the *dar al-Islam* through trade networks. While on the edge of the Islamic empire, Écija and al-Andalus were not isolated from other regions, as evidenced by material culture in the region (see Bridgman 2007). Écija is situated just 42km from Córdoba, the capital of al-Andalus. Córdoba is renowned in Early Medieval European history as a great centre of learning (Hillenbrand 1992, Menocal 2002). Muslim and Christian scholars alike came from all over the known world to study, bringing with them their knowledge of other regions. Furthermore, scholars from al-Andalus are known to have travelled to Damascus in the pursuit of knowledge (Hillenbrand 1992, Safran 2001) in order to keep al-Andalus in the acceptable remit of the *umma*. People are known also to have undertaken *hajj* (Marin 1992). In relation to this, it is of note that an unknown 12th-century scholar suggested that Iberian Muslims had their own odd customs, but how they were still situated firmly within the *umma* (Waines 1995). It is not unreasonable, therefore, to assume that although the original Muslim arrivals in Iberia were probably not fully versed in Islamic tradition, individuals arriving later in Écija, and indigenous converts, could become knowledgeable in new and forming Islamic traditions from other parts of the Islamic world, particularly as Écija was on an important trade route (Bridgeman 2007). This might explain the clear emergence of some Islamic traditions, and the increasing compatibility with Islamic tradition in the late phase.

It is thought that while Écija was initially settled by Syrian Arabs, the large majority of the population eventually were indigenous Muslims (Garcia Baena 2006). This, it is suggested, caused unrest in the region during the early period of Islam and Écija is mentioned in a number of texts as being particularly problematic (Garcia Baena 2006, Melville and Ubaydli 1992), and there were numerous revolts in the early years. The Umayyad reign however saw a more peaceful period in al-Andalus with the instalment of Abd al-Rahman and three strong successive rulers (Kennedy 1996). Marked out as the most successful period in Islamic Iberian history (Hitti 2002), it is during this time that there was increasing conformity to Islam, but possibly more importantly, the population now also contained many more individuals raised in the Islamic tradition, whereas early phases may have been far more mixed, containing people who could have lived under a different social organisation. An additional factor behind the apparent good conformity to Islamic praxis may relate to the fact that Maliki traditions, which focus strongly on the traditions in the Qur'an, including prayer, behaviours and rituals,

were strongly supported in al-Andalus from early in the 9th century (Fierro 2005) (see section 3.3.8). This may indeed count for the more solid, traditional Islamic identity observed in the late phase at Écija.

Morris (2006) argues that in order to understand religious identity, it is often important to consider the history and origins of the faith. It was therefore critical to consider the relationship between Islam and Arabs. Islam was the religion of the Arabs, and a strong link between being Arab and being Muslim existed, especially in the first century of Islam (Berkley 2003, Kennedy 1996). This is because early Islamic tradition and law was created within an Arab context, and many pre-existing Arab customs were incorporated into Islamic tradition, e.g. pilgrimage to the *Ka'ba*. Indeed, it was the first ruling dynasty of Islam, the Umayyads, an Arab clan, that became the rulers of the Emirate and later Caliphate in al-Andalus. Berkley (2003:77) states that under Umayyad rule, the *umma* had an unmistakable Arab character. Furthermore, Córdoba, just 50km from Écija, was one of the four largest centres of Arab immigration (Hillenbrand 1992). Significantly Écija and San Nicolas (Murcia), which appear to display identities rich with Islamic tradition, are also thought to have initially been occupied and settled by Syrians and other Arabs, rather than Berbers (Garcia Baena 2006). Accordingly, good adherence to Islamic tradition in Écija may appear because of the Arab influence in the region, and the link between Arab customs and Islamic traditions. This Arab link could also be reinforced by the arrival of the Maliki law and the *Muwattah* text, an early school of Islamic thought with its context as Mecca and Medina, the very birth place of Islam. It would therefore be important to realise that Islam in Écija has Arab undertones.

Another important factor to consider was that during the 11th and 12th centuries, Iberia saw the arrival of two waves of fundamentalist Muslim groups from North Africa, the Almoravids and the Almohads. Initially invited to halt Christian conquest of the region, it is thought that these groups were frustrated by the loss of the basic principles of Islam in al-Andalus, particularly after the collapse of the Umayyad Caliphate (Fletcher 2001). As more orthodox followers of Islamic tradition, their arrival may have instigated stronger adherence to traditional Islamic practices. The end of the use of the cemetery in Écija is thought to coincide with this period of history. The extent of the impact these groups had on the individuals of Écija is unknown as the cemetery falls out of use around the time of their arrival. Better dating of the cemetery is required to assess this further, but a significant amount of Almohad pottery was recovered from Écija

(Bridgman 2007). Comparative data from excavations of an Almohad cemetery in Triana, Seville, suggests that the burials conformed strongly to Islamic burial practices (Pecero Espin *et al.* 1999).

Écija's position on the edge of the Islamic world and proximity to Christendom is absolutely critical in interpretation of religious identity. Throughout the Islamic period in Iberia, Christendom slowly regained territories from the north arriving at Córdoba in AD 1236 (Kennedy 1996). Fears of identity loss have been noted by many contemporary scholars of the region (see Fierro 2005, Judd 2011, Safran 2001) including al-Mansur ibn Abi Amir who, in the 11th century, laments on dying that his sons are preoccupied with women and wine (Melville and Ubaydli 1992:59). Berkley (2003) draws attention to Hanbali ibn Taymiyya, a 13th-century Syrian jurist who thought it important to differentiate oneself from Christians and Jews both socially and psychologically. Hanbali ibn Taymiyya was critical of Muslims who joined in Christian festivals or retained pagan superstitions e.g. the evil eye. In order to understand this, it was important to turn to theories of identities. According to Durkheim (1965), identity can be understood as collective representations of self and others. Identity results from an interaction between positive and negative attributes with which a group want to be associated with. Accordingly, a dichotomy between 'us' and 'them' usually exists as a major identity strategy (Westin *et al.* 2010). In a time of conquest, it might therefore be feasible that Islamic identity was expressed more strongly in order to maintain the boundary of 'us' (Muslims) and 'them' (Christians), who were ever increasingly suffocating the Islamic region of Iberia. In addition, confrontation between Islam and Christianity was increasing in the east. This culminated with the first Crusade in AD 1096, and was disastrous for relations in Iberia. The theory of a strong Islamic identity was supported by Hillenbrand (1992) and Payne (1973) who also suggested that Iberia was ultra-orthodox due to the proximity of Christianity. For example, the relative freedom of mobility of Christian women may have been an important factor in the emergence of gender segregation of Islamic women, as identified here.

Finally, this project has been unable to offer any information regarding the debated Green revolution in Iberia. While significant changes in activity patterns may support the idea of changing technology, it cannot be directly equated with improvements in health or increasing population size. In order to see if changes in physical activity coincide with changes in health and therefore availability of more diverse food, an

analysis of patterns of metabolic disease and general indicators of health would be required. This was beyond the remit of this research.

In summary, by taking a socio-historic approach and seeing Islam as a life-structuring tradition that can shape, but not solely dictate Islamic identity, it was possible to demonstrate a number of important features of Islamic identity in Écija. Islamic traditions and customs outlined in religious and historic documentation appear to have been actively taken up in Écija, thereby suggesting a traditional Islamic identity. This was because distinctly different activity patterns were observed between Islamic and Visigothic individuals. This includes gender segregation, but possibly also prayer and handedness. Cemetery data also supports the notion that Islamic traditions were incorporated into daily life. In particular, gender and gender division appear to be an important feature of Islamic identity in Écija, highlighted through changes identified in male and female activity patterns and in cemetery data.

8.2 The interpretation of religion in archaeology

The main purpose of this research was to outline how archaeology could contribute to the analysis of religion and to demonstrate how the sacred could be integrated more effectively into archaeological theories of the past. It was argued that this was achievable through the recognition of the social element of religion and the idea that religion acts both as a constructor of society, and as a product of the people who conform to it. Socio-historic and political influences are therefore a critical factor in the development of religious identities and religions.

In terms of Islam, it is possible to observe how it is a strong life-structuring principle which can transcend other aspects of life and identity. This is evidenced by the similarity in many aspects of life in Islamic groups observed globally (e.g. mosques, prayer, *hajj*). It is, however, important to remember that Islam is not rigid, but a tradition overlain on a previous social structure. The formation and expression of Islamic identity is strongly dependent the interaction of tradition on the surrounding social, historic and political circumstances. Accordingly, the Islamic Iberian identity identified here could be described as unique, not something foreign. Unique Islamic identities could arguably exist in any region that has a different socio-historical and political background. This suggestion supports research by Marranci (2008) who advocates that anthropologists should be moving towards anthropology of Muslims,

rather than anthropology of Islam. This takes a bottom-up approach to the analysis of identity as has been utilised by archaeologists studying other areas (e.g. gender (Hakenbeck 2011)). It also seems feasible that other religions would be constructed in this manner whereby core activities or beliefs are prescribed, but adherence varies by circumstance. This could range from close obedience to none at all. Archaeologists should not be scared of the absence of religion because this still informs as to the role of religion or could simply mean that there is no relationship between the chosen study material and religion.

As archaeologists, we are well situated to study the emergence and development of religion, as the nature of our material permits us to observe long-term social change (Rowan 2011). Archaeologists therefore have a wonderful opportunity to assess what factors are important in the development of regional religious identities. This, of course, may have further repercussions for the study of modern populations and identity struggles. Archaeology, therefore, does not need to serve as a tool to assist other disciplines in the study of religion but can contribute in its own right.

8.3 ARSM as an indicator for activity, religious identity and religion

Differences in actions and activity patterns were clearly present in some data sets although it was not possible to be specific about the activity. This difference itself was often informative enough. However, this did sometimes lead to the inevitable vagueness of interpretation. The fact that multiple causes can cause the same modification, and that some modifications are not yet fully understood, prevented detailed analysis. Regardless, with the use of historic, religious and artefactual evidence, it was possible to relate some of these changes more securely to Islam, subsequently informing more about the development of Iberian Islam and, possibly most significantly, the varying role of Islam on the identities of men and women. This does, however, demonstrate the importance of such supporting evidence, and ideally ARSM should not be used without it. The continual research into activity modifications, especially bone density and distribution analyses, using imaging techniques, and new research into enthesal formation, has the potential to improve our understanding of activity patterns.

Enthesal changes proved to be the most difficult marker to both analyse and interpret. This was because the aetiology behind enthesal change is the least well understood. It was demonstrated that entheses could be used to reconstruct activity if the correct

controls were taken, and reasonable caution exerted when interpreting results. As has been argued by others (Groves 2005, Ponce 2010), this research has shown the benefit of using multiple indicators of activity. Often when one indicator failed to highlight differences between comparison groups, others did. At times results from different modifications supported each other and very little in terms of contradiction was observed. This result confirms notions that different ARSM inform about varying aspects of physical activity, and that looking at an isolated ARSM could produce a partial picture of reality.

An additional difficulty with the analysis of entheses was how to present the data. Most muscles are involved in multiple activities and creating muscle groups to analyse was difficult. This meant it was difficult to be certain about when differences in muscle-group recruitment actually existed. Furthermore, the entheses of the upper arm mostly and consistently outscored those of the forearm and hand. This, it could be argued, might relate to the fact that the upper arm is the site of attachment for many of the large weight-bearing muscles. This potentially means comparison of muscle groups may not be an efficient mode of analysis.

Data analysis was also difficult. The fact that ARSMs are influenced by so many factors means that significant statistical analysis was required to ensure patterns observed were not artificial. Even with such stringent statistical analysis, an absolute necessity in this type of research, it was still not possible to be certain that some influencing factors were entirely controlled. When age or body size was taken into account, some significant differences emerged or disappeared. While this was difficult and, at times tedious, the final results demonstrated this to be worthwhile.

The ARSM chosen for this project did highlight activity differences between the various comparison groups. This supports the notion that human skeletal remains can be used as a direct indicator of social organisation (Larsen 1997, Roberts and Cox 2001, Sofaer 2006). More uniquely, this research has demonstrated the validity of human skeletal remains as an indicator of religious identity beyond looking at funerary rites and objects, as has seldom been covered by osteoarchaeologists and bioanthropologists. This project also has further repercussions for identity studies as it supports ideas that the skeleton, and indeed the human body, is not just a passive entity that receives an identity (Sofaer 2006). It is an active agent in the construction of identities, religious or otherwise.

Therefore, the analysis of human remains potentially provides archaeologists with a vital method in which to detect agency and changes to religious identity over time.

Chapter 9: Conclusions

This research aimed to look at how Islamic identity emerged and developed in Iberia during the period AD 711 to 1200. Through viewing the body as an expression of religion and analysing physical changes to the skeleton, it was demonstrated that it was possible to identify changes to the social and therefore religious body. By assessing how these changes were initiated by historic, social and political factors, this research highlighted how religious identity, and therefore ideology was constructed and malleable.

On the basis of ARSM data, a number of important trends were identified. Critically there was a distinct transformation in the behaviour of the Iberian population with the emergence of Islam, represented by differences in activity patterns between Islamic individuals and pre-Islamic individuals. In the Islamic population, a strong gendered division of labour was identified. Females appear not to have undertaken significant loaded activities, but may have engaged in specialised activities, including cottage industries, which were important in the economy of the region (Jewell 2007, Hambly 1999). The data appeared to support historic evidence that males were probably involved in different trade and craft industries, as well as fiscal roles, as evidenced by greater male asymmetry (Shatzmiller 1994). In addition, there was distinct conformity to Islamic burial rites in the early phases of Islamic occupation (Romo Salas n.d.). Further to this, low levels of bone loading conform to economic data from al-Andalus which implied that Muslim males conformed to ideas that they were supposed to avoid heavy labour (Lindsay 2005). However, this difference may also indicate that Arab identity had an influence on the daily lives of inhabitants, as Arabs may have made up an elite group in Écija (Garcia Baena 2006), and heavy labour may have been delegated to other individuals. Due to the link between early Islam and Arab identity, it is not possible to distinguish which of the two identities was responsible for this change, and as identities are multiple, it is important to realise that both may simultaneously be active in the population.

According to ARSMs, other archaeological data (e.g. burial rites) and historic evidence, adherence to Islamic traditions appeared not only to increase over time, but also to change temporally (see data in Romo Salas n.d.). A clearer gender division of labour

was present, and despite potential technological changes in activity, it implied that males and females may have stuck more rigidly to clearly defined roles. This is in keeping with Islamic gender tradition. A decline in female mobility, a possible increase in prayer modifications, greater expression of handedness and transcendence of Islam over ethnicity also appeared to conform to ideology. This data was supported by the appearance of gender segregated areas in the cemetery (Romo Salas n.d.), an increase in heresy cases in al-Andalus (Fierro 2005) and historic evidence on a large indigenous Muslim population (Garcia Baena 2006). This research therefore supported historic documentation that an orthodox and traditional Islam formed in Iberia (Payne 1973).

As identities are a product of interaction between ideology and individual context (Morris 2006), in order to understand why the trends observed in the Écija data existed, it was imperative to explore regional and international events which would impact on the observance of tradition. Crucially, historical, political and geographic factors were all identified as playing a pivotal part in the construction of Iberian Islam.

Islam arrived into an Iberia that was Christian. Furthermore, it was also bordered to the north by Christianity. Based on social research on identity formation, boundaries are required to create a distinction between ‘us’ and ‘them’ (Schöpflin 2001). Accordingly, adherence to Islamic practices was a mechanism of creating public difference between Muslims and the remaining Christians. In particular, it also appeared that the separation of men and women was a powerful way of demonstrating Islamic identity. Historic documentation supported this trend, as records exist demonstrating that differentiation from Christians was a concern of early Islamic scholars in the region.

Multiple factors were identified as the cause of increasing conformity to Islamic tradition in the later phases of the cemetery. First, the arrival of Maliki law and the *Muwattah* text, which has a strong focus on Qur’anic teaching and practice, into al-Andalus in the 9th century. This includes information on burial rites, prayer and the activities of men and women. This law was also strongly supported by the Umayyad Caliphs, arguably to legitimise their own rule (Fierro 2005, Lapidus 2002). The emergence of any other school of law was strongly opposed until the 11th century. This demonstrated how political factors were important in dictating identity in al-Andalus. The second important factor was that the 12th century saw the arrival of two, apparently,

more fundamentalist Islamic groups, the Almoravids and the Almohads. While their influence was observed in ceramic evidence from Écija (Bridgeman 2007), it is not presently known how much impact they would have had on the individuals in the Islamic cemetery, as their arrival may coincide with the end of the cemetery's use.

Geographic factors also play a critical role in dictating identity. Écija is close to Córdoba, the capital of al-Andalus. Renowned for being an outstanding centre for learning in the Medieval period, knowledge on how to be a good Muslim could have spread easily to Écija from Córdoba via the well established trade routes between the two cities. In addition, religious authority may have held greater sway over the city due to proximity. Accordingly, towns and villages distant from Córdoba may have different identities as adherence and behaviour could vary.

Finally, and possibly most importantly was the proximity of Christianity and the fact that al-Andalus and Écija were increasingly becoming a frontier society. Confrontations amplified, especially as the Christian north became a credible threat to the Islamic south. In addition, there was also a general rise in hostility between Christian Europe and the Islamic east, which culminated with the first Crusade at the end of the 11th century. To maintain Islamic identity in a time of conflict and uncertainty, people would have adhered to tradition. This fits well with research in sociology and anthropology, which demonstrates that when identities become threatened they become more exclusive in order to prevent social chaos. This highlights how wider political factors are important in dictating identity, but also how oppositions are critical in shaping it. As the combination of these factors is unique to Écija and al-Andalus, it demonstrates how Islamic identity can be described as Iberian.

In addition to looking at Iberian Islamic identity generally, an additional important factor was revealed. Males and females may have played different roles in the emergence of Islam, and separate male and female Islamic identities likely existed. This was evidenced by a range of changes to male and female activity patterns. This however may not be entirely unexpected considering that the expected behaviour of a good Muslim man and woman differ in religious ideology (Hopkins *et al.* 2007). In terms of the ARSM data, males and females had significant differences in all skeletal modifications. Over time, male identity appeared to be more affected by the emergence

of Islam, as their patterns of activity conform more closely to Islamic ritual, but were also more distinct from pre-Islamic males. As Islam contains a set of practical traditions carried out in communal open practice, due to the gendered division of space, males, who were operating in the public sphere, would be more likely to change their behaviour, something that has also been exhibited in historic and ethnographic research. Public expression of new Islamic identity would have been important in al-Andalus, especially in later periods, when being Muslim had social benefits such as lower tax and better jobs. Females, who were operating in the private sphere, would be able to carry on as before, and in fact, greater similarities were observed in activity patterns between Islamic and pre-Islamic women (from OA and articular modifications). This was supported by historic documentation where women were found to be carrying out old traditions in Córdoba (Fierro 2005). This evidence supports ethnographic research which suggests that women are important instigators in syncretism and the variation in Islamic identities (Morris 2006). The only exception was the decrease in female mobility which is likely to represent conformity to Islamic ideals in public, thus again demonstrating the importance of publically adhering to Islamic ideology (Pomeroy and Zakrzewski 2009).

This thesis has demonstrated that Islamic identity is not the sum total of religious doctrine, but is a product of a tradition combined with local social and political circumstances. It is clear that Islamic ideals did play an important role in the actions of individuals, but this behaviour could be modified by local circumstance. Islam here acts as a uniting force, but its power over all other aspects of identity is variable. This was demonstrated by the potential impact of ethnicity and status on ARSM, which was supported by historic sources identifying persistent unrest between Berbers and Arabs in Écija (Garcia Baena 2006). The development of religion, or Iberian Islam in this case, is largely borne out by the need to differentiate oneself from Christianity. The most important factor is that Iberian Islam is not something that is foreign, but is something that has formed from local circumstance.

By exploiting the link between the social and physical body, this research demonstrated that the body can be used to assess changes in religious identity, beyond the simple observation of burial rites. ARSM were successful in highlighting changes in activity

patterns, which could be linked both directly and indirectly to religious change. Furthermore, multiple indicators proved to be useful in that more often than not, results from different indicators were in accordance. In addition, as each modification has a different aetiology, when one marker failed to expose variation, another did. Within the Islamic group, this was particularly important because of the apparent lack of OA difference between men and women. There were, however, some limitations of ARSM. While ARSM were useful for identifying changes in activity, even with multiple indicators, it was still difficult to be specific about activities undertaken. It is clear that far more research is still required on ARSM.

Through taking a social approach, this research has highlighted that archaeology can significantly contribute to an analysis of the development of religion, rather than brushing it aside as something that is too complicated. It has been demonstrated that it is possible to create more nuanced interpretations of the past. For example, a number of important features of Iberian Islamic identity have been teased out from the data, using a socio-religious approach, thereby adding to current knowledge of early Medieval Spain. Importantly, it is possible to observe that while religion is an important constructor of society, it is not immune from other aspects within the cultural milieu. Interactions with other cultural factors and identities are important in the development of religious identities and in turn, the construction of religions. However, as not all religions are like Islam, and may not have such a strong structuring role, archaeologists will have to realise that the relationship between material culture and religion may differ. As such, we cannot use a single systematic method to assess the development of religion because of its inherent variable nature. However, if we understand the role of religion in its context, we can learn more about identity, past populations and what may have motivated certain behaviours and activities.

Chapter 10: Future research

This thesis has highlighted that a great deal more research into a number of areas covered in this analysis is required. This includes the study of religion, the analysis of emerging Islamic identity in Iberia and the general use of ARSM in the reconstruction of identity. Discussions below further research that may benefit the topic in future projects.

10.1 Archaeology of religion

This study demonstrated that it is possible for archaeologists to contribute to debates and discussion on the formation and development of Islam, and religion in general. Accordingly, it would be worthwhile undertaking this sort of socio-cultural approach to analyse other religious groups to see if similar results are obtained. This could be undertaken using human remains, but other types of material culture could also be framed in this way. Further to this, while this research did use multiple types of material culture, it was not feasible to do this in significant detail within the time available. More integrated studies of archaeology could perhaps shed greater light on the formation of religious identities. In particular, the analysis of ceramic material could provide an additional perspective to human skeletal remains.

Few studies have attempted to explore religious identity directly from the human skeleton or using a socio-historic approach. Even fewer have examined Islamic identity specifically. The presence of many well preserved skeletal collections internationally, which span significant periods of religious change or conversion are therefore prime for this type of analysis.

10.2 Islamic Identity in Spain and in the wider Islamic population

This project was somewhat limited as, due to time constraints, only two populations were used. It is therefore very difficult to ascertain how general the trends are for the rest of Iberia, and the wider Islamic world. Beginning in Iberia, it would be worth increasing the Écija sample to include all of the individuals from the cemetery. It would then be worth expanding the analysis to include other populations in Iberia to explore whether there were regional patterns in the development of Islamic identity. This would permit a detailed analysis of the role of local factors in constructing Islamic identity. A

second related issue is the currently unknown conversion of rural populations. Analysis of gender division and possible adherence to other Islamic tradition in rural populations potentially could inform about the political and geographic factors impacting on adherence. It would therefore be beneficial to analyse and compare skeletal samples from rural Islamic and pre-Islamic populations. This would help address issues on the timing and conversion in rural areas.

It would be ideal to analyse pre-Islamic and early Islamic populations from other regions of the Islamic world to explore whether activity patterns do or do not change, and how this related to the arrival of Islam. In particular, in relation to Iberia, it would be worth exploring parts of Berber North Africa in order to assess whether the same patterns are observable or whether an underlying Berber culture resulted in a different identity. The impact of Berber culture could then further be explored by examining Berber-controlled areas in Iberia e.g. Seville. Further afield, the interaction of Islam with a completely different cultural background could be explored by analysing skeletal material from excavations in Egypt or Israel. By doing this, it would be possible to explore the relationship between Islam and different social and cultural traditions and how this creates new Islamic identities. In this way, the transcendence of Islam over other aspects of identity can also be examined.

As aspects of Islamic tradition have the potential to impact on the health and diet of individuals, the analysis of pathological data could also be of value. Sex differences in the prevalence of disease and trauma could demonstrate differences in living environment and the differential treatment of males and females. For instance, whether ideas surrounding the protection and veiling of women, male involvement in certain physical activities and the preferential treatment of sons were followed. All however would require significant contextual information.

10.3 ARSM as indicators of activity and identity

Few studies have directly investigated Islamic activity patterns. While the four types of modifications used generated a substantial amount of data, other methods could still highlight other changes. This would largely involve using chemical analysis. Stable isotope analysis would highlight whether particular patterns of activity were limited to those that were local or those that were immigrants, but also highlight differences in diet

(food taboos). Furthermore, the use of imaging techniques could vastly improve the information obtained from bone geometry analysis.

As many of the interpretations made in this project are based on differences in ARSM, this type of analysis could benefit from improvement in our understanding of ARSM. This could improve the reliability of the ideas extrapolated from ARSM data. Most of these improvements could be made by researching the relationship between ARSM expression and activity, as well as the impact of other confounding factors. This in particular includes age and body size.

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