# Cranial remains from the graveyard to the laboratory: restoration, conservation and craniometric analysis of medieval British skeletal samples

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# Abstract

The present thesis proposes a comparison of 16 British medieval samples by means of craniometric analysis. The purpose of this study is to determine whether craniometric variation among British medieval groups exists and what are the causes of these differences. Following the reconstruction of 267 skulls from Gloucester, Poulton and Linenhall, 45 measurements for each cranium were recorded. Craniometric data from 946 individuals were analysed with multivariate statistical analyses. A selection of 18 variables was used for comparison among samples. A further comparison with a selection from Howells' main human groups was carried out. Discriminant function analysis, principal component analysis and hierarchical cluster analysis were carried out to detect differences among British medieval samples and British and Howells' data set. The results support previous work published by other authors indicating a difference in craniometric measurement among British samples. Further discrimination is proved among samples from different geographic areas. This analysis suggests that the differences in craniometrics among British medieval samples are determined by the migration of foreign people from other European areas. A further difference is demonstrated between British and Howells' samples, with a clustering based on geographical affinity. The European groups (including the British) resemble each other, while the others cluster based on their geographical distribution. The results prove that cranial measurements follow climate adaptation trends and DNA patterns verified by other researchers' results.

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# 1. Introduction

Skulls are subject to various adaptive responses, both regarding ontogeny and over the life of a population. It has been shown that essential aspects of cranial morphology are genetically transmitted over generations (Sparks and Jantz, 2002; Relethford, 2004a; Harvati and Weaver, 2006). Craniometric research is essential for the understanding of population history as it allows reproducibility in measurements (Howells, 1973), which means that standardisation of values is recorded on different crania. The study aims to contribute to addressing further knowledge of the population history in Britain using human skulls from the Poulton and Gloucester medieval archaeological collections.

Human migrations can have differing impacts on craniometric variation in regards to both genetic and environmental factors. Craniometric information can, therefore, be used to detect within and among group variation, migration routes and ancestral origins. Migrations are essential for understanding many characteristics of a population, and there are close linkages between migration as a phenomenon and a great number of other processes or behavioural patterns. Studies of population structure and demographic change must consequently incorporate migration because its importance is equivalent to birth and death (Anthony, 1990).

Many other studies have been undertaken to prove migrations occurred, i.e. the analysis of stable isotopes and genetics. Analysis of skeletal material and teeth even has the potential to provide direct evidence on dietary intake. In fact, Strontium and Oxygen isotopes can be used as environmental tracers. These elements provide information about the kinds of environment where a person lived in childhood and whether the person migrated to a different environment during life (Schwarcz *et al.*, 1991; Leach *et al*., 2009; Chenery et al., 2010; Brettell *et al.*, 2012).

Genetic data can also provide proof of human mobility, confirmed by extensive research to date. In fact, differences in Y-chromosomes amongst populations within the British Isles have been detected by different researchers over the past few years. The resulting data suggest that different parts of the British Isles have different paternal histories (Capelli *et al.*, 2003). For example, Scandinavian populations had an impact in the northern Isles and Scotland (Berry and Firth, 1986) and substantial migration of Anglo-Saxon populations occurred in England (Weale *et al*., 2002). If migrations can be proven through interdisciplinary methods, a significant correspondence should also be expected from the craniometric analysis. However, the previous methods are destructive, and researchers are not always allowed to carry out this type of analysis on human remains. Furthermore, DNA analyses are limited by environmental conditions and the quality of preserved DNA (Brown and Brown, 2011). For this reason, examination of craniometric data is an essential alternative because it does not affect the integrity of the remains and can provide significant results regarding the history of a population.

The purpose of this study is to determine whether cranial morphological variations between British populations exist and what is the reason that causes these differences (i.e. a result of previous and contemporary migrations). Craniofacial morphology variability of these two samples was analysed and allowed the comparison within and between Poulton and Gloucester, along with other 14 British medieval samples. Moreover, new additional craniometric data were recorded following the reconstruction of the skulls of these two samples to support biological and population analyses. Finally, a further comparison with the W.W. Howells (1989) dataset was made to enable the correlation with a broader data sample.

## 1.1 Objectives

Both the archaeological and biological contexts suggest that there have been several people movements in Britain in the past, also made clear from the historical background. This thesis aims to detect whether there is a morphological craniofacial variability in medieval Britain. The reason could be a result of a contribution of external human groups as differences both within and between populations can be detected through craniometric research.

The majority of recent craniometric studies analyse the cranial variation from skeletal remains dating to earlier periods (i.e. Iron Age and Anglo-Saxon), and most of the medieval collections have not been analysed under this perspective. For this reason, to contribute to British craniometric studies that were undertaken in the early 20$^{th}$ century, this research was inspired by the following assumptions: differences can be detected in craniofacial morphology within and between British medieval populations. If variability exists, the possible causes can be identified from cranial morphological traits, i.e. environmental adaptation, diet, migration or a combination of all factors.

The methodology that was applied for this study involves the analysis of 946 skulls from 16 British medieval samples. Craniometric data were recorded by the author on samples from five osteological collections and compared with previously published data. Since most of the skulls that are part of the samples from Poulton, Gloucester and Linenhall were fragmented, reconstruction of about 300 skulls was undertaken before the analysis could commence.

Poulton is an archaeological site located in Cheshire with a history that spans approximately 9000 years. In this research, approximately 200 medieval adult remains recovered from the medieval Chapel (Emery, Gibbins and Matthews, 1996; Emery, 2000), were analysed. The adult skeletons from the Gloucester sample were also examined. These particular remains were recovered from the St. Owen’s church cemetery and are dated between the 12$^{th}$

and the 17th centuries. All of the human remains from this collection are part of an urban port population and comprise approximately 100 adult individuals. In addition, the medieval site of Linenhall, located in the city centre of Chester, was analysed. The remains belong to the Greyfriars' burial ground that was in use between 1238 and 1538. The sample size is considerably smaller (10 individuals) than the other samples analysed in this research, but it was included in the analysis for completeness.

The comparative analyses that were used to evaluate the existence of differences within and between these British medieval samples are discriminant function analysis and principal component analysis. To better show the similarities between the samples, a hierarchical cluster analysis was also carried out. Furthermore, an additional comparison to Howells' dataset was made for a more comprehensive analysis of the cranial variability. Multivariate analyses are particularly suitable for cranial measurements, which are continuous metric traits and, in this case, they are taken into consideration as a whole, determining the skull shape by the relationship between all the measurements. In fact, this method clarifies the location of the variation in skull shape (Howells, 1973; Leach *et al.*, 2009). All of these materials and methods are detailed in subsequent chapters (see section 1.4).

## 1.2 Hypotheses and Research Questions

Britain witnessed several waves of migration before and during the Middle Ages. Thanks to both the historical and archaeological records, it is known that migrations occurred from different parts of Europe. Because morphological characters are genetically inherited, it would be expected that regional differences reflect different ancestral backgrounds. Furthermore, geographical isolation can be experienced in some regions of Britain, as few rural areas saw a minor influx of people from the outside. Therefore, the analysis of craniometric data is important to detect whether differences between craniometric measurements occur that archaeological excavations might not identify due to the loss of information following the critical preservation of evidence.

To determine whether there are significant differences between the analysed samples, four main hypotheses are tested herein, and these are summarised as follows (see also section 3.1). The first hypothesis suggests that there are measurable differences in craniofacial morphology between the British medieval samples. The differences would be a result of the different waves of migration that occurred before and during the Middle Ages in the British territory from various parts of Europe, as stated previously in this chapter.

The second hypothesis will determine whether differences between and within British medieval populations do occur, and if these can be determined by neurocranial, facial or both measurements. For this reason, this second hypothesis is divided into three sub-hypotheses, to allow the determination of which area of the skull is driving the differences between the samples. As discussed in section 2.3, it has been proven that the neurocranium has a higher heritability than the facial skeleton, as the temporal bone and the neurocranium are more correlated with genetic factors (Boas, 1912; Guglielmino-Matessi, Gluckman and Cavalli-Sforza, 1979; Beals *et al.*, 1984; Kohn, 1991; Jantz and Meadows Jantz, 2000; Roseman, 2004; Roseman and Weaver, 2004; Carson, 2006; Harvati and Weaver, 2006). On the other hand, the morphology of the splanchnocranium is mostly influenced by environmental factors. This means that variability could also be detected on the facial skeleton and, as Relethford (2004a) also reported, morphological craniometric traits are controlled independently by genetics and environment, and none of these factors will obscure the other.

The third hypothesis proposes that there are also measurable differences in craniofacial morphology between British medieval samples and the W.W. Howells dataset samples. These groups will cluster together based on their geographical provenance. The comparison with Howells' dataset allows examination of the differences between the major human groups and the British samples that can be detected from the skulls' measurements. Additionally, it is possible to understand how the populations that share a recent common ancestry (or exchange a large number of migrants) should resemble with one another, more than geographically distant populations (Roseman, 2004).

The fourth and final hypothesis is also divided into three sub-hypotheses (see also section 3.1). It addresses whether differences between British medieval and W.W. Howells' dataset samples do occur, and if these can be determined by neurocranial, facial or both measurements.

To summarise, craniometric data are first compared between British samples only to detect variability across different areas, possibly as a result of migration from different parts of Europe (Scandinavia or European inland) or as isolation of a site. Secondly, the British samples are compared with the broader set of population sample data provided by W.W. Howells to test whether these show a similarity resulting from geographical proximity. Geographically closer populations should show more similarities than distant groups. First, the British sample is compared to the European groups, and secondly, the British samples are compared to a selection of the major Howells' human groups.

It is also important that this research is contextualised in a broader archaeological and historical perspective, as this study is not focused merely on data description. Two major research questions were therefore proposed and are listed as follows: did the migrations occurring in the earlier periods affect the cranial morphology of the British populations? Are the differences between the British medieval samples determined by the migrations of groups of people from different geographical areas?

## 1.3 Significance of the study

British research involving craniometric data is uncommon in the academic literature, especially concerning medieval remains. Furthermore, most of these studies are now quite dated (i.e. Little, 1943; Tattersall, 1968; Brothwell and Krzanowski, 1974; Dawes and Magilton, 1980). The majority of the studies undertaken on British craniometric data analyse Pre-Historic, Romano-British and Anglo-Saxon populations, to see whether the variation is a consequence of migration.

There has been a long debate in the archaeological field on the causes of migration and how it is reflected in the archaeological data. Movement of people is indeed a common theme in human history, which can be observed via archaeological evidence, although it can be difficult to confirm whether it was migration or acculturation (Brettell *et al.*, 2012). It is well known that the history of Britain, especially during the Roman and the post-Roman period, has been characterised by a series of migrations from continental Europe (Hunter and Ralston, 1999; Gillingham and Griffiths, 2000; Töpf *et al.*, 2005).

After the collapse of the Roman Empire (5$^{th}$ century), Britain saw the arrival of the Anglo-Saxon populations from northern Germany, who displaced the Romano-Britons in the eastern and southern regions. This migration affected just these parts of Britain because Wales and Scotland experienced separate migration histories (Hunter and Ralston, 1999). For about three centuries before AD 800, the British Isles witnessed the beginning of the Scandinavian occupation. The early occupation was limited to raids in coastal sites, and especially monasteries. These raids later led to the establishment of permanent settlements. Norse colonies were furthermore founded on the Isle of Man, in the Northern and Western Isles of Scotland and some northern parts of Britain. Even England was subject to raids from Scandinavia. Later, Anglo-Saxon England witnessed the incursion of a Danish army that seized territory in Northumbria, Mercia and East Anglia, culminating with the invasion of a new army under the Danish king Svein Forkbeard in AD 1013 (Hunter and Ralston, 1999). The conclusion of the Viking Age is usually placed at the end of the mid-11th century with the Norman Conquest, with the death of the Viking leader Harald Hardraada and the victory of William I (AD 1066) (Hunter and Ralston, 1999), although the Normans themselves were also of Viking heritage. All of these events are part of British population history and brought significant cultural and archaeological changes. Although craniometric analysis has been recently taken into consideration by a few authors (see e.g. Russell, 2007; Jones, 2014), these studies are still not comparing medieval remains. This information is presented in more detail in chapter 2.

The focus of this thesis is to analyse the craniometric data considering medieval Britain in its entirety and underline dissimilarities that occur as a result of distinct cultural backgrounds. Commencing with the curation of the remains housed at Liverpool John Moores University, this added value to the samples and resulted in a full set of complete skulls for use in this thesis. Most of the collections comprise fragmented skulls, which implies a loss of a remarkable amount of data. Following reconstruction of the skulls, craniometric data were recorded and analysed in comparison with other data sets recorded or previously published for this thesis. The study also allowed for an analysis of three samples (Poulton, Gloucester and Linenhall) that, to date, have never been published (although projects are currently being undertaken by other researchers). Furthermore, this study provided the possibility to reanalyse data that were published at the beginning of last century and produced a view of the craniometric variation in the British Middle Ages. Finally, the results provide an extensive database that can be useful for interdisciplinary research to prove the theory of migration in Britain during the Middle Ages.

## 1.4 Thesis Structure

Chapter 2 provides background for this thesis. The first part of the chapter describes the historical background of the Middle Ages in Britain, paying particular attention to the movements of people that occurred before and during this period. The second part focuses on the history of each archaeological site from where the data collected and included in this thesis. The third part of the chapter offers a comprehensive overview of population studies and the use if craniometric analysis for these purposes. The chapter also includes a review of the main craniometric studies that involve British samples and that have been published so far. Chapter 3 offers a description of the samples examined and the methods that were adopted for the implementation of the study. Chapter 4 presents the results divided by the different statistical analyses adopted. First are exposed the results regarding the comparison between the British samples, secondly the results for the comparison between British and Howells' European samples and third, the comparison between British and a selection of Howells' main populations' samples. Chapter 5 discusses the importance of cranial reconstruction and the results reported in chapter 4. Finally, chapter 6 examines the research limitations of this study, summarises the findings and proposes suggestions for future research.

# 2. Historical and Literature Background

## 2.1 Early Historic and medieval Britain

The medieval period is conventionally set to begin in 1066 with William the Conqueror and the Battle of Hastings, but for this research, it is important to understand the early historic period that precedes this event. The years between the 5th and 11th century have been a transition between the fall of the Roman Empire and the Middle Ages, which saw different waves of migration from several parts of Europe.

With the collapse of the Roman Empire in the early 5th century, Britain fell apart into several belligerent groups, both indigenous and invaders (Hills, 1999). In fact, starting from the mid-5th century (AD 449), Britain saw the migration of the Anglo Saxons. This group of Germanic people came from three different tribes: the Angles, the Saxons and the Jutes from the area comprising northern Germany, Denmark and Netherlands (Brettell *et al*., 2012; Russell, 2007). However, these tribes did not occupy the whole of Britain, but just the southern and the eastern parts of England. The Angles originated from the Anglian area of Schleswig-Holstein and the Island of Fyn and established in the middle, eastern and northern England along with part of the Saxons. The Saxon group originated from the areas at the south and west of the River Elbe in north Germany, and there is evidence for their settlements in the Thames Valley and the area of the south. Some Saxons also settled in eastern England although the highest concentration was in northern Wessex and Sussex. The Jutes instead migrated from Jutland (Denmark) to the area of east Kent (Arnold, 2005).

The new populations brought with them their culture including burial practices. During the first three centuries of their initial immigration, they cremated their dead and placed the ashes into urns. The cremation practice is typical of the Anglian Midlands and eastern England. In southern and northern England, there is evidence of inhumation in simple graves without coffins or similar structures (Härke, 1990). The resulting difference shows that there is archaeological evidence of a migration, which reflects the similarity with the burial customs of the native European continental area, as Hills (1999) suggests. Whether this is the result of the migration of a few people or a mass migration is not clear yet. In Scotland instead, a tribal organisation continued, which is historically referred to as a collective group known as the Pictish. In reality, this was a more complex group of tribes. Wales also had a different historical development, as the post-Roman culture continued without too much influence from the Germanic populations (Hills, 1999; Russell, 2007) (Fig.2.1).


Figure 2.1: Map of Anglo-Saxon Britain (adapted from Richards, 1999)

From the 7th Century, there is a substantial change in the Anglo-Saxon culture. As it embarks on the conversion to Christianity, there is a considerable change to burial practices. Cremation fell in disuse and grave goods (or lack thereof) adapted to a Christian fashion, with an east-west orientation of the bodies in enclosed cemeteries beside churches in the villages (Härke, 1990; Hills, 1999; Russell, 2007). In contrast, outside of the Anglo-Saxon territory, there seems to be relatively less archaeological documentation, as there are lower status settlements with not many burial sites. The little archaeological evidence that is available, however, suggests a continuity of practice and population until the gradual introduction of Christianity (Hills, 1999).

The arrival of the Anglo-Saxon populations was not, however, the only migration that the British island has seen. Another significant contribution has been brought from the Scandinavian populations, which started their raids shortly before the AD 800 (Richards, 1999). The term "Vikings" indicates individuals from many parts of Scandinavia: Sweden, Norway and Denmark. The populations from Denmark (Danes) seem to be the main settlers of eastern England, the Norwegians (Norse) settled instead in the western and northern Britain (Russell, 2007). Although the advent of the Vikings is seen as an invasion, in reality, it is part of a continuing process that began with initial raids targeted to the coastal sites, becoming a proper occupation and sizing of the lands. The reason for this expansion, however, is not known, but it is most likely that it happened due to internal pressures caused by a shortage of resources (Richards, 1999).

The first Vikings were Norwegians, and their attacks were a consequence of the earlier Norse colonisation of Shetland, Orkney and the Hebrides. They first established bases on the Irish coast, and from there they aimed at the monasteries and strongholds of Ireland and the coasts of Britain. Danes soon joined the first colonists, and a Danish army arrived in East Anglia in AD 865 (Sawyer, 2002), capturing York in AD 866. A territory was defined, at this point, between the inhabitants of Britain and the new Scandinavian settlers. The boundary between them followed the River Thames up to the river Lea, until Bedford and up the river Ouse to the line of the Roman road (in modern times known as Watling Street). From here, it continued across the country from London in the south-east to Chester in the north-west. The area was known as the Danelaw (Hall, 2000) (Fig. 2.2).

However, even if any settlement of diagnostically 'Scandinavian' type had ever been found in large numbers anywhere in England (Trafford, 2000), it has been demonstrated extensively that the Scandinavian presence can be proved by the toponyms that still survive in Britain (Crawford, 1995; Fellows-Jensen, 2000). Most of the Viking evidence found in Britain are burials, which are not so copious in England, as they seem more concentrated in the North. The funerary rites practiced by the first Viking invaders in Britian were traditionally pagan, as practiced in their homecountry. The later generations adopted the local burial customs and became indistinguishable from the Christian burials. Some of the buildings also adopt a Viking style; for example in York and Chester, the buildings are constructed with semi-sunken cellars, which reflect the ones that can be found in Danish towns (Richards, 1999).

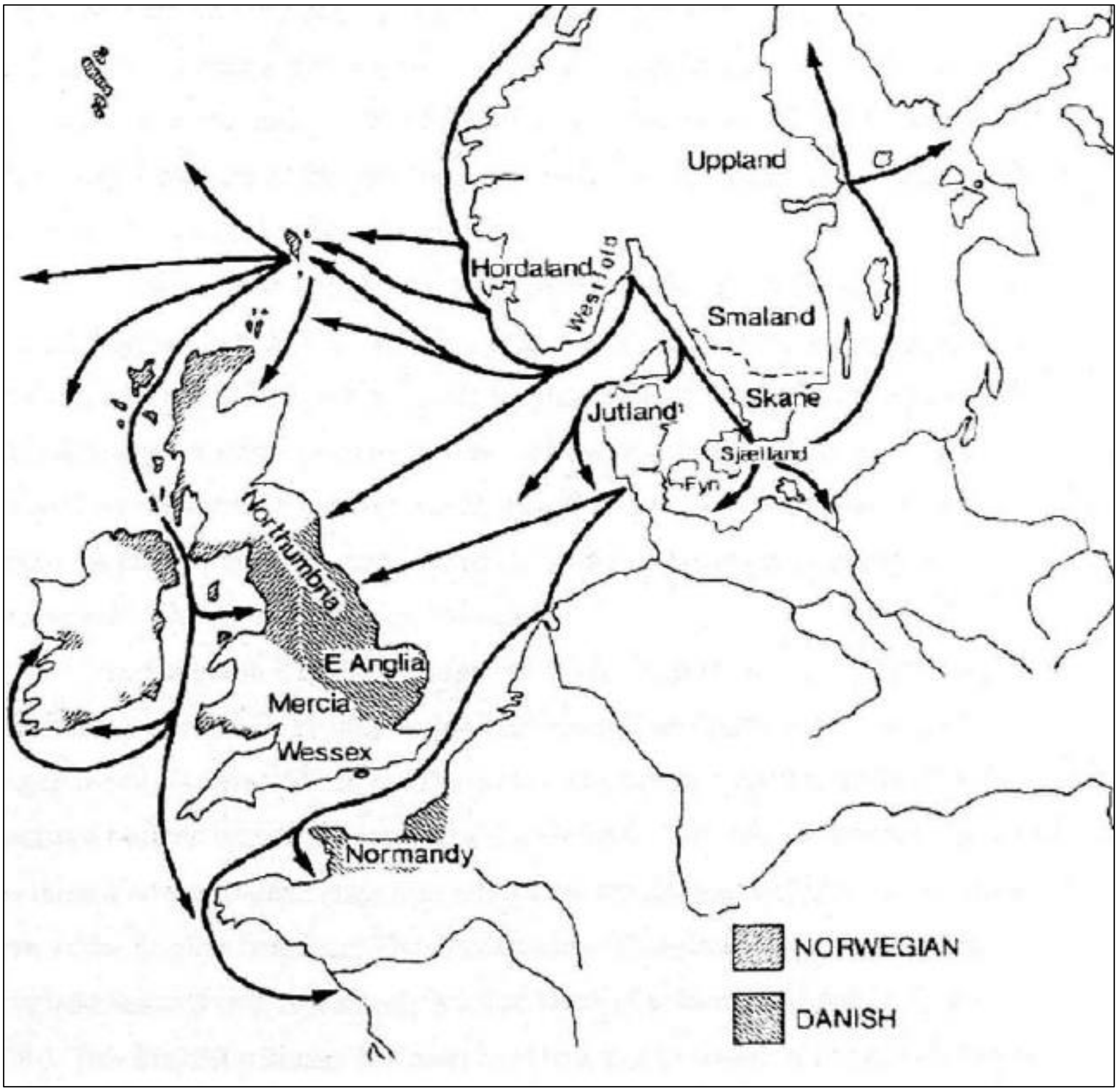


Figure 2.2: Map of Viking Age Britain (adapted from Richards, 1991)

Richards (1999) also notes that the Viking settlers were able to live with the indigenous populations. In fact, this can be observed from the artefacts from the Norse farm in Point of Buckquoy at Birsay (Orkney): the findings were from the Norse occupation levels, but they were Pictish bone pins. The evidence allows us to consider a probable inter-marriage with the local populations with the adoption of local culture, not extermination as frequently is thought. In the countryside, the Scandinavian settlers also established manorial centres creating a boom of rural parishes and parish churches in the $10^{th}$ and $11^{th}$ centuries.

The Viking Age is conventionally seen ending in the mid-$11^{th}$ century, when Harald Hardraara, the last Viking leader, died. The event coincides with the victory of William the Conqueror and the Late Saxon period. However, the Western Isles of Scotland and the Isle of Man stayed under the Scandinavian influence until 1266, while Orkney and Shetland belonged to Norway until 1496 (Richards, 1999).

The Middle Ages are set to begin in 1066 with the Norman conquest, which brought a period of significant changes that defined a new age. Parish churches multiplied, manors evolved, and towns flourished with an increase in the number of inhabitants.

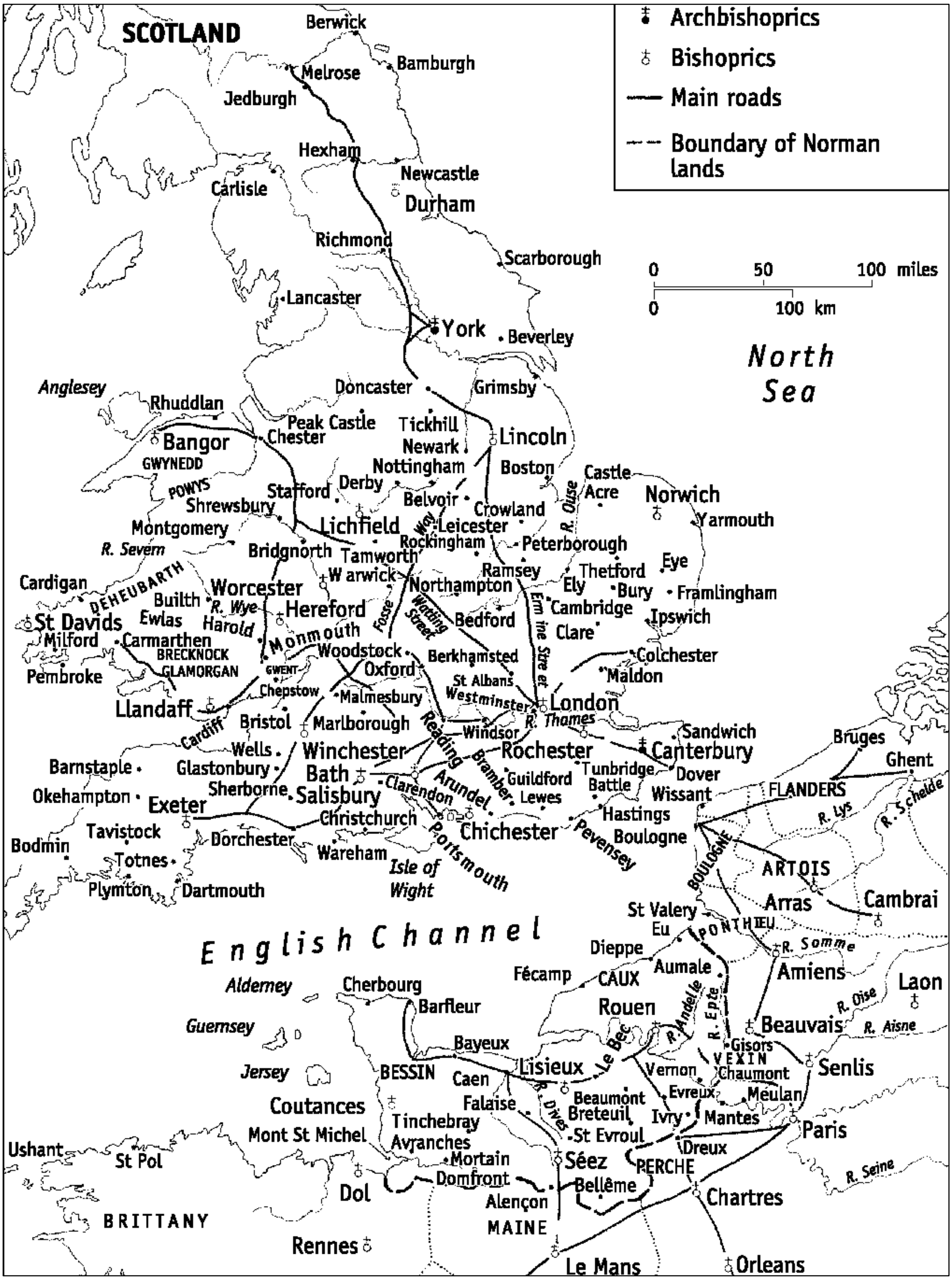


Figure 2.3: Anglo-Norman Britain (adapted from Gillingham and Griffiths, 2000)

William the Conqueror, Duke of Normandy, was of Viking lineage but living in the north of France, born from Scandinavian ancestors (Crick and van Houts, 2011). The number of Normans that followed him to Britain was not so conspicuous compared to the number of people that were on the British territory. In fact, the most significant impact was on the upper classes, which were eradicated in favour of the Norman elite. All the lands were furthermore taken away from the British people and given to the new arrivals, who also retained the lands on the Continent; this was the beginning of a single community that kept constant exchanges with the mainland (Gillingham and Griffiths, 2000) (Fig. 2.3).

Anglo-Norman was the language adopted by the upper class, and many French terms were introduced to the English language. Not only was the mainland culture becoming part of the British culture, but the genetic pool was also introduced to the existing one, as the movement of people became constant (Crick and van Houts, 2011). By the early 11th century, London was one of the biggest cities in Europe and had many trading contacts with several parts of the continent from Rouen to Germany and Flanders (Sawyer, 2002). Ships also came to river ports of York, Lincoln, Norwich, Gloucester and Chester (Schofield, 1999).

The arrival of the Normans saw a drastic change in architecture. The Normans built numerous castles that were mechanisms to keep the indigenous people under control. In fact, the caste was the fortified residence of the lords, which had a military and domestic function. It also had strategic importance, to maintain control over hostile territory. With the abolition of slavery, immediately appeared the feudalism, that characterised the Middle Ages; this was a system of vassalage where the king was the landlord and rewarded his followers with lands for their loyalty. Following the conquest, around 1500 castles were built and by 1080s, 20% of the lands were owned by the king, 50% by the baronage and 30% by the church (Gilchrist, 1999; Sawyer, 2002).

The Normans also brought a change to the communities, breaking down the large Anglo-Saxon parishes into smaller territories of individual parishes. Churches then became the focal point of the medieval communities, where the social and ritual life took place, including the burial of the dead. In fact, there is a transition from the previous concept of the grave as a self-contained place to an idea of the entire cemetery as a limited communal sacred space. It is only between the 10th and the 12th centuries that churchyards were established as the only burial place for the parish community (Zadora-Rio, 2003).

The foundation of a cemetery could have taken place as a continuum of a previous tradition (Iron Age, Roman, Anglo-Saxon or Viking), after the foundation of a new church or in the burial ground of a chapel headed by a parish church. The choice of the place of burial of the dead was dominated by two factors: which church and where in the burial ground based on the wishes of the deceased person. For the majority of the community, the only option was to be buried in the parish cemetery or church. In addition to the parish cemeteries, there were the chapels: these were dependent on the churches and could apply for burial rights. The most common reason for burial in chapels was the length and the difficulty to reach the parish church (Daniell, 2005).

The Normans also reorganised the administration of the Church of England, Wales and Scotland. New continental orders were furthermore introduced following the conquest and abbeys and priories were founded in association with castles, towns and manors. The ecclesiastical territories under the bishops (dioceses) that were established by the Anglo-Saxons, were kept and new were added in the 12th century. The head of each diocese was the metropolitan cathedral; these cathedrals were then divided into monasteries, with a community of monks headed by a prior, or secular cathedrals, with a chapter of canons led by a dean. Most of the monasteries were following the rule of St Benedict of Nursia, and this was the most common type in Britain. In fact, it is possible to count the establishment of at least 2000 monasteries between England, Scotland and Wales (Gilchrist, 1999). The 13th century also saw the arrival of the friars, who found hospitals in urban places and aimed at educating the poor (Schofield, 1999).

The period of well-being did not, however, last for long. The population growth and the wealth of England during the two centuries following the Norman Conquest led to many communities becoming overcrowded. The beginning of the 14th century is scarred by a famine in the years 1315-25 due to crop failures and cattle disease. The decreasing amount of crop fields is undoubtedly due to soil exhaustion. The land was being overexploited and over partitioned because the population increased between two and a half and four times by the year 1300. The decrease in available food was not only due to the increase in population. The relatively warm period (Little Optimum) that characterised the 11th and 12th centuries came to an end. In fact, the 14th century was distinguished by an unstable climate that brought droughts, floods, sea-level changes and storms with very cold winters. The geological instability was also caused by the cultivation that was pushed into inhospitable margins, producing an alteration in the landscape.

The situation further worsened with the great sheep murrain in 1313-17 and the cattle murrain, which immediately followed in 1319-21 (Platt, 2003). The 50% drop in production consequently caused a 400% increase in grain price and led to growing tensions in the society (Schofield, 1999). The Black Death also followed in 1348, which started in southern England, and by the end of 1349 spread to central Scotland. The disease reduced the British population by a third, and it continued affecting it until the 1370s. However, the later endemics were more localised and affected predominantly urban populations. Landowners were facing severe difficulties, and the leasing of plots was preferred to the high farming. Hundreds of villages were therefore abandoned and, following the demographic crisis, they became deserted. Only in the last part of the 15th century, the number of the population began to increase again, but the 13th century's population size was only reached in the 17th century (Gillingham and Griffiths, 2000).

The next centuries were characterised by a period of mixed fortunes, which comprised the decline of some cities and the rise of others, such as London for England, and Edinburgh for Scotland. The 15th century was characterised by prosperity in the commerce, which expanded as far as the Baltic area and some of the port towns started to grow, such as Newcastle, Colchester, Ipswich, Exeter and Chester (Schofield, 1999).

The British Middle Ages historically ended with the Battle of Bosworth in 1485. Archaeologically there is, however, a material culture continuum until 1540 when the dissolution of the monasteries brought a change to the medieval institutions accompanied by a redistribution of the lands (Stamper, 1999). When the Middle Ages came to an end, the Early Modern period started with the House of the Tudors ruling the Kingdom of England and its realms until the 17th century, bringing a period of relative stability in the country.

## 2.2 The sites

This Chapter is an introduction to the sites from which the craniometrics data have been collected and analysed. Each subchapter examines the history of the site where the human remains have been excavated, as well as the information about the distribution of the burials. The analysis of the contexts of each site is important to understand the possible causes of the morphological variation between and within the populations taken into consideration for this project.

### 2.2.1 Poulton (Cheshire)

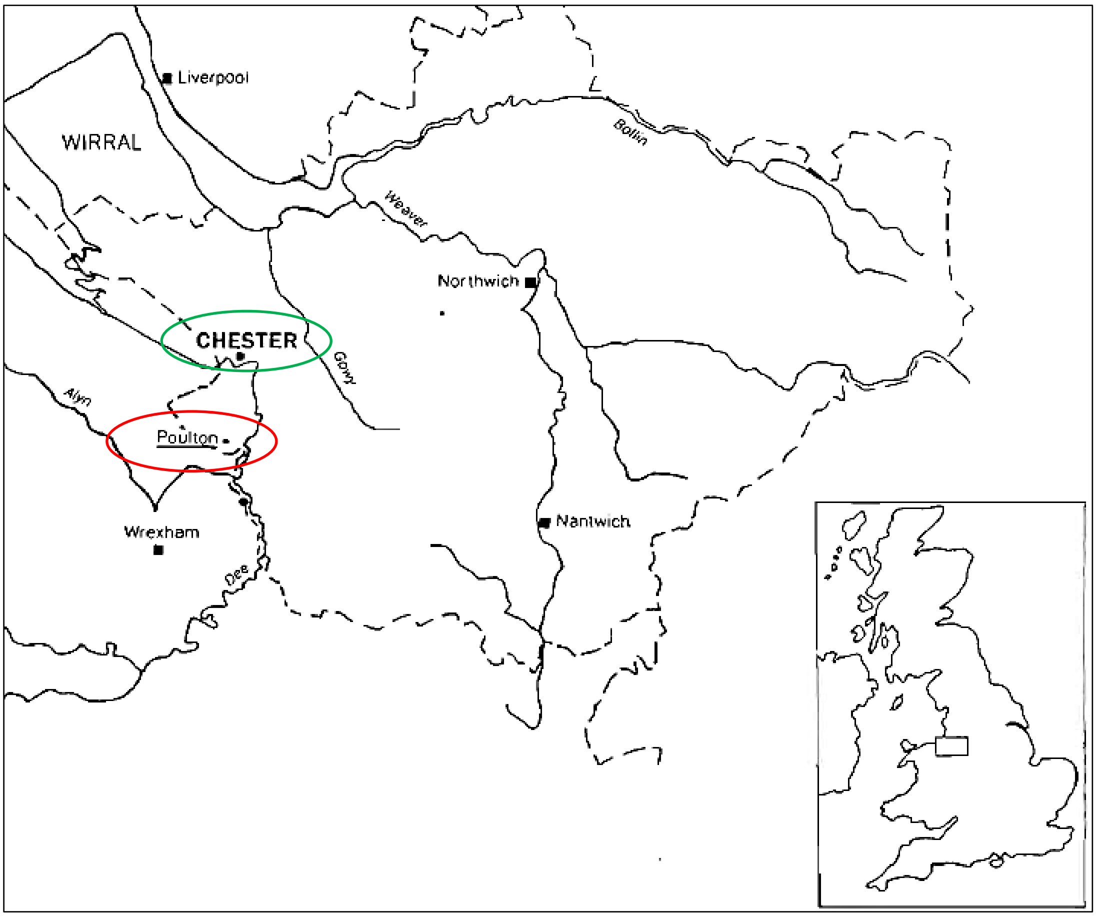


Figure 2.4: location of Poulton (red) and Chester (green) (adapted from Emery, Gibbins and Matthews 1996)

Poulton is an archaeological site located in Cheshire (Fig. 2.4 in red) with a history that spans approximately 9000 years. Poulton is mentioned in Domesday Book, which is dated to 1086. After the Norman Conquest and the ecclesiastical reform, a Cistercian abbey was founded, probably sometime between 1147 and 1153. The foundation charter survives for the abbey of Poulton at its successor Dieulacres abbey in Staffordshire, but the physical abbey has not been found yet. The site had a short life since it lasted only until 1220 when the monastery was relocated to Dieulacres and Poulton was converted into a grange. A small group of monks, however, stayed in the chapel, which remained the focus of the new abbey's agricultural exploitation of the land (Emery, 2010). The chapel was found and excavated in 1995 (Emery, 2000), and recent archaeological work revealed that probably the earliest origins of the chapel predate the foundation of the abbey, possibly 1020's (late Anglo-Saxon) (Emery, 2010).

The first mention of Poulton chapel appears in 1250, where it is reported that it was used from the people living in a village served by a monk. The building was surrounded by a burial ground, where it was estimated that there had been buried around 1200 people. The chapel appeared to have been used until the English Civil War, in the 17$^{th}$ century and disappeared after that (Emery, 2000).

The material that was analysed for this study was recovered from the cemetery that surrounds the Poulton medieval chapel. Poulton Research Project carried out the excavations since 1995 until present days in collaboration with Liverpool John Moores University (where most of the remains are housed) and uncovered about over 900 skeletons to date, together with a considerable amount of disarticulated human remains. Some of the earlier skeletal material was sent for re-burial at Mount St. Bernard's Monastery in Staffordshire, so the analysis of those remains was not possible (Burrell and Carpenter, 2013).

The number of the burials inside the chapel and in the northern part of the cemetery is lower than in the western and southern sides, as it is noticeable from Figure 2.5. A possible hypothesis could be the burial of higher status people inside the building, which could also suggest that these were later than the construction of the chapel. The majority of the burials also have an east-west orientation in extended supine position, which reflects the Christian standard.

A small sample of remains had been radiocarbon dated as part of an earlier study. Skeleton 53 gave two date ranges of 1531-1537, 1635 and 1780-1799. In 2012, the same and skeleton 535 were radiocarbon dated using tooth roots: skeleton 53 gave a range of 1470-1520 and 1560-1630, while skeleton 535 gave a chronology between 1280 and 1320. The latest analysis gave a clearer view of the chronology of the burials, which fits in the chronology of the site as well (Burrell and Carpenter, 2013). Continuous research is taking place in Liverpool John Moores University for the analysis of the human remains, which will help to provide a clearer understanding of the medieval Poulton community.

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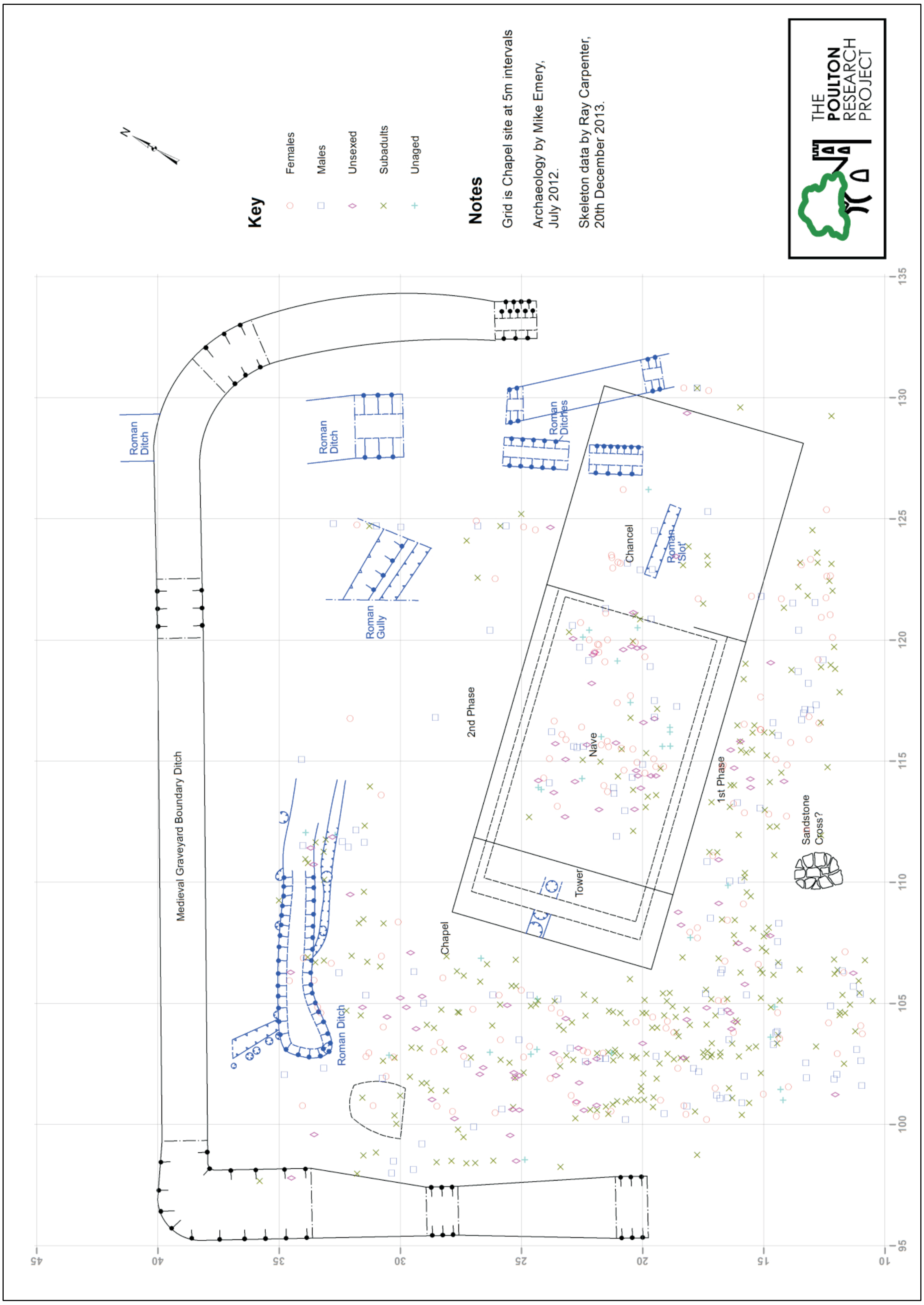


Figure 2.5: Poulton site with the location of the burials (from Burrell and Carpenter, 2013)

## 2.2.2 Linenhall, Greyfriars (Chester)

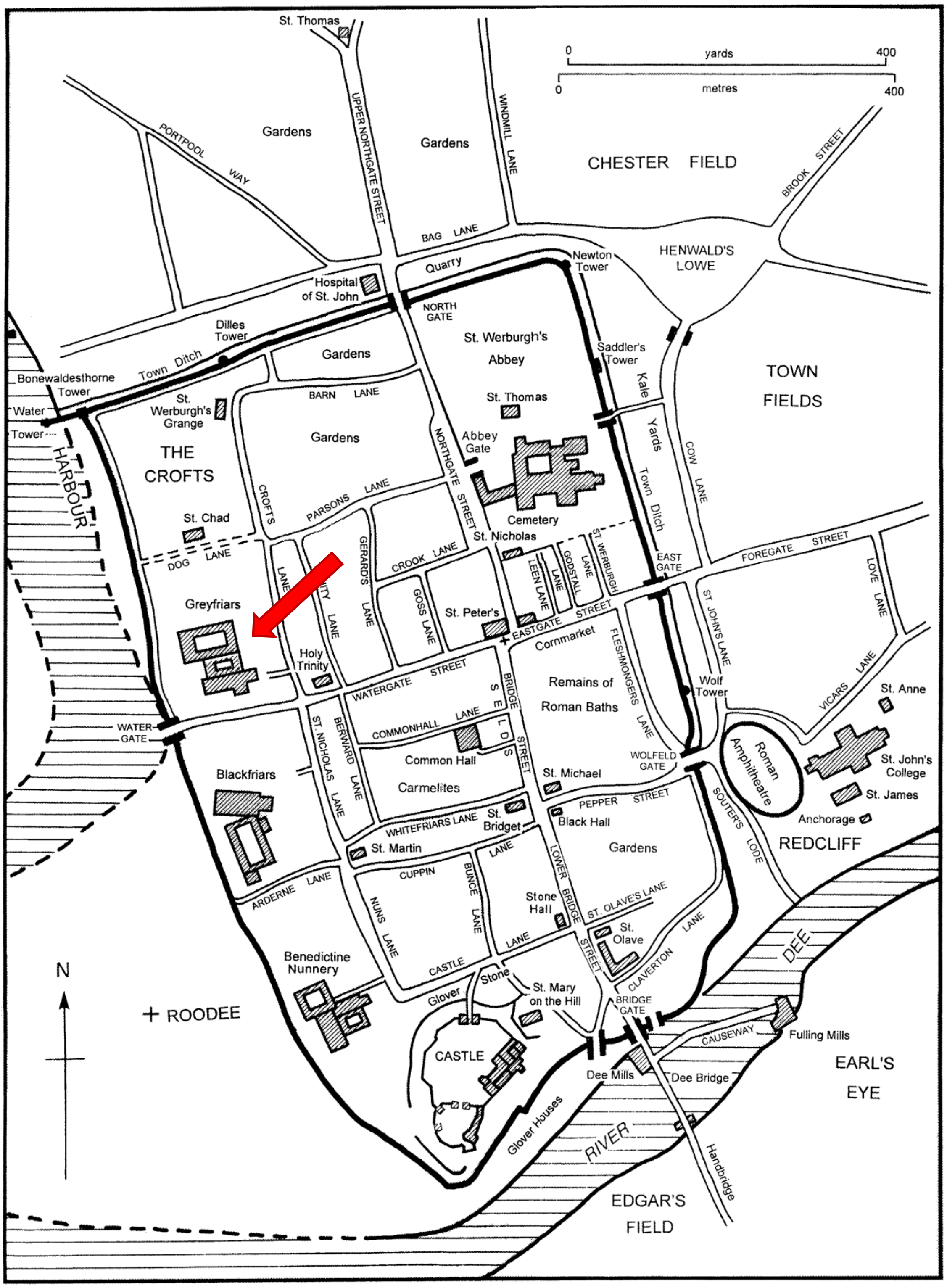


Figure 2.6: Chester in the medieval period and the location of the Greyfriars (adapted from Thacker, Laughton and Kermode, 2003)

The site of Linenhall is located in the city centre of Chester (Cheshire), in the area that belongs to the Greyfriars' site, in use between 1238 and 1538 (Fig. 2.4 in green). Chester's history began with the occupation by the Roman legions, and it acquired a significant role in medieval British history.

After the Roman army left Chester, there must have been a continuity of occupation. By the 7th century, Chester and the surrounding territory was part of the Welsh kingdom of Powys. The lack of historical records, however, does not allow us to reconstruct precisely the Anglo-Saxon period of the city. Thacker, Laughton and Kermode (2003) report that Chester passed under the Mercian influence and that a 12th century tradition states that the Mercian king Æthelred founded St John's Cathedral in the late 7th century. He also suggests that the place-name "Henwald's Lowe" (which can be seen in figure 2.6) can be attributed to an Anglo-Saxon origin.

In AD 893, the Vikings raided Chester and culminated with the occupation by the Danes, as part of the Danelaw. There is, in fact, architectural evidence in Chester of semi-sunken cellars used as storage for traded and manufactured items, which is reminiscent of the ones occurring in many Danish towns. The walls of the Roman fort were furthermore refurbished and probably extended to the river Dee by Æthelflæd in AD 907, consequent to the establishment of a Hiberno-Norse community in Wirral that was expulsed from Dublin.

The location of Chester was advantageous for the maritime trade. Starting from the 10th century, it had several connections with Ireland and the Scandinavian settlements in the Irish Sea. The Hiberno-Norse settlement was certainly located in the southern area of the legionary fortress, where the majority of the Scandinavian type architecture was found (Lower Bridge Street). The foundation of two churches, St Olave's and St Bridget's Church, furthermore date to the Scandinavian settlement of the city (Thacker, Laughton and Kermode, 2003). In this period, Chester also became an important centre for coin production, which operated in north-west Mercia (Richards, 1999; Thacker, Laughton and Kermode, 2003).

In 1066, Chester was a prosperous town within the most populated area of the surroundings. At this time, three lords administered the city: the king, the earl and the bishop. The city also continued to be very important for the external trade, and it is confirmed by the complex system of tolls imposed on the cargoes of the ships arriving into the port.

With the Conquest, Chester took part in the rising of 1069-70. William I then brought his army into the city and built a castle, replacing the earls with a Fleming, Gherbod. The new fortress also gave to the city a military role, and it became the base for military campaigns against the Welsh and the Irish. Alongside this function, Chester maintained an essential position in the overseas trade. Ships arrived in its port from Aquitaine, Spain and Germany and the town became a focal point for the interchange in the area.

The Normans brought further changes in the religious life of the city. In fact, the northwestern Mercian see was transferred from Lichfield to St John's Cathedral in 1075. In 1092, the minister of St Werburgh was furthermore changed to a Benedictine community. Other religious foundations followed this one: the Benedictine nunnery and the St John's and St Giles' hospitals. Further smaller parish churches also emerged by 1150: St Peter and St Mary (Thacker, Laughton and Kermode, 2003).

By the 13th century, Chester was a prosperous port, and its economy continued expanding reaching its peak. The city had a market twice a week, that was concentrated in the open spaces by St Peter's church, and many traders were attending them. It also continued its military role as a supplying centre for the royal expeditions in Wales. The favourable situation stimulated the local market, as the merchants had to supply the armies that were brought there by the royal order. The trading also involved France, as small amounts of pottery can be found in the city, mainly for the importation of wine (Thacker, Laughton and Kermode, 2003).

The city was moreover important as being the capital of the earldom. The castle was, in fact, the seat of the justice of Chester, the chamberlain and clerks of the exchequer and a county court. This brought to the city the permanent presence of influential officials. Its importance as an ecclesiastical centre continued in the 13th and 14th centuries. St Werburgh remained the wealthiest abbey in the North-West, with forty monks and a significant number of visitors from Wales and Ireland. St John's cathedral instead hosted the seat of the archdeacon of Chester and his court. In the 13th century, three friaries were established in the town: the Dominicans in the 1230s, the Franciscans in 1238 and the Carmelites in 1277. None of the friaries were wealthy, but they were very popular with the people, and they were favourite places of burial. Most of the higher status representatives chose to be buried in the Carmelite friary, while the Franciscan and the Dominicans were more popular between the lower classes (Thacker, Laughton and Kermode, 2003).

The sample that was analysed for this research belongs to the Greyfriars' burial site, which was discovered during the construction of a student accommodation complex. Twenty burials were excavated by L-P Archaeology between November 2015 and January 2016, and the remains were stored in Liverpool John Moores University until they went for reburial in August 2017. Only ten of these burials were however analysed due to taphonomical changes that caused damage on the other remains.

All the recovered burials were in an east-west orientation, typical of the Christian standard. Eight of them appeared to be shrouded, while the remaining eight seem to indicate a coffin burial. The positioning appears to be supine for all the burials, except for one that shows to be flexed. Radiocarbon dating was carried out on seven of the adult skeletons, which involved teeth samples (mostly molars). The dates span from 1155 to 1470, which appears to be consistent with the historical record of the use of the Greyfriars' abbey (Davenport, 2018).

## 2.2.3 St Owen's Cemetery, Gloucester

The site of St Owen's church in Gloucester is located in the city centre, on the west side of Southgate Street, between Kimborose Way and the entrance to the Docks (Figure 2.7 and 2.8) (Atkin and Garrod, 1990).

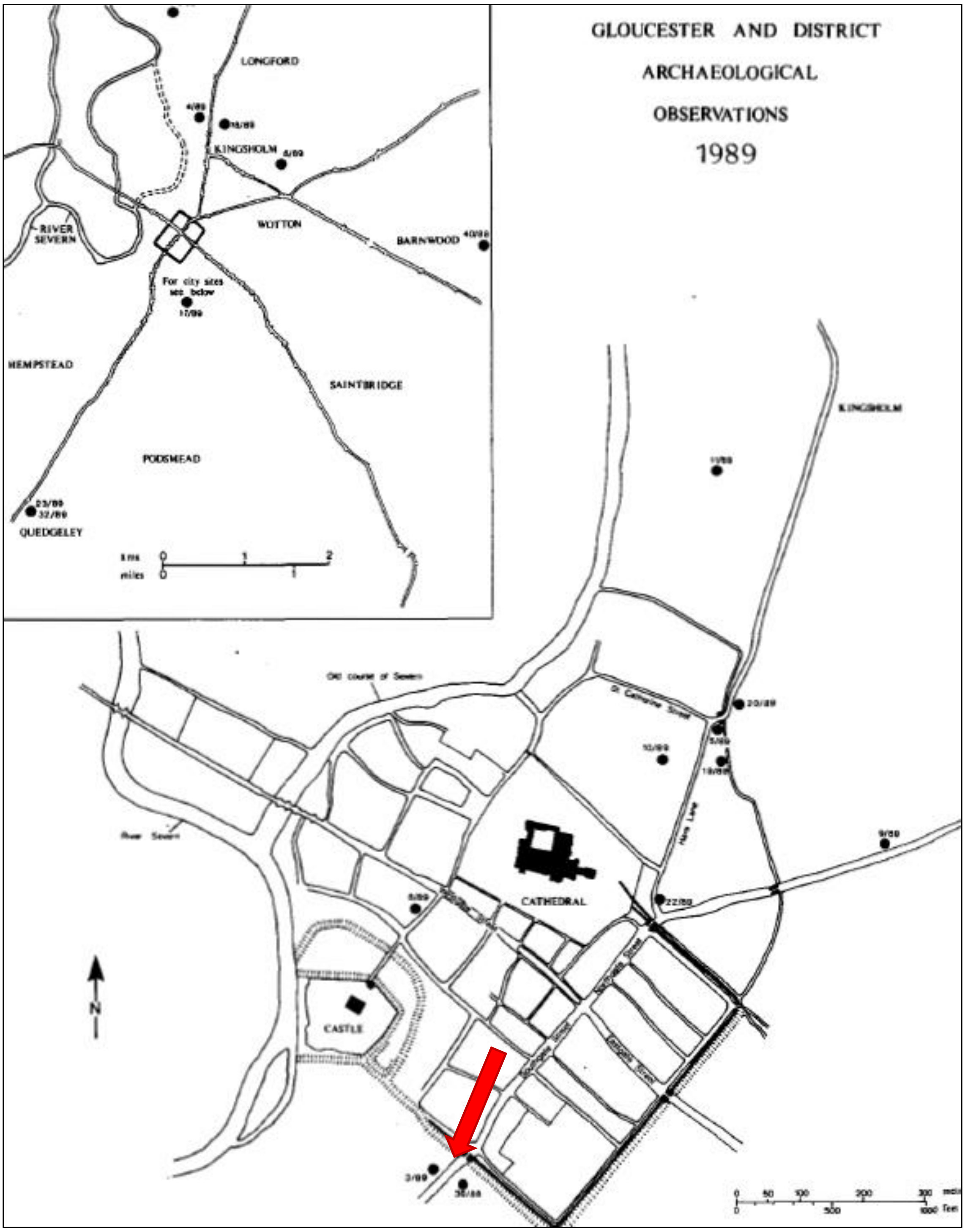


Figure 2.7: Map of Gloucester and the archaeological excavations carried out in 1989 (adapted from Atkin and Garrod, 1990)

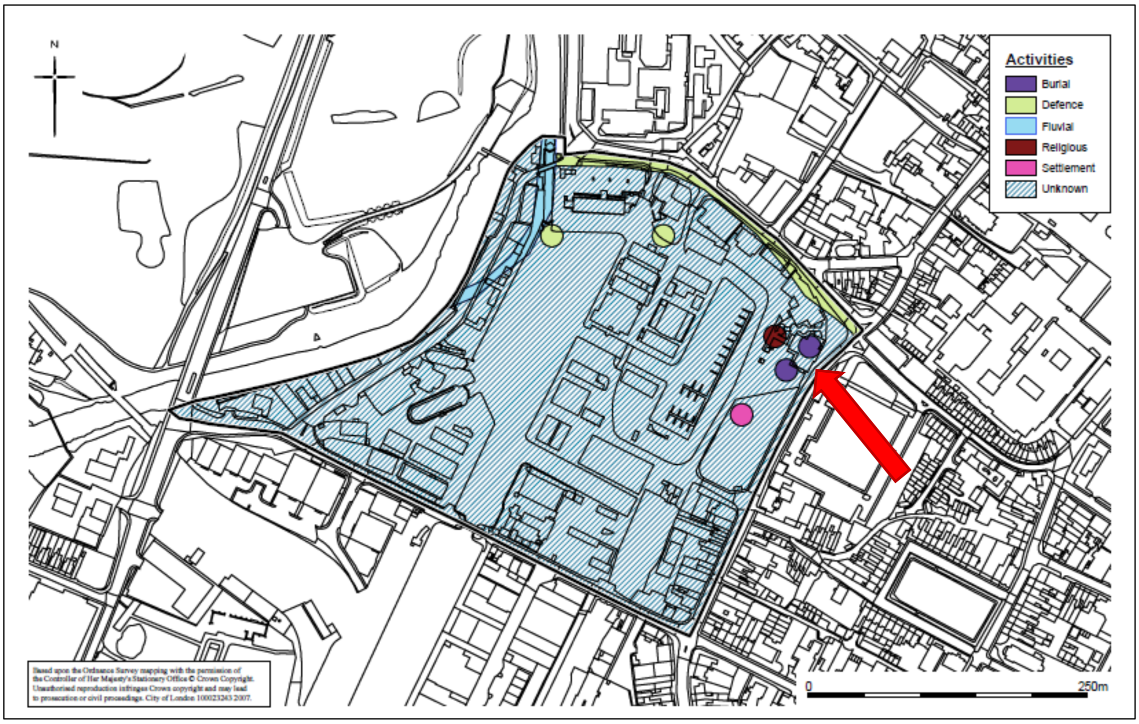


Figure 2.8: Medieval period Gloucester (adapted from The Docks Archaeological desk-based assessment © MoLAS 2007)

The town has its origins since the prehistoric times, but it is with the Roman presence that it became important. In fact, the Roman town of Gloucester was built as a fortress in the 1st century, which became a *colonia* in the 2nd century (Bryant and Heighway, 2003). There seems to be continuity from the Roman and the later occupation, as a Roman cemetery became the site of the late Anglo-Saxon minster of St Oswald. The church of St Mary de Lode also had its foundations on a post-Roman burial chapel, and the high-status Roman cemetery of Kingsholm became the site for a late Anglo-Saxon royal palace in AD 896.

In AD 577 the city of Gloucester was captured by the Anglo-Saxon invaders and declared head of the district. By the 7th century, the town became part of the kingdom of Hwicce and passed under the influence of Mercia in AD 628. Although Gloucester did not have a Viking influence, in AD 877 part of the Danish army camped in the town (Herbert, 1988). In the 10th century, Gloucester acquired an administrative and military status and was organised for defence by AD 914 by Æthelflæd of Mercia, who also founded the minister of St Oswald in AD 900. Differently from the earlier centuries, the town was given attention that was the start point of the economic growth for the following centuries.

By the Norman Conquest, Gloucester had already many close links with the rulers of England. In the 12th century, the castle was rebuilt, and its importance increased thanks to its strategic position in relation to South Wales. In the century that followed the Conquest, the town also had ten churches, and most of them were founded before 1066. One of the later ones was St Owen's church, probably founded by Roger of Gloucester. Three hospitals were furthermore built in the $12^{th}$ century: the leper hospital of St Mary Magdalene, the hospital of St Margaret and St Bartholomew.

The largest religious house was the Benedictine abbey of St Peter, which was also involved in the affairs of the town. It was a major landlord of most of the surrounding lands, owning many manors around the town and along the river. The house also had the patronage of two of the churches in the town, St Mary de Lode and St John, and secured St Michael and Holy Trinity.

Gloucester was also in an excellent geographical position, not only for its military importance but also for its trades. The town was known for its ironworking and cloth making, which insured the trade in the country through the river Severn and, through Bristol, also overseas. Bristol also involved the trade of wine from Gascony (Herbert, 1988). Gloucester was further important as an administrative centre because the sheriff carried on from the castle the county government. By the end of the $12^{th}$ century, Gloucester registered a growth in population caused by conspicuous immigration in the area. Most of the immigrants were from the surrounding areas, such as the Midland towns, but the friars were also attracted to this city. The Franciscans and the Dominicans in fact founded communities in the 1230s and the Carmelites in the 1260s.

In the $14^{th}$ century, Gloucester experienced the economic problems that were affecting the whole country. Its position as a trading and administrative centre, however, helped the community to get through this hard period without too many changes. The Black Death also affected the town and left the LLanthony Priory with a third of its canons and Gloucester Abbey lost a quarter of its monks. Though disease and economic problems affected the country nationally, Gloucester retained its prosperity for the remainder of the $14^{th}$ century. The trades, in fact, continued with goods coming from London, Bristol and Southampton to be redistributed in the area and South Wales. St Mary de Crypt and the chancel of St Michael were also rebuilt, that could be identified as a sign of wealth (Herbert, 1988).

The prosperity of the $14^{th}$ century seemed to have declined by the $15^{th}$ century. A significant number of the population had been lost to the plague and, as a result, many of the numerous churches were in disuse. Even the number of foreign people, which were paying for trading rights in the town, diminished: from a number of about 300 listed in the $14^{th}$ century it went down to about 100 for the $15^{th}$ century. The drop indicates a decline in trade and affairs. With the dissolution of the monastic houses and the end of the medieval period, Gloucester entered a new era: the Gloucester Abbey became a cathedral, and the town finally was proclaimed city in 1541.

The human remains analysed for this research were recovered from the site located on Southgate Street (site 3/89) (Figure 2.9). The occupation of the site after the Roman period started in the 10th/11th century. Timber buildings were built and report a cut by a ditch, believed to be the east boundary of the Norman castle's orchard (Atkin, 1990). This site was then acquired by Llanthony Priory in 1137, and it seems that was abandoned in the late medieval period with a reorganisation in the mid-15th century. The cause of the abandonment of the site is not known, but it seems to coincide with the increased density of the burials in the cemetery of St Owen's church, probably linked with the Black Death (Atkin, 1990; 1992). More than 300 burials were recovered, together with the later burials from the Independent Chapel and the Royal Infirmary. The site of the church was then destroyed in 1847 during the extension of the docks (Atkin and Garrod, 1990). The human remains are currently housed at Liverpool John Moores University and are analysed for several undergraduate and post-graduate projects.

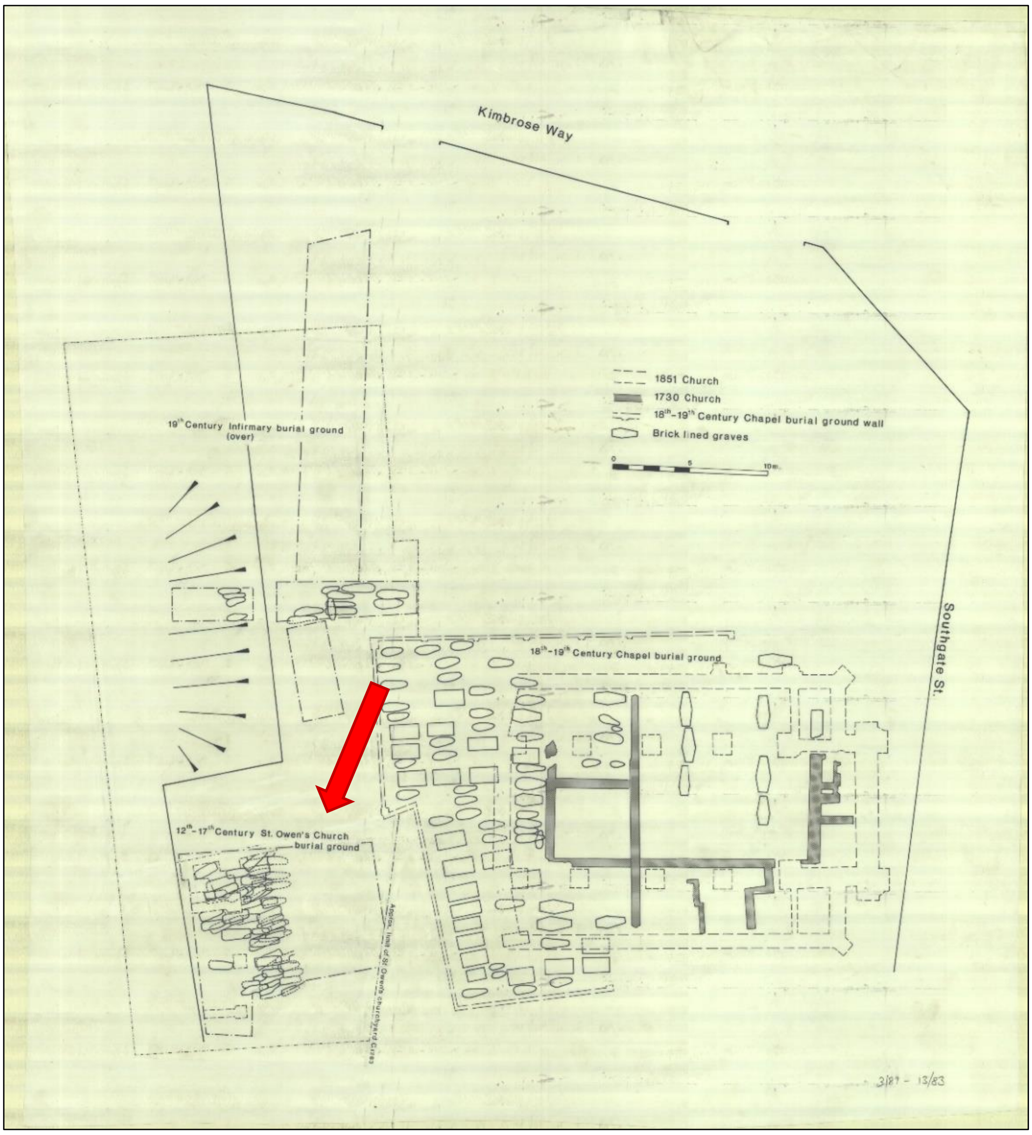


Figure 2.9: Gloucester Southgate Street excavation original plan (©Gloucester City Museum)

## 2.2.4 Monastery of St Saviour, Bermondsey (Southwark)

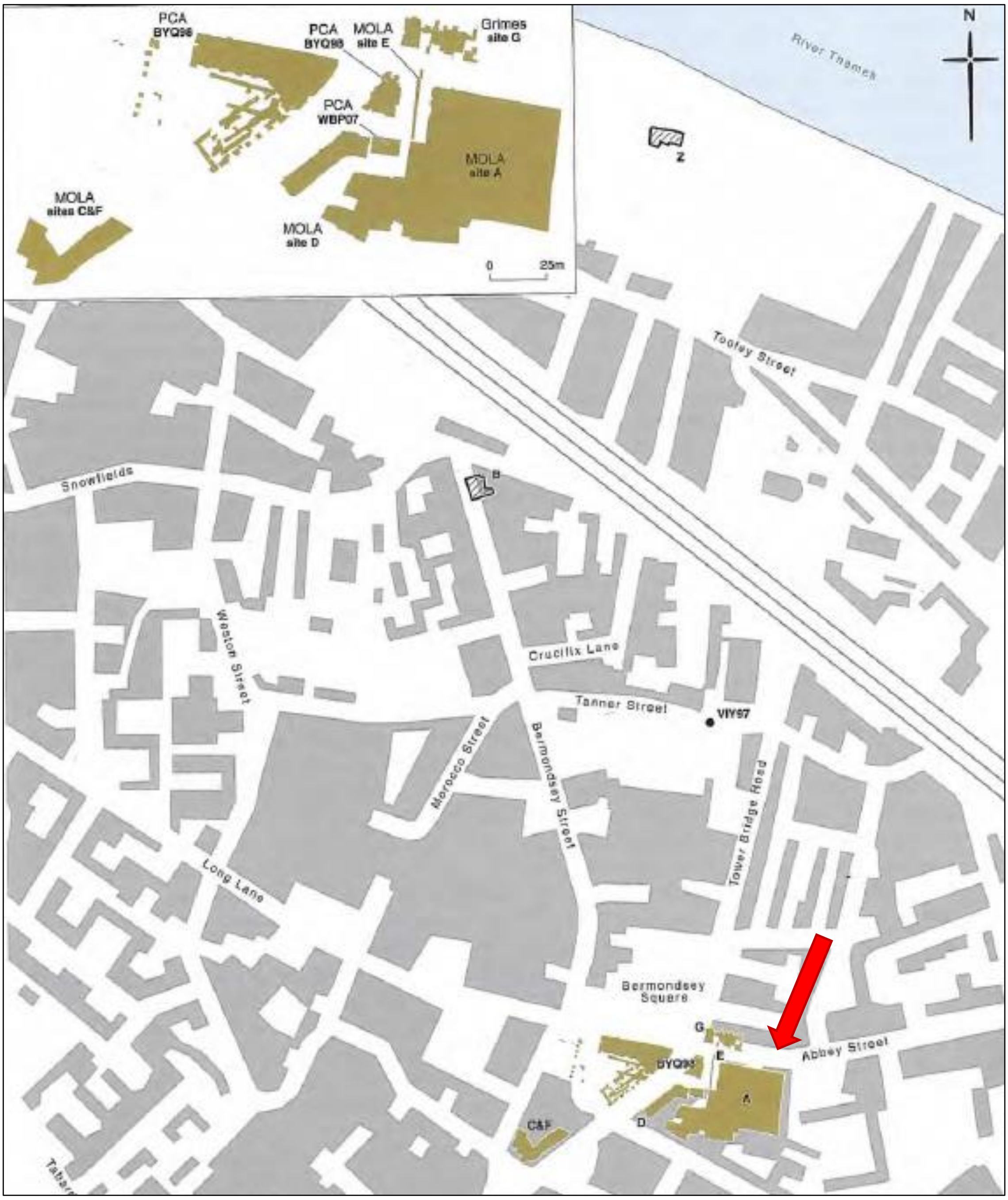


Figure 2.10: location of St Saviour Abbey, Bermondsey (adapted from Dyson et al., 2011)

Bermondsey Abbey was located in the south side of the River Thames, opposite the Tower of London, at what is now Abbey Street (Fig. 2.10). The evidence of occupation of this site dates from the Neolithic and Bronze Age periods. The Roman artefacts and burials also suggest the proximity of a settlement in the area. The majority of the archaeological evidence indicates an increase of finds for Mid-Saxon and Late Saxon period. In fact, the first buildings on the site are represented by a small apsidal chapel enclosed within ditches. This suggests that probably the area was on or near the centre of a high-status settlement, possibly of a religious nature with a Saxon minster church.

The area is also mentioned as "*nova et pulchra ecclesia*" in Domesday Book, as the site of the royal manor of Bermondsey. It is possible that the church mentioned was the chapel commissioned by William I (Dyson et al., 2011). Before the Norman Conquest, the manor was held by Earl Harold, and later Alwin Child founded the priory of St Saviour, Bermondsey, in 1082 for the monks of the Cluniac Order. This order was the medieval organisation of the Benedictines which had its origin from the abbey of Cluny, France.

The Conqueror's first intention was to use the Cluniac monks to reform the English church (Knowles and Hadcock, 1971), carrying an expression of a newly found sense of Anglo-Norman rather than a Norman identity (Burton, 1994). The French house sent four monks to establish a cell in Bermondsey after William Rufus had granted the monastery his manor between 1093 and 1097 (Graham, 1926). By 1150, the monastery was equipped with a *necessarium*, an infirmary, the infirmary chapel and other peripheral buildings. In the north side, outside the chapel, was situated the cemetery where the human remains analysed for this research were excavated.

With Henry I and the Norman kings, the order of Cluny received a lot of care and respect. This led to a discrete amount of donations and lands to the Monastery, and it is confirmed by the archaeological evidence of the expansion of the priory buildings. Important benefactors were also buried here: Mary Countess of Boulogne, Leofstan domesman of London, William Count of Mortain and Adelaide wife of Hugh de Grantmesnil (Dyson *et al.*, 2011). Bermondsey was well known as it claimed to house the relic of the Holy Rood and attracted a high number of pilgrims. Its building was suitable for large assemblies and councils of state during the 12$^{th}$ and 13$^{th}$ centuries (Graham, 1926). In fact, in 1152 the king's court convened here to consider the state of the kingdom and the expulsion of foreign people. Furthermore, between the late 12$^{th}$ and the beginning of the 13$^{th}$ century, Prior Richard built a hospital for lay brethren and boys (Malden, 1967; Dyson *et al.*, 2011).

The wealth of the monastery, however, did not last, as in the 13$^{th}$ century, the financial position worsened and the earliest records that can be found in Cluny, mention a delegate from Bermondsey who stated that the house was nearly reaching the bankruptcy. Later reports mention that the primary cause of the crisis of the monastery in the second half of the century was caused by repeated flooding and consequent loss of revenue from lands, with the following factor of alienation of priory lands and properties. In 1337, Bermondsey was sequestered as an alien priory (Dyson *et al.*, 2011). In 1381, the monastery was denized and got its independence from the motherhouse in France. In 1399, Pope Boniface IX proclaimed it abbey under King Richard II.

In the 14$^{th}$ century, the abbey also seemed to have returned to its first respectability and several influential people, such as Katherine widow of Henry V and Elizabeth widow of Edward IV, retired in the monastery (Malden, 1967). After the Dissolution of the monasteries, the Abbey became the basis for Sir Thomas Pope's mansion and in 1556 became the residence for the family of Radcliffe, Earls of Sussex (Dyson *et al.*, 2011).

The Department of Greater London Archaeology (DGLA) and the Museum of London Archaeology (MOLA) excavated the site between 1984 and 1988. The location is now part of the London Borough of Southwark, and it is a Scheduled Ancient Monument.

The number of individuals that were recovered amounts to 201 skeletons and are currently stored in the Centre for Human Bioarchaeology at Museum of London Archaeology. The earlier burials pre-date 1089, but the cemetery continues to be also used after the Dissolution of the monasteries. All the burials appear consistent with the Christian standards, and 19 of these burials are placed in a stone or mortar cist, while 21 report evidence of wooden coffins, as suggested by the presence of coffin nails. The burials in the external cemetery began in the western part north of the chapel and south of the priory church and developed eastwards, while three were inside the chapel (Dyson *et al.*, 2011; Gilchrist and Sloane, 2005).

## 2.2.5 Dominican Friary, Carter Lane (London)


Figure 2.11: location of the Dominican friary in London (adapted from Harrison, 1877)

The Dominican friary in London (also known as London Blackfriars) is located in the south-west corner of the area of central London, on the northern side of Carter Lane (Fig. 2.11). The earliest features found on the site are truncated pits and parts of the ditches dated to the Norman period fortress, probably Montfichet's Tower. The lowest and oldest excavated fills are dated 1050-1200. From the excavation data, it can be assumed that the fortress was in ruins by 1272 and that the Dominican friars used the building materials to build their friary nearby. The South ditch instead, which corresponds more or less to Carter Lane, was gradually infilled (dated by pottery 1150-1350) and used as part of the friary cemetery (Gaimster, Margeson and Barry, 1989).

The first Dominican friaries arrived in Britain in 1221, and in the same year, three of them reached London, settling in Holborn, near the Old Temple. Hubert de Burgh must have been their chief benefactor and bequeathed them his mansion near Westminster. By 1250, the order could count 400 members that already settled in the building.

The Blackfriars received conspicuous popularity in the English aristocracy, assisting Henry III and Henry IV. The position within the area of Westminster though did not facilitate their popularity, because it was located outside the city centre of London. In 1276, the archbishop of Canterbury, Robert Kilwaldby, managed to move the friary to the site on the Thames by Ludgate with Edward I being the official patron (Page, 1909). Even Edward II appears to have resided in the house a few times, and the number of state businesses carried out in the convent proves the importance that was given to the friary. The acquired prosperity was also a reason that caused a loss of popularity of the Dominican friars within the city, being accused of a lack of humility.

There was, however, a shift in public opinion regarding the Blackfriars as is evidenced in a large number of general citizens opting to be buried at the Dominican friary's cemetery. Furthermore, in 1382 the council for the discussion over the Wycliffe heresy and in 1413 the examination Sir John Oldcastle took place at the monastery. Even in the 15th century, the friary kept its good reputation, as Henry IV chose one of the friars as his confessor and the ambassadors of the Duke of Brittany in 1413 and the French ambassadors in 1445 stayed at the monastery. In 1436, Sir John Cornewaill, linked to the Lancastrian family, established a chantry in honour of the Virgin in the chapel located in the churchyard, and in 1470, Jon Tiptoft Earl of Worcester requested to be buried in the chapel that his family built in the nave of the church.

During the 14th and 15th centuries, the number of friars in the monastery decreased compared to the previous centuries, but it was still a centre of religious activity and an aspired place of burial for all the classes. In its last century of life, the friary was so involved in political affairs with the English aristocracy that the whole institution was considered "antichristian", and in 1538, the house surrendered with its prior and fifteen friars (Page, 1909).

The excavations of the area were undertaken by the Museum of London Archaeology (MOLA) in two phases during November 1987 to March 1988 and June to July 1988, supported by the funding from Eagle Star Assurance and London and Paris Properties. The articulated burials amounted to 60 individuals, 13 of which were part of a mass grave and two in a double burial. There was evidence of 25 coffin burials, one lead coffin and five possible empty or unused graves. Based on the finds from the burials, the dating suggested spans from 13th to the 14th century, but two of the burials might be later ones (16th century) (Gaimster, Margeson and Barry, 1989). The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology.

## 2.2.6 St Mary Graces Abbey, London

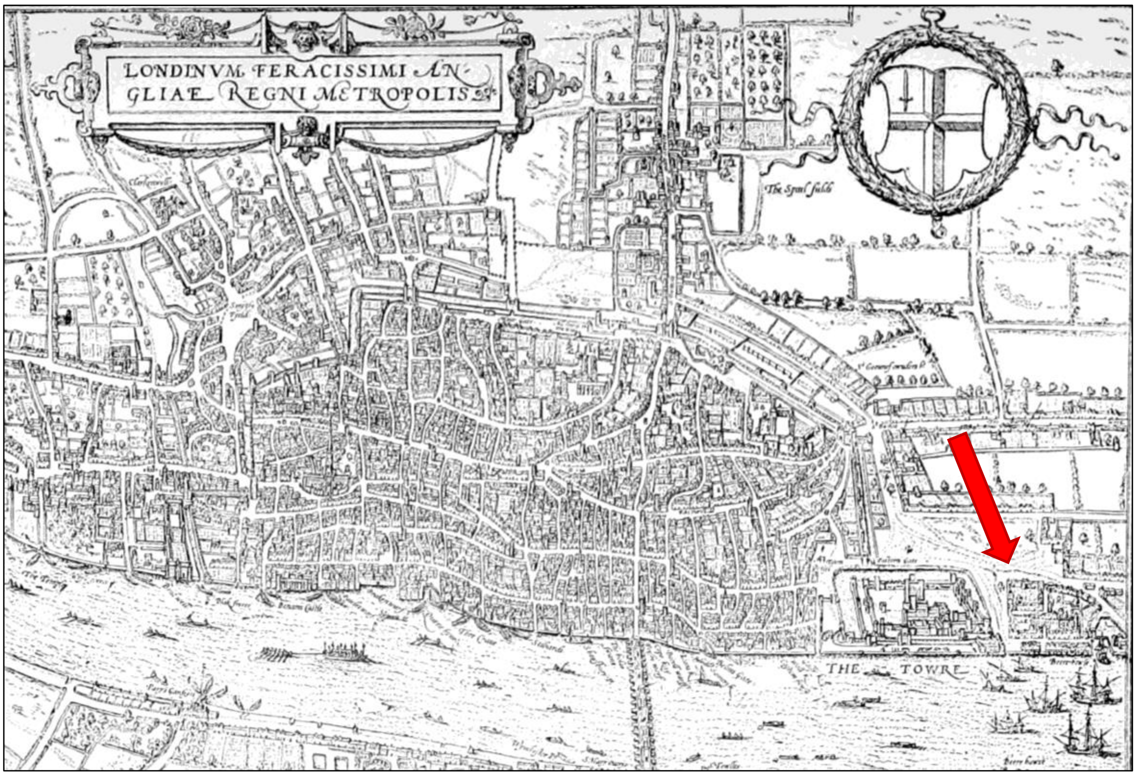


Figure 2.12: location of St Mary Graces Abbey (adapted from Besant, 1904)

The site of St Mary Graces abbey is located where the site of the Royal Mint was, just on the east side of the Tower of London (Fig. 2.12). The Cistercian Abbey of St Mary Graces was established in London after the first wave of the Black Death in 1350 (Grainger and Hawkins, 1988). The parish was founded by King Edward III in honour of the Virgin, and the site was called the New Churchyard of Holy Trinity, as it was acquired by John Corey, a clerk, for a burial ground during the plague (Page, 1909).

Initially, the Abbey was not a wealthy institution, and the donations were only sufficient to sustain the monks that were living there. The construction of the buildings took several years, and they were not completed until 1379. By the end of the 14th century, the Abbey already had a position of some importance. During this period, the abbot of St Mary Graces, along with the ones of Boxley and Stratford, were asked to convoke the order and the abbey was the meeting place of the chapter general. Some eminent people also decided to be interred in the Abbey, such as Sir Simon Burley, and this explains the importance of the church for few members of the London aristocracy.

During the 15th century, the abbey maintained its status and the abbot served on the commissions for the administration of the confining district under Edward IV and Henry VIII (Page, 1909). The abbey survived until the Dissolution of the monasteries (circa 1540) and later in 1560 was purchased by the Crown and converted into a storage yard for the Royal Navy until the mid-17th century. When the Abbey was in use, the general population used the churchyard, while monks and eminent people were buried within the abbey's church and chapels (DeWitte and Bekvalac, 2011).

The excavation of the site was carried out by the Museum of London Archaeology (MOLA) in 1986-1987, and 420 burials were uncovered, divided into two groups between the abbey and the churchyard. The inhumations were placed at the north of the church and extended westwards, overlying the earlier Black Death cemetery. Inside the abbey, the burials were mainly concentrated in the nave, but some were also recovered from the choir, the chancel, the chapels, the porch and the cloister. All the burials, external and internal, followed the Christian standards (Fig. 2.13) (Gilchrist and Sloane, 2005; Grainger and Phillpotts, 2011). The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology.

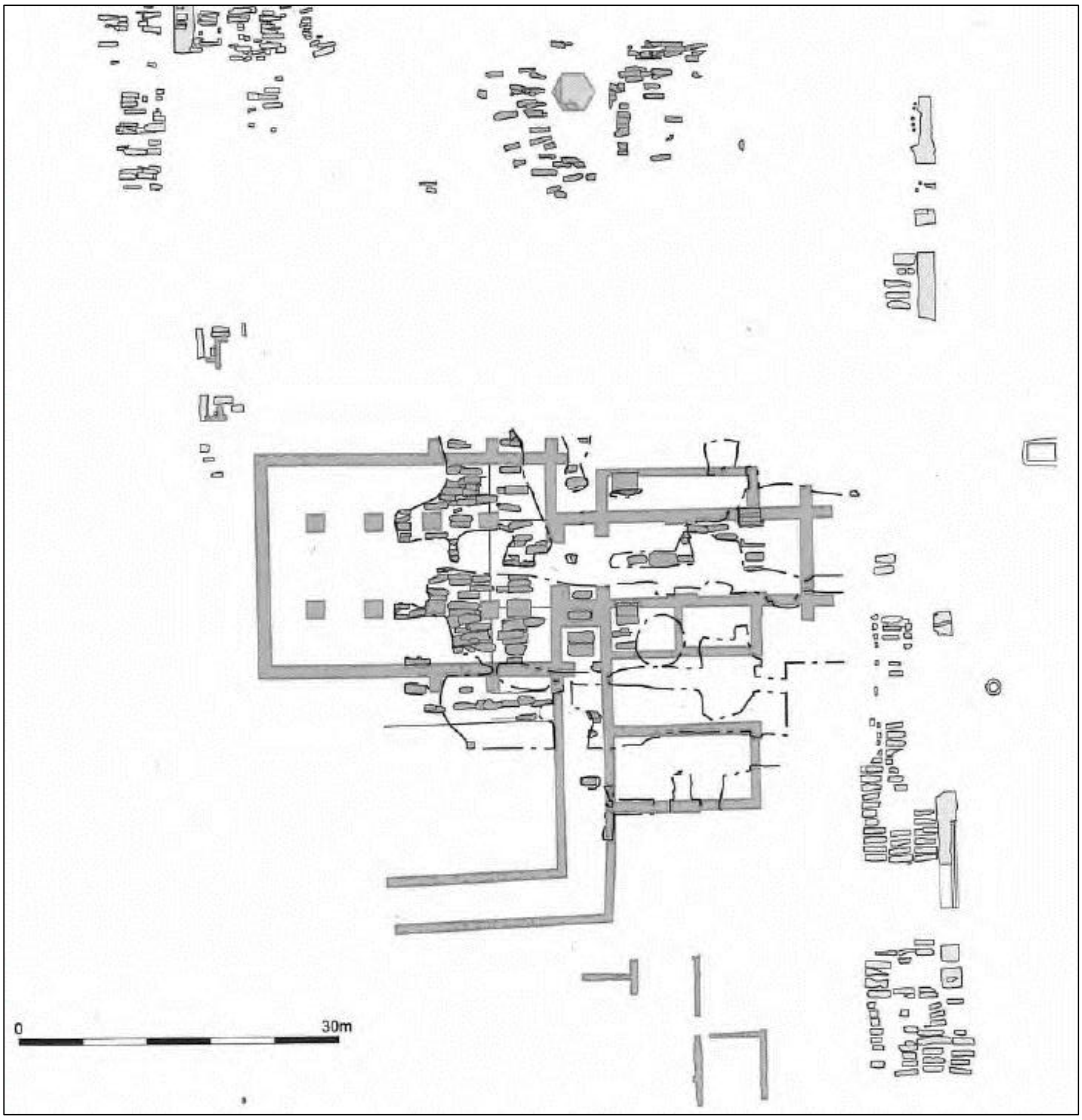


Figure 2.13: St Mary Graces Abbey burials (adapted from Gilchrist and Sloane, 2005)

## 2.2.7 East Smithfield Black Death Cemetery (London)

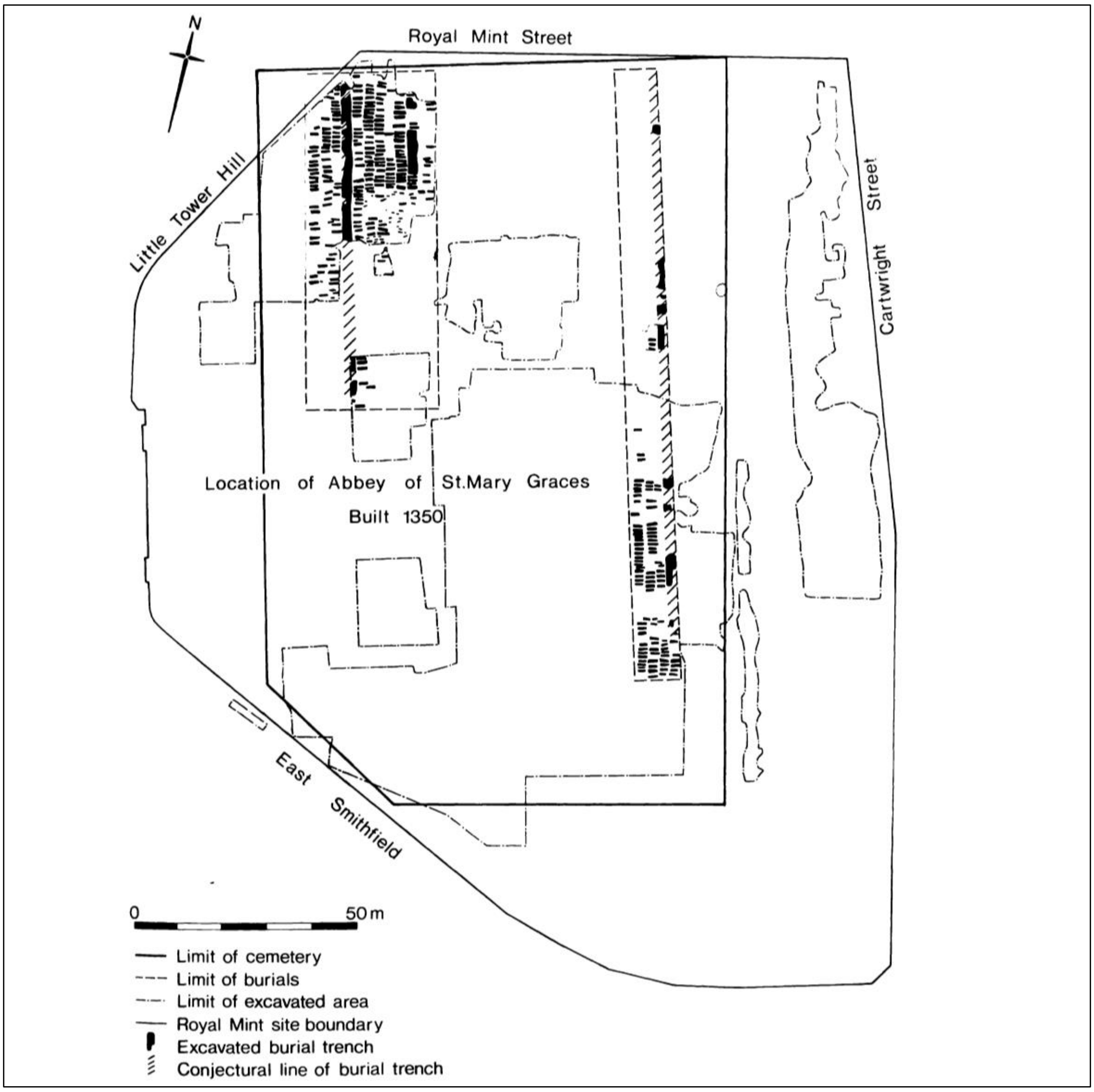


Figure 2.14: location of the East Smithfield Black Death cemetery (adapted from Hawkins, 1990)

The East Smithfield Black Death cemetery is located in the northern side of St Mary Graces Abbey (Fig. 2.14). East Smithfield (also called "no mans land") was one of the areas purchased in 1348 by John Corey and was consecrated by the Bishop of London to be used as an emergency burial ground for the victims of the Black Death that were exceeding in the other cemeteries. The burial ground was used only for the period from 1348 until 1350 before St Mary Graces Abbey was built. The site was then used as a storage for the Royal Navy, and later, with the subsequent building of the Royal Mint, substantial damage and truncation of the burial site occurred in the eastern part of the cemetery (Grainger *et al.*, 2008).

The Black Death arrived in Britain in 1348, probably through infected ships arriving at a borough of Weymouth, Dorset (Hawkins, 1990). The population of the city was estimated to reach between 45000 and 80000 inhabitants and between a third and a half are thought to have died during the Black Death. The cemetery was one of the two emergency burial grounds established in London to cope with the crisis. The second was located in West Smithfield, that later became the site of the London Charterhouse (Grainger *et al.*, 2008).

The excavations of the site were carried out between 1986 and 1988 by the Museum of London's department of Greater London Archaeology (DGLA), funded by City Merchant Development, as part of the Royal Mint excavation project. The excavations brought light to the fact that only a small portion of the area, which was supposed to be designated for the burial ground, was used for the inhumations. In fact, the burials occurred just in two areas: the west and the east (Fig. 2.14). The lack of burials in the central area could be explained by the fact that probably the number of fatalities did not reach the number that was expected (Hawkins, 1990).

All the burials were in supine position and following the Christian standards. In the western area, a total of 558 skeletons were exhumed, of which 300 uncovered from a mass burial. The eastern cemetery contained 192 individuals, of which 102 from a mass grave (Grainger and Phillpotts, 2011). At least 167 individuals recovered from the western area were buried within coffins, 14 in shrouds and 13 interred with deposits of ash. Furthermore, two coins were found, and this gave the possibility to give a *terminus post quem* of 1344 (Hawkins, 1990). In the eastern part of the cemetery instead, 63 individuals appeared to be buried in coffins, one with a shroud and two with deposits of ash. In addition, some of the graves appeared to be empty: it may be possible that this could be the result following the dissolution of the bones due to chemical contamination from the Royal Mint manufacturing processes (Hawkins, 1990; Gilchrist and Sloane, 2005). The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology.

## 2.2.8 St Mary Merton Priory (London)

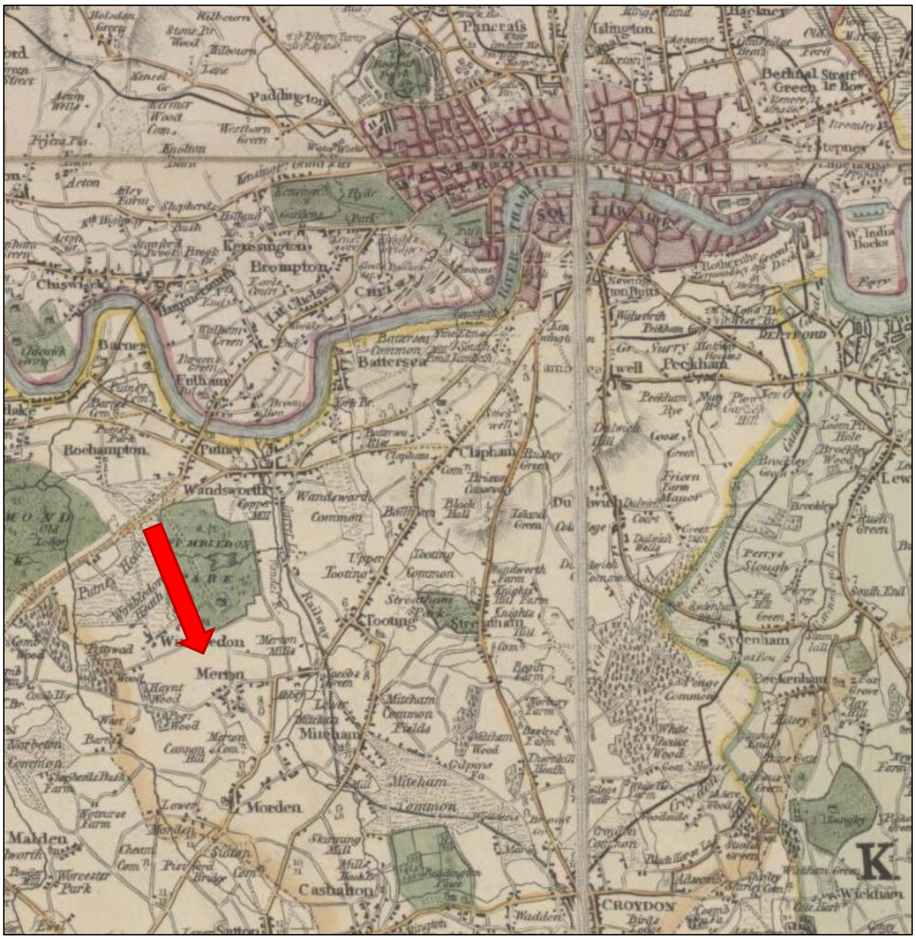

Figure 2.15: Location of Merton (adapted from Faden and Wyld, 1829)

The priory of St Mary Merton is located about nine miles in the south-west of London (Fig. 2.15). Merton is well known for two historical facts that took place in the area before the Norman Conquest: the murder of Kenulf, king of the West Saxons in 784 and a battle between Danes and Saxons in 871.

Gilbert Norman, sheriff of Surrey, in 1115 appointed the building of the first Austin convent that was initially made of wood. Robert Bayle was the first prior of the convent and, after living in Merton for two years, thought that the place would have been better for religious retirement. After this decision, the sheriff built a wooden chapel, removing part of the cloister and some of the cells. In 1130, the construction of the abbey with stone started; in the same year, the sheriff died and was buried inside the walls of the convent. The cloister and the other buildings were finally completed by 1136 (Brayley *et al*., 1850; Lysons, 1972).

During the 13$^{th}$ century, the monastery saw several historical events. In 1217, the pope's legate, Cardinal Gualo, concluded the peace between Henry III and the French prince. In 1232, an armed mob directed towards the convent to get Hubert de Burgh, the great justiciar of

England, as he refused to leave the priory after the order of the King. In 1236, the priory was used for the holding of the Parliament, which passed the Statute of Merton that is considered the first English statute, between King Henry III and the Barons of England. Furthermore, Thomas Becket, archbishop of Canterbury, was educated in the priory school (Brayley *et al*., 1850).

In the 14th century, the convent funded the royal house several times, because it was made the collection point for the royal aid levied in Surrey for its strategical position, and became a place for maintenance for several exponents of the English aristocracy. In 1538, like all the other monasteries and priories, Merton was surrendered by John Ramsey, the prior, and other 13 other people who were living in the monastery. The church was demolished and the materials used for the construction of Nonsuch Palace (Malden, 1967).

The excavations of the site were undertaken by DGLA between 1977 and 1983 and by MOLAS in 1986-1987 (Thompson, Westman and Dyson, 1998). The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology. A group of 738 burials was excavated, clustered in four main areas: the church, the cloister and the chapter house (Fig. 2.16 in blue), the north cemetery, the south cemetery and the western cemetery (Fig. 2.16 in brown).

The burial practice was varied, and all the burials followed the medieval standards. The use of wooden coffins was 18%, but 43 stone cists, three lead and four stone coffins were also recovered. Four graves had head support stones and two pillows (Gilchrist and Sloane, 2005).

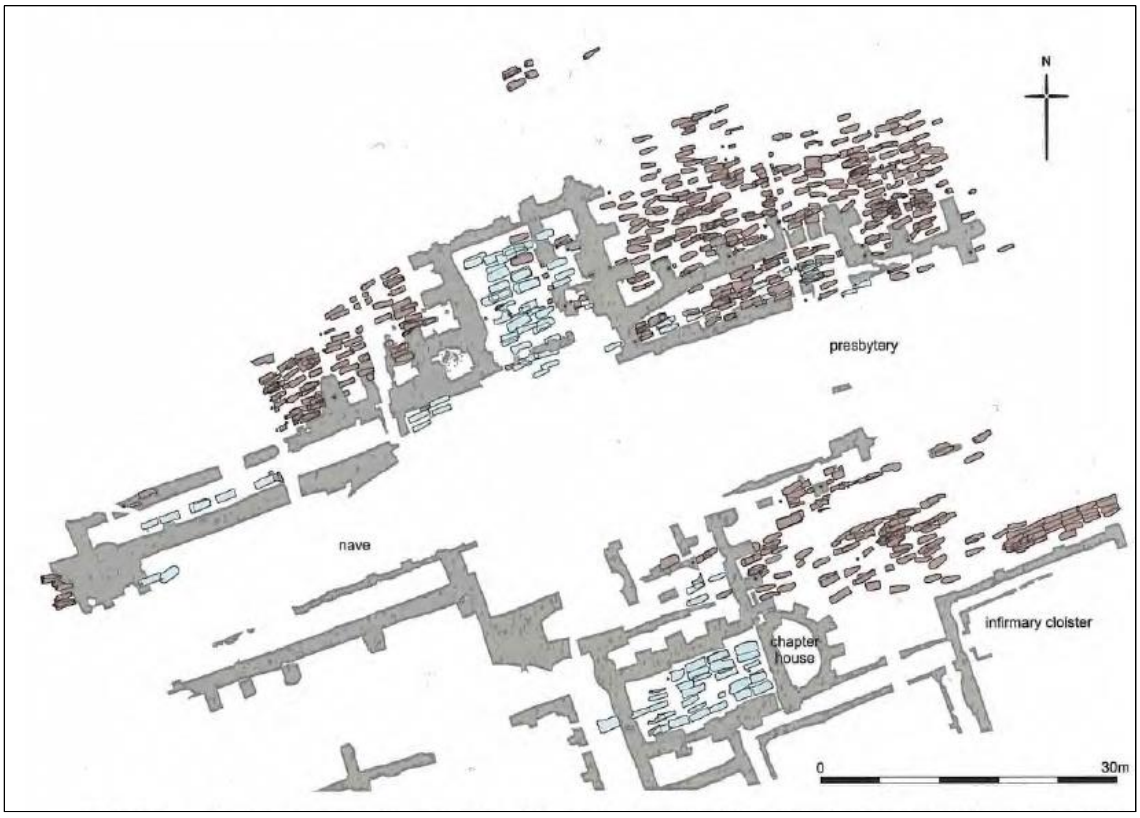


Figure 2.16: St Mary Merton burials (adapted from Gilchrist and Sloane, 2005)

## 2.2.9 St Mary Spital (London)

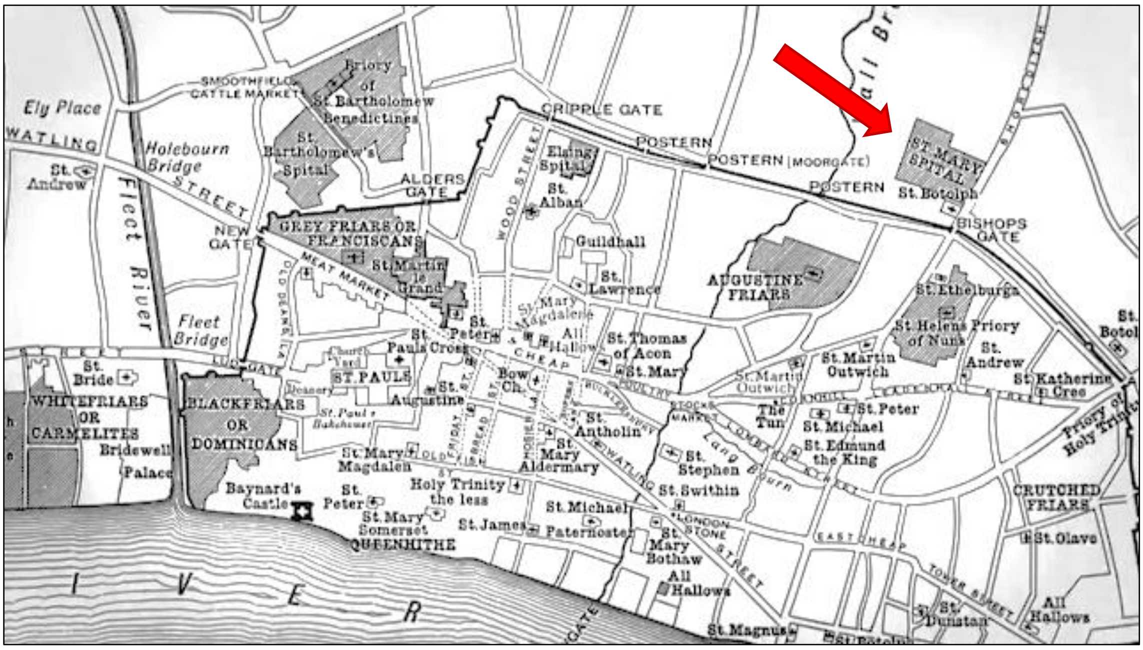


Figure 2.17: location of St Mary Spital (adapted from Green, 1884)

The Augustinian priory and hospital of St Mary Spital are located in the northern side of Folgate Street, in the northeast of London (Fig. 2.17). The cemetery seems to have been used before the founding of the hospital, and the land where it was located was situated outside Bishopsgate.

The medieval priory and the hospital were established in 1197 by a group of London merchants as a result of an increasing population and consequently a rise in need of care for the diseased (Connell *et al.*, 2012). Walter Brunus and his wife Roisia (two of the founders) confirmed the foundation of the house and in 1235 when the church was rebuilt further east (Sheppard, 1957). The house belonged to the Augustinian order, and it accommodated both canons regular and lay brothers and sisters. Until 1280, the infirmary used a different cemetery. In fact, the continued use suggests that the main cemetery was not used by the hospital, but for the burials of the canons, lay individuals, residents and benefactors (Connell et al., 2012).

In 1341, the hospital was reported to be established to receive pilgrims and the infirm until they recovered, pregnant women and children whose mothers died there during the childbirth. In the 14$^{th}$ century, the hospital also housed a few people from the aristocracy, such as the servant of Edward I's confessor, two of Edward III's yeomen and Robert de la Naperie (Sheppard, 1957). In 1391, a chapel dedicated to St Edmund and St Mary Magdalene was founded by William Evesham. The chapel was destroyed by the end of the 17$^{th}$ century, but the charnel house survived instead. This section of the building was used to store bones that had been disturbed from the cemetery, but it was cleared by the Dissolution.

At the end of the 14th century, a stone pulpit was built in the centre of the cemetery, to held sermons on Sundays and Easter Mondays, Tuesdays and Wednesdays. In this period, a part of the cemetery on the western side of the pulpit went out of use, although there is a small group of burials dated to the 15th century. In the north side of the pulpit and to the east of the chapel instead, a remarkable number of juveniles are buried, indicating that this area might have been used just for the interment of children (Connell et al., 2012). Finally, in 1538, after the Dissolution, the church was already in ruin, but the infirmary kept its use (Sheppard, 1957).

The excavation of the area has been carried out by the Museum of London Archaeology (MOLA) between 1985 and 1989. The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology. As a result of the excavation, the area reported multiple sites within the hospital cemeteries, divided into four main groups of burials, which date to four different periods based on stratigraphic interpretation: *c* 1120-1200 (Fig. 2.18), *c* 1200-1250 (Fig. 2.19), *c* 1250-1400 (Fig. 2.20), and *c* 1400-1539 (Fig. 2.21). Burials probably ended between 1485 and 1510, before the closure of the priory after the Dissolution.

The excavation produced a conspicuous quantity of individuals, which amounts at 10516 skeletons. Half of the individuals were interred in single burials and the other half in multiple graves. The multiple burials (175), with bodies buried in a number of horizontal rows on top of each other in a single grave, tend to be placed further away from the church. The maximum number of bodies found in a single grave cut was 45 individuals, which Connell *et al.* (2012) interpret as a catastrophe. The bodies in the mass graves were disposed with care and orientated roughly in the Christian standards, although some of them were orientated north-south, probably with the intent of filling in the gaps. The burial pits were found in each of the phases of the cemetery and the majority of them pre-dated the Black Death so that it is not possible assigning them to this event. Connell *et al.* (2012) provide possible explanations to these events: the cemetery run out of space due to the rise in population and a need for mass burials followed; or a rise in mortality necessitated for multiple burials. However, outbreaks of infectious diseases were not infrequent in medieval London, along with famines. The earlier excavations also revealed 16 burials inside the church, which might indicate individuals of higher status.

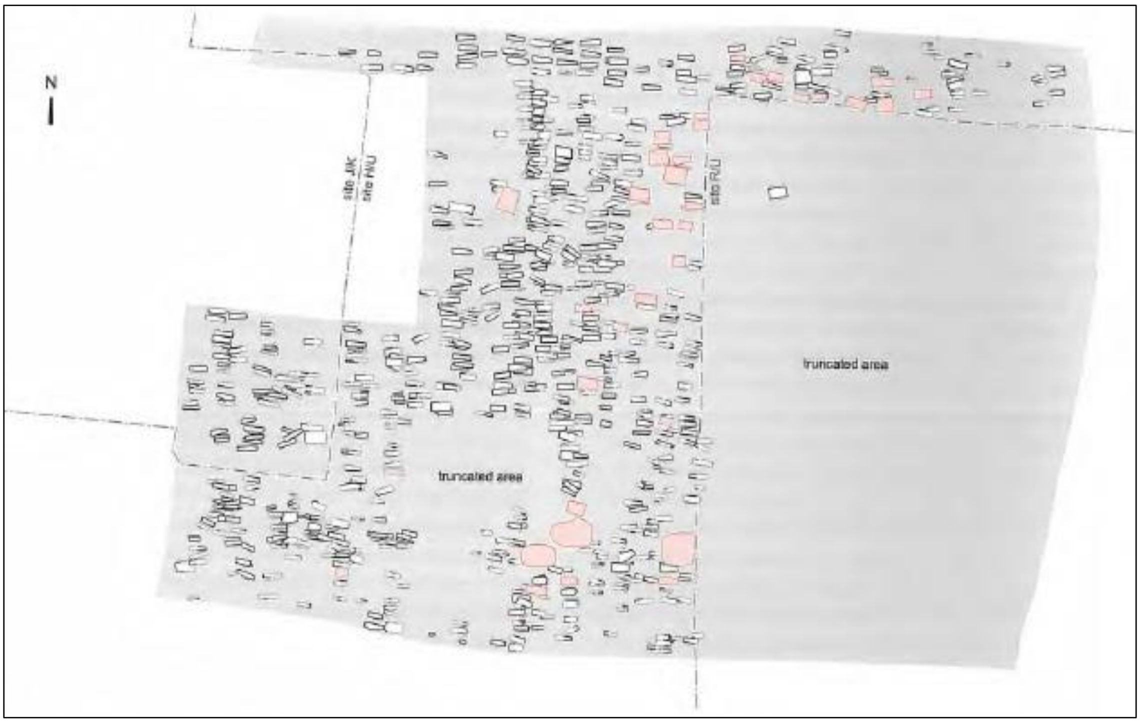


Figure 2.18: St Mary Spital burials. First period (*c* 1120-1200) (adapted from Connell *et al.* 2012)


Figure 2.19: St Mary Spital burials. Second period (*c* 1200-1250) (adapted from Connell *et al.* 2012)


Figure 2.20: St Mary Spital burials. Third period (*c* 1250-1400) (adapted from Connell *et al.* 2012)


Figure 2.21: St Mary Spital burials. Fourth period (*c* 1400-1539) (adapted from Connell *et al.* 2012)

## 2.2.10 St Nicholas Shambles, Newgate Street (London)

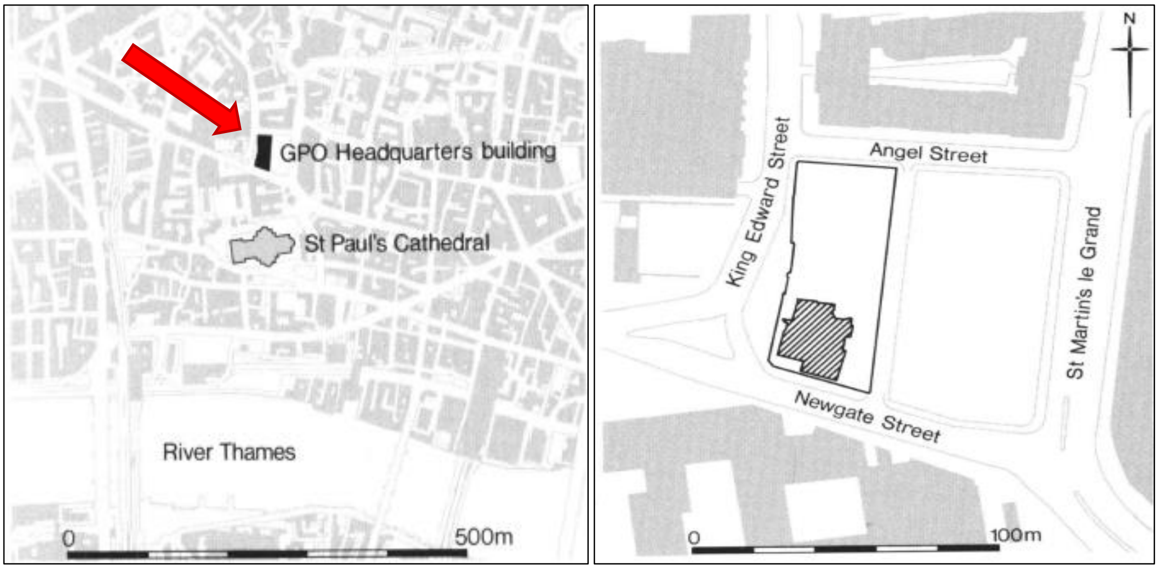


Figure 2.22: location of the site of St Nicholas Shambles (adapted from White and Dyson, 1988)

The site of the parish church of St Nicholas Shambles is located on the north side of Newgate Street in the City of London (Fig. 2.22). The church of St Nicholas Shambles is first attested in 1144, and it is also mentioned in 1187 as being located next to the meat market, from where it takes its name (Thornbury, 1878). In 1196 it was also called as St Nicholas de Westrnacekaria (Harben, 1918)

It is not known much about the history of this parish church. Everything that was written about St Nicholas Shambles comes from the records in its final years before it was demolished. The archaeological excavation brought to light a circular hut and a boundary ditch that predated the establishment of the Roman street beneath Newgate Street. Two rectangular buildings are also present that were destroyed by fire, probably Boudican. In the later Roman period, the area saw the rebuilding of commercial premises with smaller chambers that were again destroyed by fire, probably Hadrianic (Schofield and Maloney, 1998).

The church was built in an initial structure of a nave and a chancel probably in the 11$^{th}$ century and then extended in the second half of the 12$^{th}$ century. In the wills that have been registered in the City court of Hustings from 1341, can be traced that 13 people desired to be buried in St Nicholas: only one of them (Nicholas de Thame) in the burial ground and the rest inside the church (Schofield, 1997). Later in the 1540s, the parish was abolished before its incorporation within the parish of Christ Church, together with the Greyfriars and the parish of St Audoen. All of these parishes and the St Bartholomew's Hospital in 1546 were granted by the King to the Mayor and Corporation of the City to take care of the poor. In February 1548, the

City issued the order to removal of the altars and the plate of the church, which brought to the abandonment of the building and the dismantlement in May 1551. In early 1552, as the church was completely demolished, the works for the construction of the Bull Head started: 14 dwellings surrounding a central courtyard were precisely dug on the perimeter of the church, churchyard and the parsonage. This building was demolished in the 1860s for the construction of the General Post Office buildings (Schofield, 1997).

The site was excavated by the Department of Urban Archaeology of the Museum of London between 1975 and 1979. A total of 234 skeletons have been excavated, the majority of which were fairly intact, but others present truncation. A number of 189 of them had a simple burial, perhaps in a coffin; 22 cases report stone pillows; 10 graves had a floor of crushed chalk and mortar; eight skeletons were buried in cists, and one case represents a charcoal burial (White and Dyson, 1988). The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology. All the burials seem to be supine following the Christian standards. The cemetery was situated in the area at the north of the church and east of the patronage (Schofield, 1997) (Fig. 2.23). As reported by White and Dyson (1988), the burials that have been excavated might relate to the early stages of the church, which span from the 11th to the 12th centuries.


Figure 2.23: plan showing the burials associated with St Nicholas Shambles church (adapted from White and Dyson, 1988)

## 2.2.11 Guildhall Yard (London)

Figure 2.24: plan showing the location of the Guildhall in the city of London (adapted from Ordnance Survey 1898. Reproduced with the permission of the National Library of Scotland)

The London Guildhall Yard site is located within the medieval walls of the city of London, on the northern side of Gresham Street (Fig. 2.24). The site of the Guildhall was previously occupied by a Roman amphitheatre that was abandoned at the end of 4th century. Some of the walls were dismantled for the reuse of the building materials for the city walls bastions or the riverside walls (Bowsher *et al.*, 2007). Later, by the 9th century, the Saxon occupation was situated in two main areas: one located outside to the west of the Roman walls in the mercantile settlement of Lundenwic and the second was an ecclesiastical and administrative centre inside the city walls (Malcolm, Bowsher and Cowie, 2003). The archaeological research suggests that the Saxon settlement reached the excavated area, with evidence of a sunken-floored building, finds of pottery, plants and animal bones indicating a domestic type of occupation.

The Norman Conquest seems not to have affected the structure of the city immediately, but later in the 11th and 12th centuries, several parish churches were built, together with a more developed settlement outline. This growth also brought to a change in the Guildhall area. The site of the Guildhall also comprised a church: St Lawrence Jewry. The church took its name “Jewry” for its proximity to the Jewish quarter called “Old Jewry”. The building of the original pre-Conquest church was made of timber and was located in the north of the settlement, probably used as a private chapel. Like many other parish churches, St Lawrence had an annexed churchyard, established in the 11th century.

The archaeological excavation unearthed for the end of the 11th century a temporary wattle structure from the cemetery, probably suggesting that the timber building was demolished to be rebuilt in stone as a parish church. In this period, the north-east corner of the churchyard contained two burial areas enclosed by two wattle fences that disappeared in the early 12th century. In the northern section, six burials were excavated, while in the southern section 12 burials were unearthed. Additionally, three later burials were recovered in the northern side of the cemetery. Clearly, these individuals date to the beginning of the 12th century, as in the early phase of the cemetery, this area was not used as a graveyard. The theory is also confirmed by the dendrochronological analysis (Bowsher *et al.*, 2007).

The church is first mentioned in documents dating to 1197, but it is suggested that William I granted it to the abbey of St Salvius at Montreuil (France). In the 13th century the church was granted to William Facet, canon of St Paul's, and at the end of the century sold to Hugh de Wichambrok, canon of St Martin le Grand. At the end of the 12th century and the beginning of the 13th, the cemetery continued to be used after about 70 years, and in the southern part, it is noticeable an intercutting, suggesting pressure on space, probably due to the growth of the population. For this period, 50 burials were excavated. The Guildhall instead was probably first built in the 1120s, representing the royal power and authority. In fact, the building hosted the headquarters for the collection of the tax, the Court of Husting and the meeting place for the aldermen. Also, the area showed for this period an urban growth with evidence of higher standards of living reflected in the type of pottery recovered in the residential buildings.

As stated above, in the 13th century the population of the City was in constant growth, and this is reflected as well in the archaeological evidence. The area surrounding the Guildhall had particular importance, as people part of the political life of the City were living here. John Fitz Geoffrey, a baron who challenged Henry III in the 1250s together with Simon de Montford, acquired the hall on Basinghall Street, enlarging the structure and building a chapel. Stephen Bukerel, one of Montford's military commanders, was living on Aldermanbury instead. On the southern side, all the buildings continued to be occupied by Jewish families, which had close relationships with the king as his supporters. To the north of the Jewish quarter instead, the expansion of building continued with a denser occupation, but probably of lower social status, as it was occupied by families of artisans. By the 13th century, St Lawrence Jewry was a well-established parish church (Bowsher *et al.*, 2007). For this period, two burials were excavated and were located under the line of the later gatehouse, which provides a *terminus ante quem* of 1303.

The tensions between the Crown and the City continued until the reign of Edward III when he rewarded London for the support provided. The improvement is also marked in the archaeological evidence, as the Guildhall shows a series of construction programmes that led to an enlargement. Similarly, the religious buildings show an expansion: St Lawrence Jewry in 1294 was acquired by Balliol College (Oxford), with the addition of the new Lady chapel, and St Michael Bassishaw church in the north saw the construction of a new aisle. As in the previous century, the population density saw an increase and several mercer shops appeared in the area, especially in the south of Aldermanbury and in the north of Basinghall Street. There is no evidence of the use of the cemetery for the period that comprises the end of the 13$^{th}$ and mid-14$^{th}$ century. The archaeological and historical evidence also suggests that two shops were built in 1333 in the northern corner of the churchyard and it may be possible that the burial practice was carried out in the southern corner, which has not been part of the archaeological investigation (Bowsher *et al.*, 2007).

Between 1358 and 1350 the Black Death spread in the City and across the country, killing thousands of people. However, the two parishes of this area do not show in the archaeological record any evidence of the pestilence, as the cemetery connected to St Lawrence Jewry did not expand or show an increase in burials. In this period the mayor, Adam Fraunceys, established the Guildhall College, consisting of a chapel, an accommodation block, a garden and a separate gatehouse. St Lawrence Jewry also saw an increase with the building of a tower at the church's west end and a newly enlarged vicarage in the late 14$^{th}$ century. The economic growth of the City also led to the growth of the markets that were more open to the exports of foreign cloth through London. An example of this is the market of Woolwharf (Bowsher *et al.*, 2007).

After the Black Death, a complete redesign of the Guildhall and the precinct took place, as the Crown was investing many resources in this wealthy area. In fact, the redevelopment project comprised the construction of a new Guildhall, a new chapel, more civil court buildings in the north and a gatehouse. Both the churches were also enlarged in the 15$^{th}$ century, and the flow in the residential area of wealthy people continued through time. The eastern side of the cemetery was re-established in the 15$^{th}$ and 16$^{th}$ centuries, but the burials were damaged during the removal of the soil with mechanical excavators (Bowsher et al., 2007).

The excavation of the site was carried out by the Museum of London Archaeological Service (MOLAS) between 1992 and 1997. A total of 68 individuals were excavated, and all seem to follow the Christian standards, with a supine deposition and aligned east-west. The remains are currently stored in the Centre for Human Bioarchaeology at the Museum of London Archaeology.

## 2.2.12 St Gregory's Priory, Northgate, Canterbury (Kent)

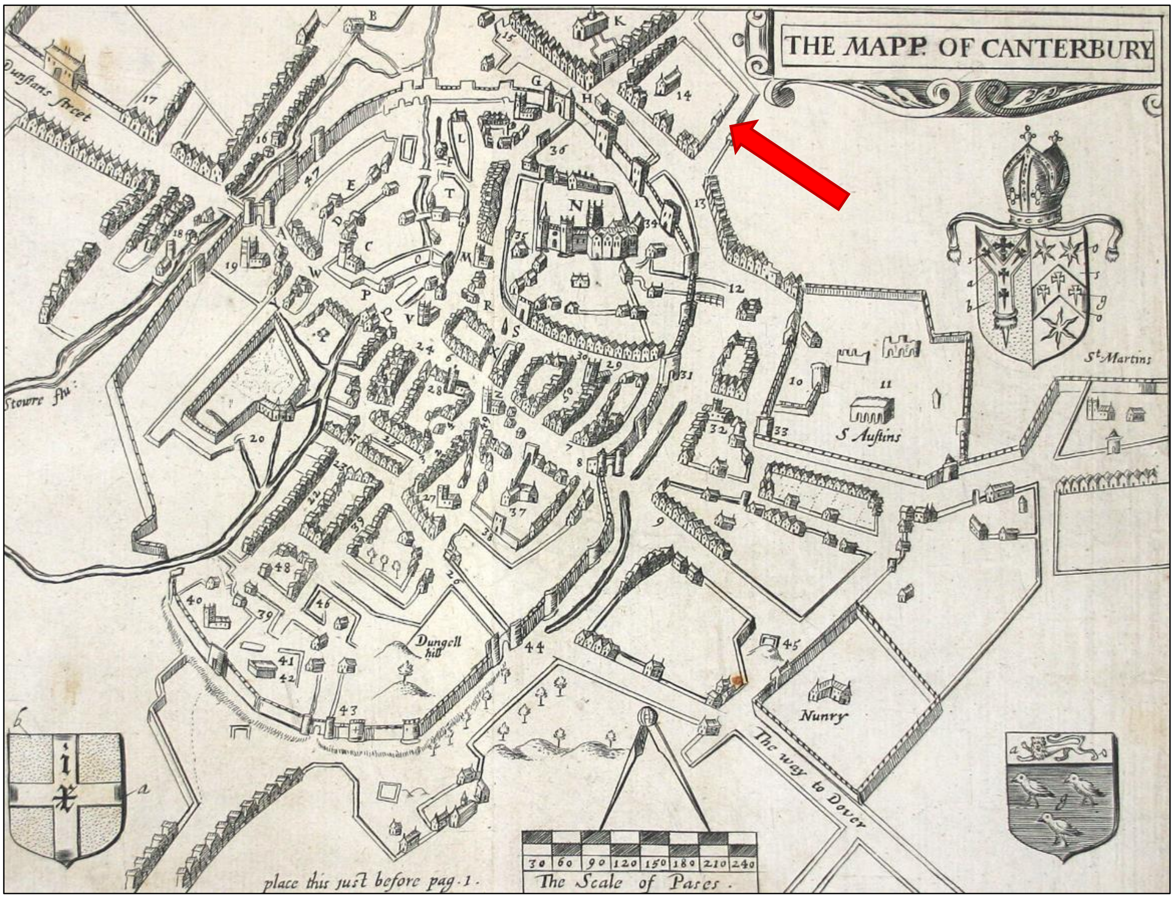


Figure 2.25: location of St Gregory's Priory (adapted from Somner, 1703)

The site of St Gregory priory is located 300 m north of the Canterbury Cathedral, just outside the medieval city walls (Fig. 2.25). The occupation of the city of Canterbury dates to the Roman period. In fact, Northgate road was the primary way into the city, and Roman activity has been uncovered in the area. Clay quarries, rubbish pits and a possible ditch were identified, but no structural remains were excavated, and it is impossible to say whether the site was of an actual occupation nature (Hicks and Hicks, 2001). The city of Canterbury, called *Durovernum* in the Roman period, is mentioned by Antoninus as a Roman station situated on one of the main military roads. The city of *Durovernum* is also cited on Peutinger's table (Hasted, 1800).

The first evidence of occupation dates to the Anglo-Saxon period. Rubbish pits, timber-lined wells, gullies and ditches suggest the presence of property boundaries, which are dated between 450 CE and 1050 CE due to the pottery that has been recovered (Hicks and Hicks, 2001). Historical records report the closing of a charter by Kenulph, king of Mercia, in the city in 810. Furthermore, the city was the residence of King Ethelbert, until 596, when he moved to Reculver. Because the city was situated not far from the two islands of Thanet and Shepey, it has been subjected to several raids from the Danes. In fact, in 851, 1009 and 1011 they landed with a great army and sacked it, burning the city and decimating the population in their last raid (Hasted, 1800).

The foundation of the house is attributed to Lanfranc, archbishop of Canterbury, in 1084. There are several versions of the foundation of the site, but the most probable seems that Lanfranc placed there secular canons that were later replaced by regular canons by William, the archbishop in the 12$^{th}$ century. The possession of the clerks of St Gregory is also mentioned in the Domesday Survey (Page, 1926). Lanfranc, Norman and Abbot of Caen, was appointed archbishop by William of Normandy. He undertook several programs of rebuilding, such as Christ Church Priory and St Augustine's Abbey. He also founded several minor institutions, such as St Gregory, the leper hospital of Harbledown and the nunnery of St Sepulchre.

St Gregory was built as a sister establishment to the hospital of St John and was formed by a community of six priests and 12 clerks. The church initially comprised a long nave and a square chancel to the east. The burial ground was instead located in the south of the church (Hicks and Hicks, 2001). Certain religious houses, as in this case, had links also with other institutions. In fact, the church was sharing the cemetery with St John's hospital, as this did not have one (Gilchrist and Sloane, 2005).

In 1133 St Gregory became a priory thanks to William of Corbeil, who installed Augustinian canons from Merton Priory. The arrival of the new canons required some building work and a new choir was erected on the eastern end of the chancel. Transepts were also built in the northern and southern sides of the nave, each ending into two chapels. The new areas were suitable to house a coffin or reliquary (St Eadburgh and St Mildred), which St Gregory claimed to own (Hicks and Hicks, 2001). Furthermore, the prior was involved in administration and legal affairs by the archbishops, and the church was often used as a court for legal disputes (Sparks, 2001).

In 1145 historical records report that the priory was burnt, causing significant damage, and it can be identified from the archaeological evidence. For this reason, the building was reconstructed under the patronage of the archbishop Theobald. The church was the first building to be rebuilt. While the building of the new church was in progress, the surviving areas were being used, but it is known that the second building was ready by 1181. The building of the church was followed by the construction of the eastern side, consisting of a chapter house, a dormitory, an infirmary courtyard and a passage (everything in use by 1225) (Hicks and Hicks, 2001). As the priory was also used for legal affairs, in 1293 it was chosen as the place where the chancellor of England would have lodged if he was in Canterbury and 1329 the Great Seal was used by the temporary Seal Keeper Henry Cliff at St Gregory (Page, 1926; Sparks, 2001).

As many other priories, St Gregory gave hospitality to many people (for example William de Brickhill, sent by the king in 1309), who most probably lodged in the infirmary cloister area or in the infirmary itself. Finally, in January 1535 the last prior, John Symkins and six canons accepted the royal supremacy and the priory was accordingly dissolved (Sparks, 2001).

The excavation in St Gregory's priory was carried out between 1988 and 1991 by the Canterbury Archaeological Trust. The first archaeological examination of the site was carried out at the beginning of 1988, for which trial trenches uncovered remains of the priory. This excavation revealed evidence of truncation and disturbance of the archaeological levels following the foundation of the Post Office in the 1950s. In June 1988, the proper archaeological excavation started and continued until April 1991 (Hicks and Hicks, 2001).

A total of 1342 articulated burials were excavated from the cemetery, church and later priory, of which 91 were recovered from inside and around the priory (Mahoney et al., 2016). Out of these burials, 45 were located within the church structures, and the remaining ones were mainly excavated from the west side of the new church built in 1181. All the articulated skeletons were supine and extended. The majority of the burials were not placed in a coffin: only three males reported the presence of a wooden coffin. Two adult males were buried in the chapter house, and a third young adult was buried in the middle of the later church nave. Seven graves were stone-lined: two senescent males and a female all placed outside the west side of the church. Three further adult males were buried in the extreme west part of the cemetery in stone settings. Only two graves showed a multiple burial: one outside the west side of the church contained two infants and another within the nave contained an adult female and an adult male (Anderson and Andrews, 2001). The remains recovered from St Gregory's Priory are currently stored at the School of Anthropology and Conservation at the University of Kent, Canterbury.

# 2.2.13 St Leonard's Church, Hythe (Kent)

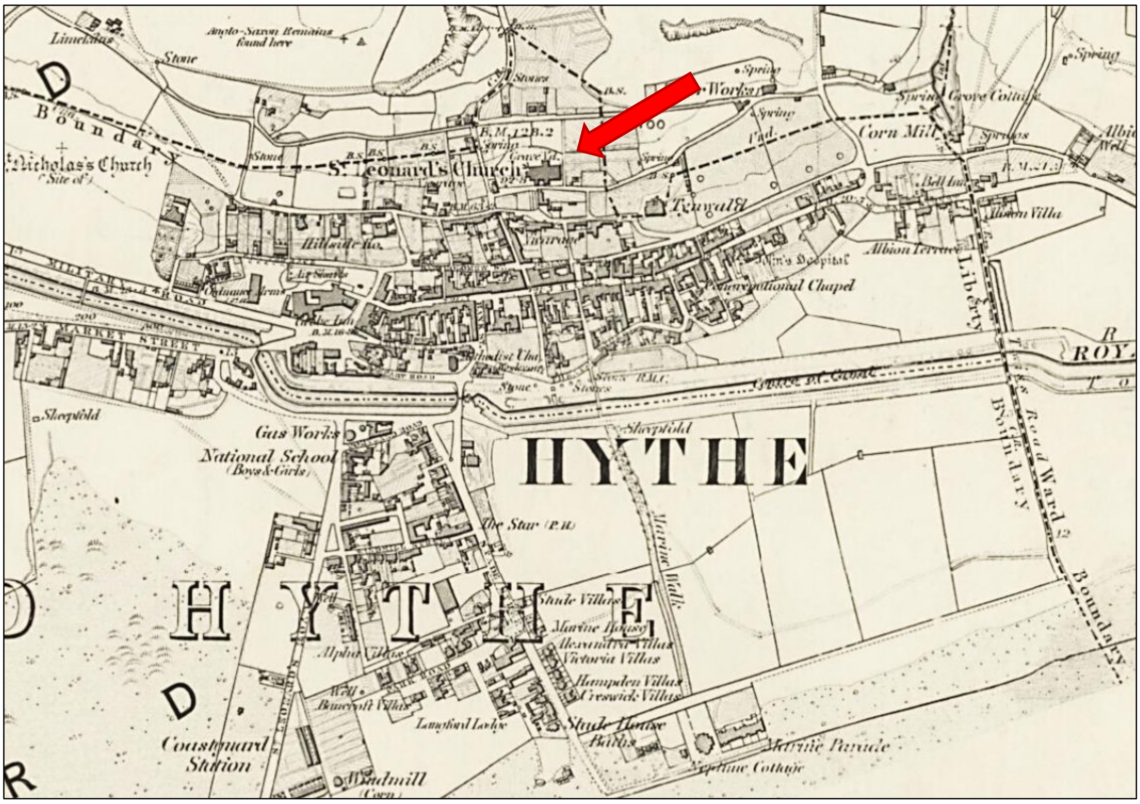


Figure 2.26: location of St Leonard's Church in Hythe (adapted from Ordnance Survey 1877. Reproduced with the permission of the National Library of Scotland)

St Leonard's Church is located in the northern side of the town of Hythe, Kent (Fig. 2.26). The collection of human remains at St Leonard's church is one of the largest in Great Britain: almost 1500 skulls are present (Stoessinger and Morant, 1932).

Historically, the area has been noted from the Roman times when the Roman militia constructed a heavily defended building to ward off sea-borne Saxon Raiders. This particular building was later given a Saxon name: Stutfall Castle. Stoessinger and Morant (1932) agree to assign the name *Portus Lemanis* mentioned in the Antonine Itinerary and by the Anonymous Geographer of Ravenna to the town of Hythe or the Stutfall Castle. The castle was excavated in the late 19$^{th}$ century, and it was probably one of the last Roman stations built along the south coast.

It is reported by several historians that the area between Hythe and Folkestone witnessed a battle between the Saxons and the Britons, which saw a remarkable number of casualties. The remains in St Leonard's church are, in fact, told to be the ones from this conflict, but there are not enough evidences to prove the theory (Stoessinger and Morant, 1932).

According to Hasted (1799), the manor of Hythe was given by Halden, a Saxon thane, to the Priory of Christ Church (Canterbury) in 1036. The town is also mentioned in the Anglo-Saxon Chronicle, with the revolt of Earl Godwin in 1052, and in Domesday Book in 1088. Anglo-Saxon evidence have also been found in the area surrounding Hythe in the 19th century and it is clear that the town was an important port already before the Norman Conquest. This evidence is proved by the fact that Hythe was part of the Cinque Ports, together with Sandwich, Dover, Romney and Hastings, and amongst the most flourishing and populated English towns. For this reason, Hythe and all the other towns had to provide ships and men for the king, in return for immunities and privileges that they enjoyed for few years (Hasted, 1799; Stoessinger and Morant, 1932).

According to the tradition, Hythe saw several French incursions, as the town did not have walls and therefore was an easy target. However, there seems to be only one occasion that is historically recorded for 1295. One of the first mentions of the human remains in St Leonard's Church states that these were from French people who died on the coast nearby Hythe.

The beginning of the 14th century saw Hythe's, like many other coastal towns, disbandment. The harbour started filling up with deposits that were brought by the sea and the once flourishing ports lost their purposes. Stoessinger and Morant (1932) report that a historical document from 1422 states that in the town there were many Frenchmen. Similarly, earlier documents reveal that during the reign of Edward III many foreigners lived in Kent, especially Flemish and of Walloon origin.

St Leonard's Church was founded in the early Norman period and was expanded in the late Norman period and later in the 13th century. The ambulatory where the human remains are stored is located below the ground level on the north side of the church. Parsons (1908) and Stoessinger and Morant (1932) propose the hypothesis that the collection originated when the church was expanded, covering part of the original cemetery. In fact, during the 150 years after the foundation of the church and the later centuries, a remarkable number of skeletons have been uncovered. However, the theory made by Canon Scott Robertson (1899) that the remains were placed in the ambulatory after the Reformation, cannot be excluded, even if it seems unlikely. The most likely dating of the collection must be set starting from the early 13th century, when the ambulatory was built, until the Dissolution in the 16th century.

The human remains found in St Leonard's Church are all disarticulated and the skulls are stored inside the ambulatory (Fig. 2.27). As these are not the result of an archaeological excavation, there is no information about the location in the cemetery and the positioning of the skeletons.

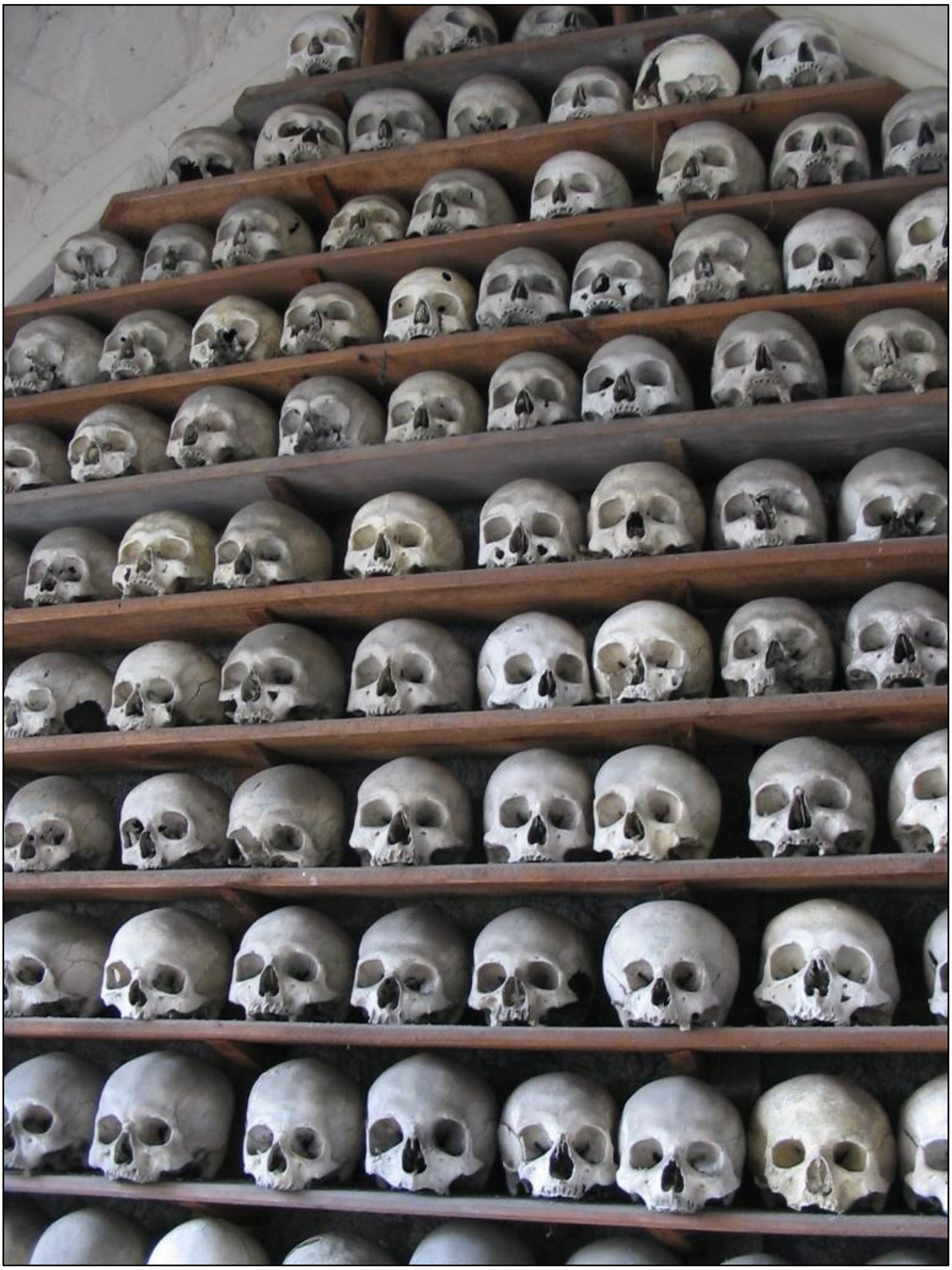

Figure 2.27: some of the Hythe skulls stored in St Leonard’s Church ambulatory (St Leonard's church ossuary, Hythe – skulls, n.d.)

## 2.2.14 Castle Hill, Scarborough (Yorkshire)

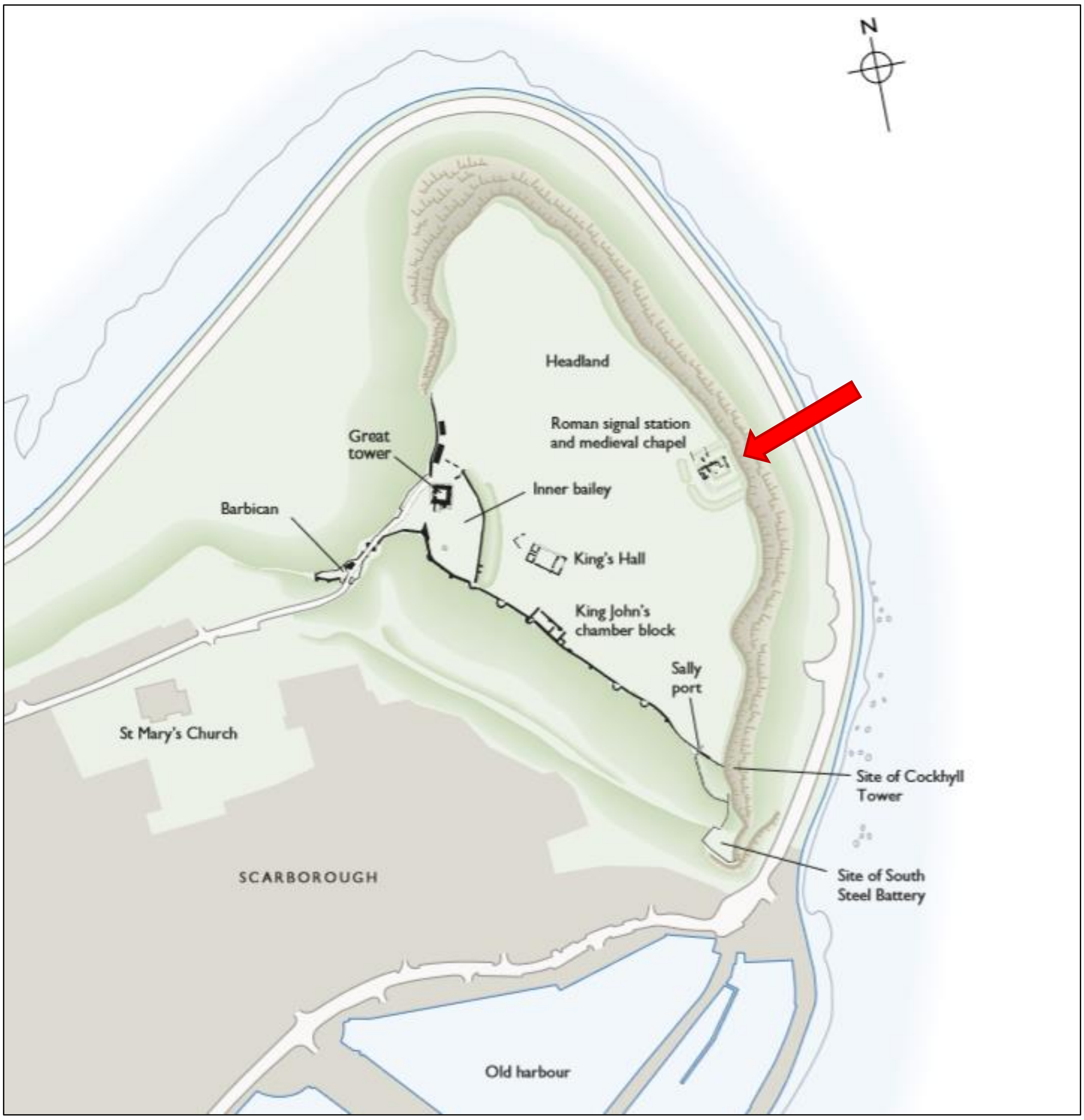


Figure 2.28: map of Scarborough and location of the medieval chapel within the castle (adapted from English Heritage, 2015)

Scarborough is a town on the coast of North Yorkshire, located on a headland that extends in the Northern Sea (Fig. 2.28). The history of the city dates back to the Bronze and Early Iron Ages, as archaeological remains have been found here. There is also evidence of Roman occupation, as the excavations in Castle Hill uncovered a signal station, probably built at the time of the general Theodosius against the raids of the Saxons (Little, 1943).

A manuscript from the 13th century reports that three centuries before, a group of Danes headed by Knut and Harold, defeated Adalbricht, son of Adalmund, at *Skardaborg* and from there marched towards York. Later in 1066, Harold Hadraara, together with Earl Tosti, lord of

Falsgrave, seized and set fire to the castle. In fact, the town is not mentioned in the Domesday Survey (Page, 1923).

The building of the first castle started during the 12th century by William 'le Gros' of Albemarle and consisted of a tower overlooking the entrance and a wall surrounding the perimeter of the headland. The second phase of the castle was then built by Henry II who took the site from William in 1154 and established a town immediately to the west of the castle hill. The castle remained in royal hands for the whole duration of the middle ages, but it suffered two attacks during the English Civil War that left it in ruins (Pearson, 1999).

Initially the owner of the chapel was the holder of the castle, but later on, it was given by Richard I to the abbot and convent of Citeaux. The transfer resulted in the establishment of a small community of Cistercian monks. The link with the convent of Citeaux lasted until 1400 when the chapel was transferred to the prior of Bridlington. The building was used as a chapel until 1538, when it was converted to domestic use (Little, 1943).

In 1225 the town obtained a grant from the King's wood and the right for three years to put tolls on the ships that were arriving in the town. All of these events contributed to the growth of the town and between the 13th century and the 14th century, a set of walls were built for protection. Page (1923) reports that the town was later affected in the 14th century by several conflicts that took place in Scarborough. In fact, the sailors were imprisoned and the goods seized by the pirates from Scotland, Flanders, Zealand and Normandy that invaded the coast. There are also historical records for the constant arrival of Spanish and French ships in the port: this led to a continuous attack from foreign fleets and an impoverishment of the town.

The first recorded archaeological excavation took place in 1888 when the foundations of a medieval hall dating to the 13th century were discovered during the levelling operations of the War Office. At the beginning of the 20th century, more clearance work was carried out on the site, but no structure was brought to light, except for some smaller findings. A more extensive excavation of the Castle, and in particular of the chapel, was carried out between the years 1921 and 1925 under the supervision of F. G. Simpson. The excavation brought to light the Roman signal station, consisting of a central tower surrounded by a curtain wall. The excavation also revealed that the signal station was occupied later by the chapel and a burial ground, from which over 400 burials were recovered. It is likely that the interment ended in the 16th century when the chapel was converted to domestic use. The report of the excavation has never been fully published, and it is not possible to gain more information about the burial ground (Pearson, 1999).

## 2.2.15 Guisborough Priory (Yorkshire)


Figure 2.29: location of Guisborough Priory (adapted from Ordnance Survey 1856. Reproduced with the permission of the National Library of Scotland)

Guisborough priory is an Augustinian priory in Guisborough, located in the borough of Redcar and Cleveland, in North Yorkshire (Fig. 2.29). The excavations carried out in 1985 on the location of the priory brought to life evidence of pre-monastic activity on the site. Post holes, a small quantity of pottery and a sceat dating to 737-758 (Saxon period) were discovered, probably delineating a fence that was part of a building on the peripheral area of a settlement. This phase is then followed by an episode of agricultural activity (Heslop, 1995).

The earliest mention of Guisborough is made by Symeon of Durham shortly before 1066: he states that Copsi, who ruled in the County of York under Earl Tosti, gave some lands, including *Gisburham*, to the Church of St Cuthbert. The place is also mentioned in the Domesday Survey as *Ghigesburg*, being in the hands of the King and held by Ulchel. The land was part of the Conqueror's half-brother, Robert Earl of Mortain, possessions. By the time that Guisborough was mentioned in the Book, the manor was suffering for the effects due to the Conquest and lost half of its monetary value (Brown, 1889).

Guisborough Priory was among the first 20 houses of regular canons in Great Britain and one of the first in northern England (Heslop, 1995). The foundation of the priory dates to 1119, when Robert de Brus of Skelton dedicated the church to St Mary "*ex consensus et confirmatione Calixti papæ, et Thurstini Eborum archiepiscopi, et etiam ipsius regis Henrici*" (Brown, 1989: vii). In 1129, the foundation was confirmed with further donations. When Robert de Brus donated Guisborough to the canons, he ensured them the dominance of the area, as it was the only house in the proximity. He also comprised the whole town and part of the land and woods in the vicinity, together with the mills, ten churches and the whole Kirleatham and Coatham. Furthermore, the canons received the permission to use Robert's lands for the building material that they needed from his forest of Eskdale (Brown, 1889).

During the last years of the 12th century, the possessions of the priory continued to grow thanks to the gifts from different wealthy men, adding more lands and churches to the properties. After the death of Robert de Brus, the convent passed in the hands of his son Adam I in 1142, and to Adam II in 1143. The last one had a dispute with the convent over the advowson of the churches of Kirklevington and Skelton, but the church was confirmed to the monks by Roger de Pont L'Eveque. In 1263 King Henry III grants to the priory a three-day market and fair in Guisborough to celebrate the feast of the Assumption, which helped to support the convent. The priory stayed then under the Brus family until the end of the 13th century, when it passed in the hands of Walter de Fauconberg, by his wife Agnes, and to the Marmaduke de Tweng, by his wife, Lucy.

In 1289 the convent was destroyed by a fire and, in order to receive funds for the reconstruction of the church, the priory was permitted to appropriate several churches. The disaster was followed by repeated rides of the Scotts in the north of England, which reduced the value of the lands and slowed down the reconstruction of the church. For this reason, at the beginning of the 14th century, the priory was exempted from the clerical tenth to invest in the rebuilding of the church.

By 1380, the priory could count only 25 canons and two lay brothers and in the following year, William le Latimer orders the completion of the vaulting of the aisle in the northern part of the church (Harrison and Heslop, 1999). Guisborough Priory, differently from other medieval priories, did not play a great role in the political affairs of the time but retained its dominion just in the Cleveland area. Finally, the priory was formally dissolved in 1540 and was one of the last to surrender to the King in England. Henry VIII in this year gave the order to demolish the priory and the building materials to be reused in the construction of other buildings. The priory was then given in the hands of the Chaloner family since 1550, and in 1932 the Office of Works assumed the Guardianship of the ruins of the church.

Between 1947 and 1954, the Ministry of Works exposed the west range, outer parlour, part of the north cloister wall and a paved floor in the west end. The excavations carried out later in 1985 and 1986 allowed to distinguish six phases: phase I and II predated the monastery, phase III represented the early building of the priory (12$^{th}$ century), phases IV and VI for the rebuilding of the priory, that were separated by phase V consisting in the interruption of the liturgical use of the nave.

During the excavation of phase III, five burials were recovered in the north-west corner of the site. In fact, Heslop (1995) states that they may predate the foundation of the priory or they might be contemporary. Other three inhumations were excavated from against the northern wall, but the author thinks that it is not possible to establish whether they date to the earlier church or the later Norman priory. Nine graves were also located in the 13$^{th}$ century southern aisle, beneath the foundation rubble levelling. A further three burials were excavated from against the northern wall and, together with the above mentioned, they were all aligned with the priory walls.

The excavation of the site brought to light a total of 53 burials. As a consequence of the lack of space inside of the priory, some of the graves cut other earlier ones, and some of the skeletons are incomplete (31 undisturbed). Primary depositions and secondary burials consisting in the deposit of disturbed bones (in the backfill of later burials and piles of human remains) are also represented (Heslop, 1995).

## 2.2.16 Ballumbie, Dundee (Scotland)


Figure 2.30: location of Ballumbie (Adapted from Edward, 1616-1696. Reproduced with the permission of the National Library of Scotland)

Ballumbie is located in Eastern Scotland in the area of Angus, also known as Forfarshire (Fig. 2.30). The site was a rural area situated four miles north of Dundee, one of the central boroughs of Scotland. The historical documentation on the site is not conspicuous, and the location of the church was not known until the excavation undertaken in 2005.

Ballumbie is first mentioned in 1470, when it became a parish church, as part of the parish of Lundie, in the diocese of St. Andrews (Cowan, 1967). Furthermore, in the mid-16th century, Ballumbie seems to acquire the status of a separate parish and terminates its role after the Reformation. Warden (1882) reports that the parish of Ballumbie is not mentioned in the Old Taxation or any other register. For this reason, he did not know when the church was erected into a church and parish. The author also states that there is the possibility that the parish was suppressed and annexed to Morehouse soon after 1574. However, Ballumbie appears in a map dated between 1616 and 1696 composed by Robert Edward (Fig. 2.30).

The Lovels, an eminent family, were living in Ballumbie. It seems that they were of Norman origin and moved to the area from Hawick at the end of the 12th and early 13th centuries. The Lovel family also built a castle around 1545 and later converted it into a mansion. Nowadays it is still visible, but unfortunately in ruins (Warden, 1882; Hall, 2007). Warden (1882) reports that the lintel of the church that the owner of the time located there is visible on the top of the east wall.

The excavation of the church and churchyard of Ballumbie was carried out by SUAT (Scottish Urban Archaeological Trust) in 2005. The church presented a simple rectangular plan with a Laird's Aisle associated in its southern part (Fig. 2.31). Underneath the church, a previously unknown long cist cemetery enclosed within a ditch was discovered (Hall and Cachart, 2005). A total of 197 articulated individuals were excavated, of which 103 were recovered from the cemetery, 52 inside the church, seven from the aisle, 18 within the long cist cemetery, seven predating the cemetery but not buried in cists and 10 for which no burial location is provided (Willows, 2016). The collection is currently stored at the Osteology Laboratory in the School of History, Classics and Archaeology at the University of Edinburgh.

All the burials seem to follow the Christian standards, apart from Sk 501 that faces east (Fig. 2.31 marked with a red circle). Regarding the burials recovered in the Aisle, Hall (2007) suggests that they might belong to the Lovel family. The cemetery seems to be used in two distinct phases: the early Christian phase and the later phase. The early Christian phase is represented by a number of cists burials, which produced a calibrated $^{14}$C date of AD 560-660 and is the earliest date for the site (Cachart and Hall, 2014). The most recent carbon date is from inside the church and produced a date between AD 1450 and 1640 (Willows, 2016).

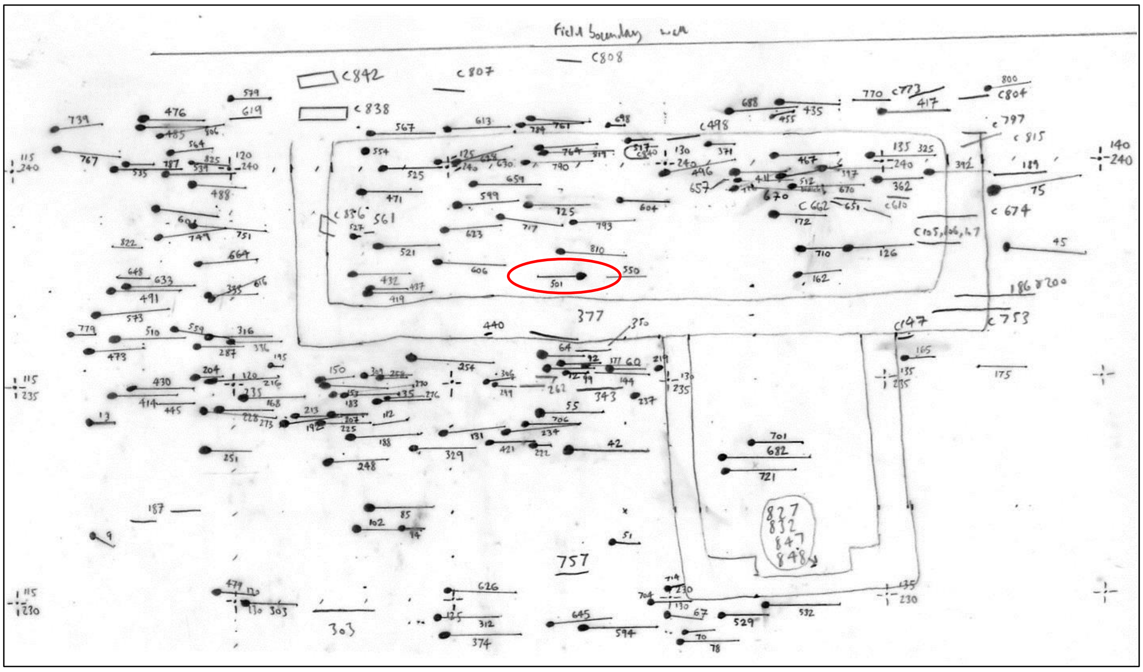


Figure 2.31: location of the burials in the site of Ballumbie (adapted from Willows, 2016)

## 2.3 Literature review

There has been a remarkable lack of recent published craniometric research in Britain, with Mays (1997; 2010) reporting a proliferation of studies on for example disease and paleodiet. In the United States and Japan, variability and population studies using craniometrics data are still prevalent (83% and 63% respectively). The reason for this scarcity is due to the reported misuse of craniometric data (e.g. eugenics) between the 19th and the early 20th centuries. In fact, at the beginning of the 20th century, craniometric data was prevailing in anthropological research, while by the 1950s paleopathology took over this discipline (Brothwell, 2014).

Samuel George Morton was one of the first intellectuals (after Camper, 1791 and Cuvier, 1802) who based his research on craniometrics in order to distinguish between "human races". His theory was based on the idea that cranial capacity can affect the growth of the brain and consequently the behaviour: he was convinced that differences in cranial capacity reflected innate mental ability (Morton, 1849). In other words, intelligence was considered precisely as a capacity of civilization (Perrin and Anderson, 2013). As also confirmed by Gould (1978: 503), "their research display an enormous excess of speculation based on a paucity of information". In fact, the author reanalysed Morton's collection. He concluded that Morton chose to include or exclude large subsamples with the aim to match means with a priori expectation, including the Peruvian sample to reduce the Indian mean and excluding Hindus to raise the Caucasian mean. More researchers of the time followed Morton's example and theory, such as Earnest Hooton and Aleš Hrdlička who took part to the "Committee on the Negro", a national council designed to study the anatomy of the African-American populations. Fortunately this concept has been passed and nowadays the scientific community does not accept this theory anymore.

One of the most important studies for this topic has been performed by Franz Boas (1912), who focused his research on immigrant children in the United States. He concluded that the cranial vault is highly plastic and therefore responds quickly to the environmental stimuli.

At the beginning of the 20th century, Fisher published his *"the Coefficient of Racial Likeness" and the Future of Craniometry* (1936a). The author, who was part of the Eugenics Society (UK), tried to apply the statistical method to distinguish different "races" using cranial measurements. As he states, the coefficient of likeness is not able to discriminate between samples, but contrarily it detects the likeness between the samples. On the other hand, he underlined the importance of the cranium in the study of human variability.

A pioneer of craniometric study finalised to population analyses has been W.W. Howells. On a study regarding 100 male skulls from the collection of Hythe, he determined, out of 54 measurements, which ones are the most significant and independent variates (Howells, 1957). In his *Cranial Variation in Man. A Study of Multivariate Analysis of Patterns of Difference Among Recent Human Population* (1973), Howells analysed the craniometric data from 17 different populations (Europe, Africa, Asia, Oceania, North America and South America) of approximately 50 individuals for each sex. The study aimed to find the relation of the variation among individuals to the variation between populations in skull shape using discriminant and factor analyses. A few years later, the author published an extension of his previous work, to more widely cover the modern humanity. In his *Skull Shapes and the Map: Craniometric Analyses in the Dispersion of Modern Homo* (1989) he added more populations (for a total of 28) with the intent of detecting the differences between the populations of different major regions.

Boas' work has been reviewed recently by Gravlee, Bernard and Leonard (2003) and Sparks and Jantz (2002) utilising statistical techniques that were not available at that time. They determined that the morphology of the skull is more heavily influenced by genetic components, rather than environmental. In fact, as stated by Kohn (1991), a trait observed in an individual (phenotype) is the sum of the genotypic value and the environmental deviations. Environmental deviations can be identified with specific influences such as diet, climate, maternal care and the environment. The author also concludes that the dimensions of the neurocranium (bregma to nasion, nasion to basion and the angle formed by nasion, bregma and basion) have a higher heritability than the facial skeleton. The reason is explained from the differential growth of the skull regions, as the vault attains approximately 90% of its adult size at the age of five, while the face finishes its growth at about 12 years of age (Landauer, 1962). This theory has been confirmed by other authors (Guglielmino-Matessi, Gluckman and Cavalli-Sforza, 1979; Beals *et al.*, 1984; Jantz and Meadows Jantz, 2000; Roseman, 2004; Roseman and Weaver, 2004; Carson, 2006; Harvati and Weaver, 2006), who report that the morphology of the splanchnocranium is mostly influenced by environmental factors, while temporal bone and neurocranium are more correlated with genetic factors.

Another important aspect which is worthy of consideration is the mandibular shape. Traits that differ in human populations due to masticatory behaviour and adaptation are ramal height and breadth, ramal obliqueness, corpus robusticity, mandibular notch shape, bicondylar breadth and mental foramen position (Nicholson and Harvati, 2006). Numerous studies showed that mandibular shape could change depending on the type of food that is consumed during life. An anteriorly rotating growth of the mandible is common among individuals with a hard and attritive diet. This growth direction resulted in an acuter gonial angle and more horizontal orientation of the mandibular base. In association with this change, the upper incisors appear more palatally inclined, and the interincisal angle appears larger than in individuals consuming soft food (Varrela, 1992). A study on facial growth has been proposed by Corruccini, Henderson and Kaul (1985), who compared rural and urban Punjabis population samples. In fact, as Lieberman *et al.* (2004) state, softer foods are widely hypothesised to lead to less facial growth, especially in the lower face and the alveolar crests. This differential growth can be due to the effects of strain that can stimulate periosteal growth and/or inhibit resorption in skeletally immature individuals, to adapt bone shape and structure.

Luther (1993) compared the differences in facial shape, especially the maxilla and the mandible, between a medieval and a modern population. The main changes that the author detected in the facial skeleton seem to be a result of a different diet, with a passage to a softer diet in modern times. This thesis is also confirmed by González-José *et al*. (2005) in their work carried out on populations with different subsistence strategies. The results that the authors found were that the masticatory component exhibits the most interesting deviation from the pattern depicted by the set of analysed variables. In fact, it is stated that there is a clear plasticity of the masticatory complex, which reflects the environmental influence of diet and mechanical loading of the face. They also suggest that craniometrics should not be disregarded as a source of data for the genetics of population models. These hypotheses led to the exclusion of the mandible from this project, as it is dependent on the type of food processed by the individuals.

Craniometric information is a result of population history and can be used to detect within and among-group variation, migration routes and ancestral origins. Relethford (2004a) established that morphological craniometric traits are controlled independently by genetics and environment, and none of these factors will obscure the other. Furthermore, Relethford (1988) states that analyses of anthropometric data provide additional time depth in studies of population structure so that they should integrate the genetic research.

A number of studies have assessed how appropriately the craniometric data can be used to reconstruct population history (Relethford, 1988; 1994; 2004a; 2009; 2010; Harvati and Weaver, 2006; Smith, Terhune and Lockwood, 2007; Smith, 2009) and proved that the data taken from the entire cranium reflects the evolutionary expectations. For instance, Relethford and Crawford (1995) in their analysis of the population of Ireland, examined the patterns of anthropometric variation concerning population history, estimating genetic distances from anthropometric data. As Ireland boasts a history of different populations' waves and dramatic shifts in size, it offers an interesting opportunity for research. In their conclusions, the authors have been able to detect two major determinants of biological variation, which consist of the Viking contact in the Midlands and the relative isolation of the western regions. Roseman (2004) suggests in fact that populations that share recent common ancestry and/or exchange a large number of migrants should resemble with one another, more than geographically isolated and distantly related populations.

Furthermore, several studies analysed the different regions of the cranium or individual bones (Harvati and Weaver, 2006; Smith, Terhune and Lockwood, 2007; Smith, 2009; Von Cramon-Taubadel, 2011) to test how reliable they can be for studies of population affinity. The results proved that these regions vary in equivalence to molecular data (Relethford and Harpending, 1994; Von Cramon-Taubadel, 2009; 2011). In his research, Relethford (2002) states that the apportionment of global genetic diversity estimated from craniometric data reflects the patterns observed in several studies of genetic markers and DNA polymorphisms. The study showed that the majority of the diversity exists within local populations. In fact, based on the genetic data, 10% of the total diversity exists among major geographic regions, 5% among local populations within regions and 85% within local populations. Craniometric data mirrors the genetic results, with 13% among regions, 6% among local populations within regions and 81% within local populations.

As discussed by Brothwell (2014), because a noticeable amount of metric data (measurements and means) has been produced, it is possible to draw a view overtime for the British population. The author states that the use of osteometric data to prove the impact of external groups of people on the indigenous Neolithic and Bronze Age populations is still not overall accepted. However, the variation that is demonstrated is not likely simply derived from rapid microevolution. The same thesis can be applied to the differences showed by Anglo-Saxons and the medieval population.

British studies involving craniometric data are infrequent, especially for the medieval remains, and most of them are dated. The first extensive study made in Britain regarding a population, and more in particular regarding craniometry, was *Crania Britannica* by Davis and Thurnam (1865). The authors analysed a total of 261 individuals that ranged from the Neolithic to the Anglo-Saxon period. Even though there are some doubts about the type of equipment used and the accuracy of the measurements (tenths of an inch), it is out of doubt that it started a series of publications that were taking in consideration the variation of the British population.

The majority of the following studies analyse the Pre-Historic, Romano-British and Anglo-Saxon populations, to develop an understanding of variation migration (Huxley, 1866; Beddoe, 1885; Horton-Smith, 1896; Myers, 1897; MacDonnell, 1904; Wright, 1904; Keith, 1913; 1915; Hooke, 1926; Morant, 1926; Hooke and Morant, 1926; Buxton, 1935; Howells, 1937; 1938; Goodman and Morant, 1940; Fereday, 1956; Brothwell, 1960; Leese, 1991). It is worth of mentioning that studies concerning Scotland are very few and the majority of them were carried out on the Pre-Historic or undated material (Young, 1915; Turner, 1915; Reid and Morant, 1928; Wells, 1956-1957).

It is not until 1908 that medieval remains received detailed attention. Parsons (1908) published his work *Report on the Hythe Crania*, recording craniometric data for a sample of 590 individuals. He recorded just six measurements for each skull, which are not sufficient to give detailed conclusions on the morphological variation of the population. For this reason, later on, Stoessinger and Morant (1932) reanalysed the collection to obtain a better-detailed view of the Kentish population. The data of this last research was included for population analysis in this thesis. In the same year, Duckworth and Pocock (1909) published their analysis of a series of crania unearthed during an excavation of the Augustinian friary in Cambridge. The authors compared the collection with other British medieval series, noticing an increase in brachycephaly during the medieval period.

Buxton (1937) in his *The Anthropology of Mediæval Oxford* already points out the problem that not much research was carried out on medieval human remains. His contribution to the anthropological research of the beginning of the 20$^{th}$ century added craniometric data for a total of 86 crania. For each cranium, the author collected three measurements to calculate three indices. He concluded that the medieval skulls differed significantly from the earlier Anglo-Saxon ones and the later British ones (which he included in his research).

Another study that needs to be mentioned is the one carried out by Little (1943), who analysed a series of more than 70 medieval crania coming from the graveyard surrounding the post-Norman conquest chapel from Castle Hill (Scarborough). The author compared the series with seven British samples and seven non-British samples, as the site has been subject to different occupations over the centuries. He concluded that the Scarborough population descended from a foreign community because there were no similarities between this population and the other British samples. The data of this research were also included for population analysis in this project. Tattersall (1968) compared 12th-15th Centuries remains from Clopton (Cambridge) with those from sites in Hythe, Dunstable and Scarborough. The research demonstrated that the populations were generally homogeneous, even with different group features (e.g. Hythe groups showed reduced cranial length).

More recent work by Brothwell and Krzanowski (1974) focused on cranial measurements and the variation between British populations due to migration during different chronological periods (Neolithic, Bronze Age, Iron Age, Romano-British, Saxon and medieval). Dawes and Magilton (1980) compared medieval human skeletal remains from St Helen-on-the-Walls (Aldwark) with remains from the Neolithic to the Middle Ages in the North of England. The results showed that the medieval skeletons were relatively homogeneous in comparison to the human remains from the different time periods studied, from which they tended to be separated. Brothwell (2014) agrees with the fact that further research is needed because few attempts of comparison between samples from medieval cemeteries from Yorkshire has been made (Dawes and Magilton, 1980; Mays 2007).

# 3. Materials and Methods

## 3.1 Introduction and Hypotheses

The aim of this thesis is to provide and discuss the findings from a craniometric analysis of 16 British medieval samples. Following the reconstruction of 267 skulls from the Gloucester, Poulton and Linenhall collections, up to 45 measurements for each skull was taken, excluding the mandible, using traditional anthropometric methods (e.g., Martin and Saller, 1957; Howells, 1989). Further craniometric data, collected by the author and previously published, were included for a total 946 individuals from these 16 samples. These data were compared with those in several major human groups from the W. W. Howells dataset (Howells, 1989).

To carry out the project, four main hypotheses were proposed (see chapter 1, section 1.2). For implementation of the statistical analysis, the following null hypotheses and alternative hypotheses were proposed:

- **Null Hypothesis 1:** There are no statistically significant differences for the craniometric measurements among the British medieval samples.

  - **Alternative Hypothesis 1:** There are differences in the craniometric measurements among the British medieval samples.

    Craniometric measurements were analysed with discriminant function analysis (DFA) to show whether there are differences between and within the population samples and between sexes. Discriminant function analysis provides a set of weightings that allow to distinguish the groups. If there are differences, then they can take different forms depending upon the region of the skull, which can be stated alternately as follows:

  - **Alternative Hypothesis 1a:** If there are differences among British medieval samples, the differences are determined by the neurocranial measurements.
  - **Alternative Hypothesis 1b:** If there are differences among British medieval samples, the differences are determined by the facial measurements.
  - **Alternative Hypothesis 1c:** If there are differences among British medieval samples, the differences are determined by both the neurocranial and facial measurements.

Means calculated on the set of craniometric measurements were analysed with principal component analysis (PCA). Principal component analysis can be applied to any large dataset, and it synthesises it into a set of compound axes to understand which measurements contribute most to the differences between datasets.

- **Null Hypothesis 2:** There are no differences between the British medieval samples and the W.W. Howells dataset groups.

    - **Alternative Hypothesis 2:** There are differences in the craniometric measurements among British medieval samples and the W. W. Howells dataset groups. These samples will cluster based on their geographical proximity.

As for the alternative hypothesis 1, cranial measurements were analysed with discriminant function analysis (DFA) to determine whether there are significant differences among the different sets of data and it is predicted that these differences will reflect geographical distances. If there are differences, then they can take different forms depending upon the region of the skull, which can be stated alternately as follows:

- **Alternative Hypothesis 2a:** If there are differences among British medieval samples and the W. W. Howells dataset groups, the differences are determined by the neurocranial measurements.
- **Alternative Hypothesis 2b:** If there are differences among British medieval samples and the W. W. Howells dataset groups, the differences are determined by the facial measurements.
- **Alternative Hypothesis 2c:** If there are differences among British medieval samples and the W. W. Howells dataset groups, the differences are determined by both the neurocranial and facial measurements.

## 3.2 Materials

### 3.2.1 Collections and Samples

In the selection of the samples used, the aim was to acquire data from anthropological material uncovered from the North to the South of Britain. As discussed in the previous sections, the amount of skeletal material from the South is greater than the northern one, as the number of recovered remains available for the North is limited.

The samples from the anthropological collections from Poulton and Gloucester are housed in Liverpool John Moores University, and the data acquisition was made by the author. Following the excavation that took place between 2015 and 2016, the Linenhall sample was stored in Liverpool John Moores University until August 2017, when it went for reburial. Data from the human remains excavated from London archaeological sites were also included in this project, thanks to the Museum of London Archaeology (MOLA), that made them available online in its Wellcome Osteological Research Database. The sample from St Gregory's Priory, Canterbury, is stored at the School of Anthropology and Conservation at the University of Kent, Canterbury. The author recorded the measurements at the osteology laboratory at the University of Kent. The data for the Hythe crania were recorded and published by Stoessinger and Morant (1932) in the early 20$^{th}$ century, same as the data from the skeletal material recovered at the Castle Hill site (Scarborough) published by Little (1943). The human remains from Guisborough were analysed and published by Anderson (1994) and the ones uncovered at the church of St Nicholas Shambles were analysed and published by White (White and Dyson, 1988). The Ballumbie sample, from Ballumbie Church, is stored at the osteology laboratory in the School of History, Classics and Archaeology, University of Edinburgh.

In Fig. 3.1, it is possible to see the location where the remains analysed for this project came from. In Table 3.1 a summary of the archaeological sites, samples and dating, with the number of males (M), females (F), possible males (?M) and possible females (?F) is given.

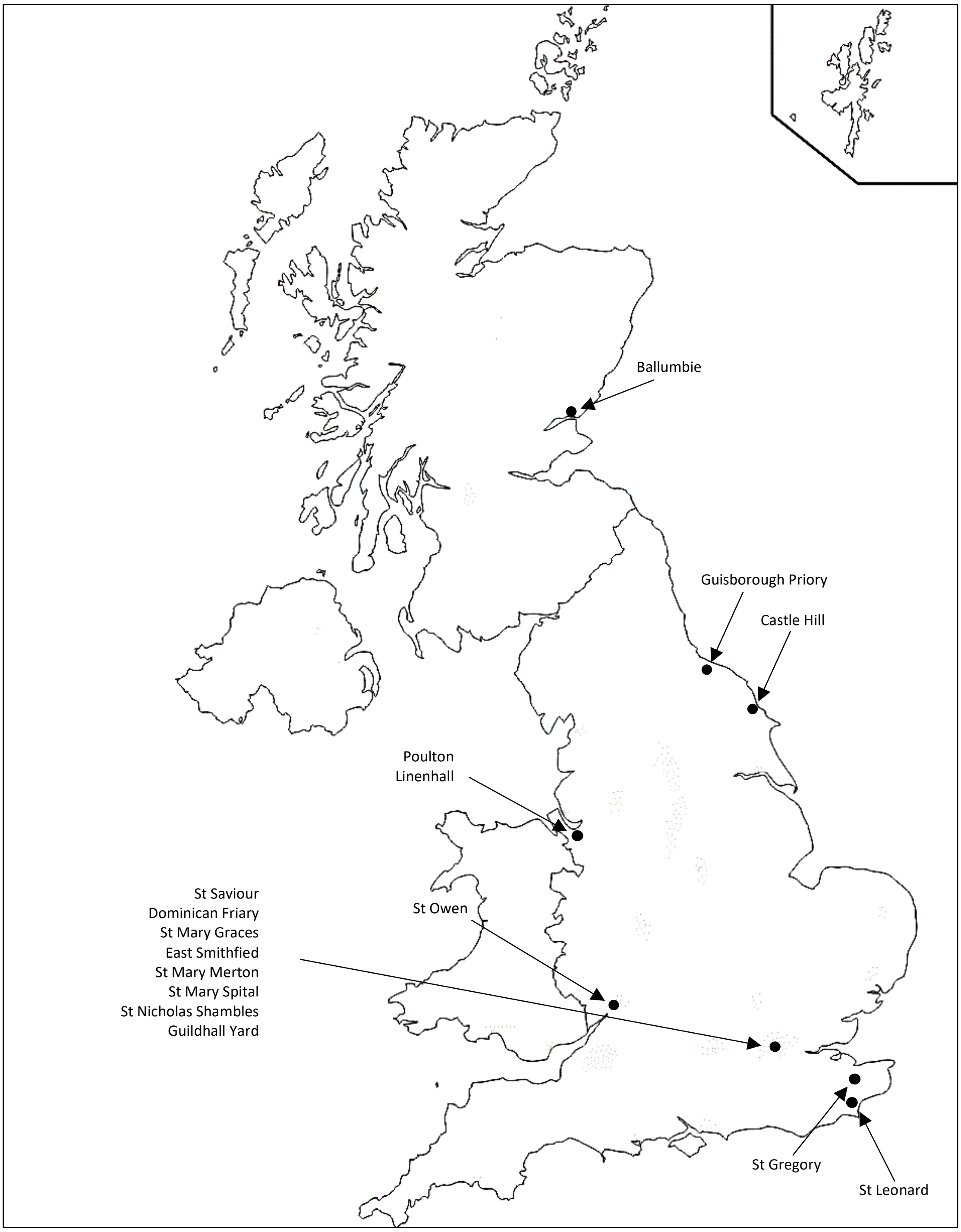


Figure 3.1: Location of the origin of the samples analysed for this project

| Site | Period | Number of Males | Number of Females | Number of ?Males | Number of ?Females |
|---|---|---|---|---|---|
| Poulton | 14th-16th AD | 106 | 41 | 11 | 4 |
| Linenhall | 12th-15th AD | 7 | 3 | 0 | 0 |
| St Owen | 12th-15th AD | 48 | 25 | 3 | 3 |
| St Saviour | 11th-16th AD | 52 | 0 | 0 | 0 |
| Dominican Friary | 13th-16th AD | 3 | 0 | 0 | 4 |
| St Mary Graces | 14th-16th AD | 14 | 8 | 7 | 3 |
| East Smithfield | 14th AD | 31 | 15 | 6 | 4 |
| St Mary Merton | 12th-16th AD | 59 | 4 | 10 | 1 |
| St Mary Spital | 12th-16th AD | 13 | 7 | 4 | 2 |
| St Nicholas Shambles | 11th-12th AD | 14 | 19 | 0 | 0 |
| Guildhall Yard | 11th-14th AD | 4 | 4 | 3 | 1 |
| St Gregory | 11th-16th AD | 45 | 22 | 3 | 4 |
| St Leonard | N/A | 75 | 34 | 37 | 53 |
| Castle Hill | ?12th-16th AD | 43 | 18 | 0 | 0 |
| Guisborough | 12th-16th AD | 14 | 8 | 4 | 6 |
| Ballumbie | 7th-17th AD | 22 | 9 | 4 | 2 |
| **Total** | | **550** | **217** | **92** | **87** |

Table 3.1: Dating and number of individuals analysed for the project

### 3.2.2 W.W. Howells' Database

W.W. Howells contributed significantly to craniometric analyses in relation to human variability and population history. With his contributions *Cranial Variation in Man. A Study of Multivariate Analysis of Patterns of Difference Among Recent Human Population* (Howells, 1973) and *Skull Shapes and the Map: Craniometric Analyses in the Dispersion of Modern Homo* (Howells, 1989), the author produced one of the largest-scale analyses of modern and historical human populations to date.

In his first study, Howells used 17 different population samples, each comprising 50 individuals for each sex. He recorded 70 measurements and angles on each cranium, and the craniometric analysis was limited just to the calvarium. As stated by the author (Howells, 1973:32), indices and linear combinations are not used for the statistical analysis, as the statistical method makes linear combinations of all the measurements at ones. He also considered that circumferences, arches and cranial capacity were not needed, as in his opinion, they do not give any information about the shape, but only regarding the size. Minimum frontal diameter was also excluded in favour of maximum frontal diameter. Howells stated that the measurements should be interrelated and common landmarks used as possible (1979:33). Therefore, he chose the ones that are a consistently and coherently distributed set on all the regions of the cranium and can therefore define the shape of the skull.

The aim was to examine contiguous populations, or those who are known or thought to be related, proceeding systematically from the greatest similarity to the least (Howells, 1973:6). Another purpose was to provide other researchers with a database to which compare any single or groups of fossil or recent skulls. The samples were chosen so that the series represent a real population unit and time span, to maintain the integrity of the intrapopulation variation in all the groups. In the case of the European groups, the author chose medieval samples, as it is more likely that in this period the admixture was lesser and hence more likely to have comparable dental histories, age distributions and causes of death.

The Howells database is therefore represented by five major geographic regions: Europe, Africa, Asia, Pacific and America. To these population samples, Howells added further individual recent specimens from every region or of unknown origin, along with some other prehistoric specimens from the late Pleistocene, as well as casts of some other fossil hominins. In his later publication, the author added ten more groups to the ones he defined as "core populations" (Howells, 1989:1) to represent in a better way some areas where the sample was not enough representative, as the Far East and the Pacific. His later work was then divided into the following geographic areas: Europe, Africa, Far East, Australia and Melanesia, Polynesia, Americas.

As in the previous publication, 600 "test" specimens were added to the data, such as modern skulls and Pleistocene hominin skulls. Table 3.2 sums up the database sample and the groups analysed in this project as a comparison are indicated in bold.

| Population | Number of Males | Number of Females | Date of publication |
|---|---|---|---|
| **Medieval Norse (Oslo)** | **55** | **55** | 1973 |
| **Medieval Zalavár (Hungary)** | **53** | **45** | 1973 |
| **Berg (Carinthia, Austria)** | **56** | **53** | 1973 |
| Teita (Kenya) | 33 | 50 | 1973 |
| Dogon (Mali) | 47 | 52 | 1973 |
| **Zulu (South Africa)** | **55** | **46** | 1973 |
| **Australia, Lower Murray River** | **52** | **49** | 1989 |
| Tasmania | 45 | 42 | 1973 |
| Tolai (New Britain) | 56 | 54 | 1973 |
| Mokapu Peninsula (Oahu, Hawaii) | 51 | 49 | 1973 |
| **Easter Island** | **49** | **37** | 1989 |
| Moriori (Chatham Islands) | 57 | 51 | 1989 |
| Arikara (South Dakota) | 42 | 27 | 1973 |
| Santa Cruz Island (California) | 51 | 51 | 1989 |
| **Yauyos District (Peru)** | **55** | **55** | 1973 |
| Hokkaido (North Japan) | 55 | 32 | 1989 |
| Kyushu (South Japan) | 50 | 41 | 1989 |
| **Hainan Island (South China)** | **45** | **38** | 1989 |
| Atayal (Taiwan) | 29 | 18 | 1989 |
| Philippine Islands | 50 | 0 | 1989 |
| **Guam (Mariana Islands)** | **30** | **27** | 1989 |
| Gizeh (Egypt, 26th-30th dynasties) | 58 | 53 | 1973 |
| **Bushmen (South Africa)** | **41** | **49** | 1973 |
| Andaman Islands | 35 | 35 | 1973 |
| Ainu (South-Central Hokkaido) | 48 | 38 | 1989 |
| **Buriats (Siberia)** | **55** | **54** | 1973 |
| Inugsuk (Eskimo, Greenland) | 53 | 55 | 1989 |
| **Shang Dynasty (Anyang, China)** | **42** | **0** | 1989 |

Table 3.2: W.W. Howells database population samples (Howells 1973; 1989)

## 3.2.3 Anthropometric Instruments

For the craniometric data collection, a set of sliding calliper, spreading calliper with rounded tips, measuring tape, Mollison's craniophor and auricular head spanner were used. The sliding calliper usually is used for measuring linear measurements or thickness. The spreading calliper with rounded ends instead, provides accurate measurement of short distances between points where both or one might be not on a flat surface. The measuring tape allows to record the exact distance on a curved surface between two points. Finally, the Mollison's craniophor (Fig. 3.2) is used in connection with the auricular head spanner (Fig. 3.3) to place the cranium on the Frankfurt horizontal plane. The Frankfurt horizontal plane is determined by the right and left porion and the lowest point of the inferior margin of the orbit (preferably left). The Mollison's craniophor is not used to record measurements unless it is connected with the auricular head spanner. The auricular head spanner is instead used to measure different heights of the cranium from the porion. All these standard anthropometric tools have an accuracy of 1.0 mm.

Figure 3.2: Mollison's craniophor

Figure 3.3: Auricular head spanner

# 3.3 Methods

## 3.3.1 Cranial Reconstruction

The reconstruction of 300 skulls was carried out by the author in the osteology laboratory, to enable the analysis of the samples. Following excavation, the human remains were washed with cold water and brush to remove the soil covering the surface of the bone. The bones are usually recovered in damp soil, which adds weight to the remains, resulting in crushing and breakage. If the washing process is not done immediately after the excavation, the soil hardens causing damage to the bones (Bowron, 2003). The cleaning procedure is also essential for the analysis of the remains and to enable the exact reconstruction of the skulls, avoiding any error caused by the presence of sediment in the fractures (Borrini, 2007). The sample from Gloucester was cleaned immediately after the excavation and later acquired by the University. The samples from Linenhall and Poulton were cleaned in the osteology laboratory.

When the skeletal material was dry, photographic documentation was carried out. The skull fragments were first divided by anatomical position (as suggested by Brothwell, 1981) and then photographed to document the state of preservation of the remains before the reconstruction (Fig. 3.4).

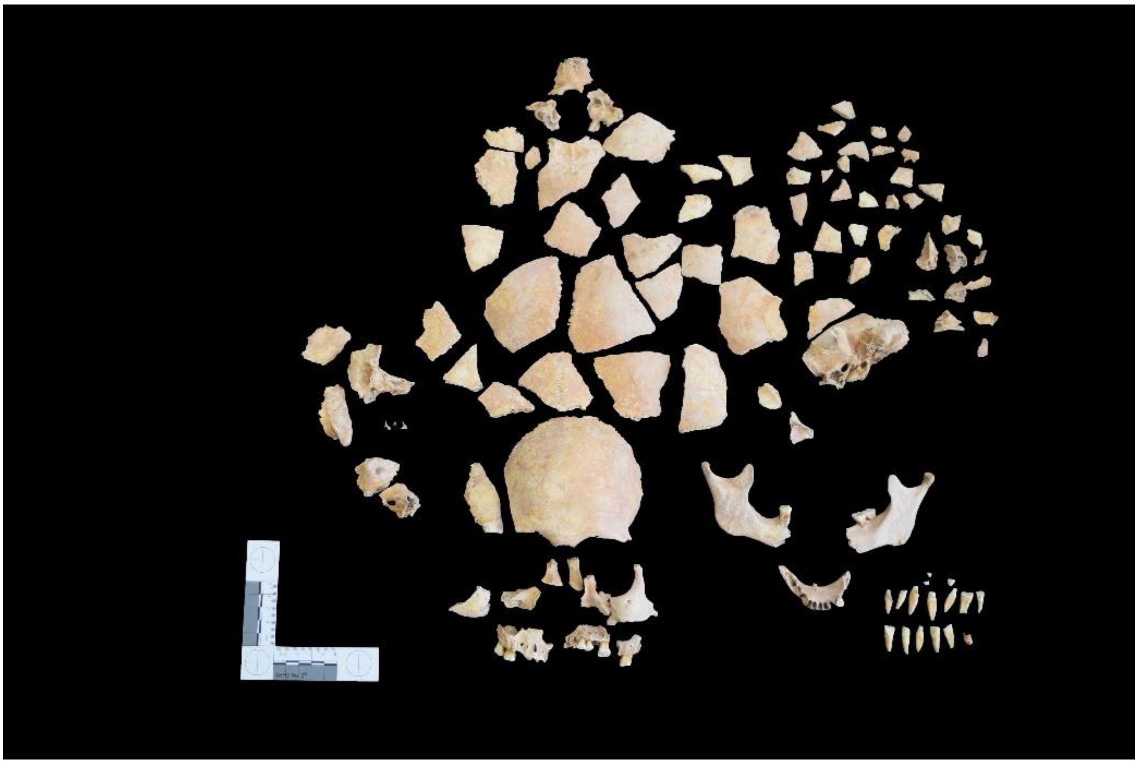

Figure 3.4: Photographic documentation of Skeleton 110 skull from Poulton before reconstruction

The reassembling was carried out with non-permanent reversible glue. As suggested in the Code of Practice of the British Association of Biological Anthropology and Osteoarchaeology (2018), a solution of HMG Paraloid B-72 (60%) and acetone (40%) was used. Thanks to the fact that the skull fragments were previously divided for documentation, the reconstruction was first carried out separating the different anatomical parts. The reconstructed parts were then joined together to recreate the complete skull (Fig. 3.5).

Figure 3.5: Reassembling process of a fragmented skull.

Frequently, after the recovery of the remains, it might be noted that some parts of the skulls are missing due to taphonomical factors. For this reason, pigmented wax was used to reproduce bone’s natural colour, following the guidelines published by Borrini (2007), to fill in the missing parts and give more stability to the sample. This procedure was carried out after the reconstruction and the assessment of the skulls’ preservation, as only after the reassembling of the entire skull it was possible to determine whether its stability was adequate.

The wax is made by a combination of different components (Fig. 3.6) and, in the same way as the Paraloid glue, it is fully reversible. The basic formula of the wax is:

- 20 g of beeswax
- 20 g of paraffin (candle wax)
- 10 g of pine rosin
- 60 g of casting powder
- 60 g of calcium carbonate (limestone flour)

Figure 3.6: Different components of wax before mixing.

After the preparation of the components, the materials were placed in a metallic tray located on a hot plate. First, the beeswax and the pine rosin had to be melted entirely to avoid the presence of solid residues in the mixture (Fig. 3.7 A). After these materials formed a homogeneous blend, paraffin, casting powder and calcium carbonate were added (Fig. 3.7 B). This admixture creates a compound that is suitable for the reconstruction of missing parts in the skull, as it is stable, reversible and does not damage the bone surface. For the best performance in the reconstruction with wax, a mix of pigments (brown iron oxide and raw sienna) was used to recreate a natural colour.

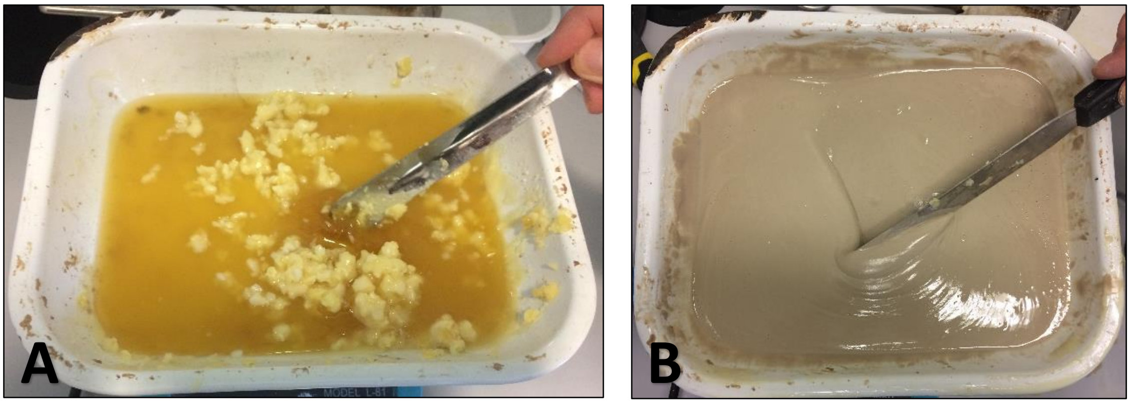


Figure 3.7: Wax initial mix made with pine rosin and beeswax (A) and final compound (B).

Once the compound acquired a natural colour, a layer of tin foil was placed in the internal side of the skull. This procedure avoids the excessive accumulation of wax on the inner surface of the cranial vault and gives to the reconstructed area the same thickness of the bone. Reconstruction with wax was also used to recreate parts of the cranium that were missing. The splanchnocranium is more fragile than the cranial vault, and because it is formed by thinner anatomical parts, it is possible that these elements are more prone to taphonomic degradation and/or excavation damage. For this reason, some parts of the face, such as the nasal bones or the zygomatic processes, were recreated to give increased stability to the reconstruction. The result was a complete and stable skull that allowed the full recording of measurements (Fig. 3.8).

Figure 3.8: Reconstructed skull from Skeleton 155 from Poulton

## 3.3.2 Sex Determination

When the data were collected personally by the author, sex and age determination were carried out (discussed in section 3.3.3). For a study of this nature, sex determination is essential to allow the analysis to be made separately on males and females. This permits the effects of sexual dimorphisms to be accounted for and allows analyses of pooled sex samples to be carried out.

When sexual maturity was evaluated, sex determination was carried out following traditional methods (Bass, 1995; Buikstra and Ubelaker, 1994; White and Folkens, 2005). The skull is one of the most reliable areas of the skeleton for sex determination, second only to the pelvis, and it reaches levels of reliability of 92% (Krogman and Isçan, 1986). In general, sex assessment is based on the evidence that male individuals are morphologically more robust than females (Bass, 1995). The reason for this dimorphism is linked to stronger muscular attachments that are developed in male individuals.

Male crania usually display more prominent supraorbital ridges, pronounced glabella and marked temporal and nuchal lines compared to female skulls. Male frontals show a lack of bossing, the orbits are squarer and mastoid processes are larger than female skulls. The mandible also shows sexual dimorphism, as males have square mental eminence, gonial flaring and the gonial angle is more likely to be close to 90°.

Sex determination methods adopted for this study are based on the development and robusticity of five aspects of the skull, according to the criteria proposed by Buikstra and Ubelaker (1994). A scoring system is given to each trait, from a value of 1 indicating gracility (female) to 5 indicating robusticity (male). Because human sexual dimorphism is complex, intermediate values are also possible, and in some cases, determining the sex of an individual can be difficult. For this reason, in ambiguous cases, the sex determination on the pelvis was carried out to have an optimal evaluation of the sex of the individual. The female pelvis, like the skull, results overall more gracile and the pelvic inlet appears wider than the male one. The greater sciatic notch and the subpubic angle are broader in females than in males. Females tend to have a sharp medial aspect of the ischiopubic ramus, while in males this surface is relatively flat and blunt (Buikstra and Ubelaker, 1994). Even if these two methods give an accurate sex determination, due to the amount of variation within and between populations, it is always important to consider the inter- and intra-population differences to avoid any misclassification of the individuals.

### 3.3.3 Age at Death Determination

It is fundamental that all the individuals taken into consideration have reached the developmental maturity. The brain and head reach their adult size in childhood (Cunningham, Scheuer and Black, 2016), but the face continues its growth. The age of an individual also affects dimorphic sexual features and for this reason, for an immature skeleton sex estimation cannot be carried out. Furthermore, age estimation is easier in younger individuals, as the skeleton is still in a growth phase.

Dental eruption as an aging method has not been taken into consideration for this project. This method may give an age at death determination up until 23 years of age, when all the adult teeth have formed and erupted. As this thesis focusses only on the adults in the respective populations, dental eruption would add little to no value to the project (AlQahtani Hector and Liversidge*,* 2010). Additionally, the impaction or mal-eruption of the third molar could affect the aging of the individual using this method. The Lovejoy (1985) method based on dental wear was not used, because it is much influenced by the diet and cultural background of different populations. Furthermore, it has to be considered that different factors lead to attrition, such as bruxism, the form of temporomandibular joint, size and shape of the condyles, size of the teeth, deliberate dental modification (Prince, Kimmerle and Konigsberg, 2008), which could affect a correct age at death determination.

For an efficient selection of adult individuals, two indicators of age at death were used: the fusion of the spheno-occipital synchondrosis and the ectocranial sutures closure. The spheno-occipital synchondrosis is a suture that is located between the anterior quadrilateral surface of the basilar portion of the occipital bone and the posterior surface of the body of the sphenoid. In children, these two parts are united by a cartilaginous disc that ossifies in the later period of adolescence when also the permanent dentition has nearly completed its development (Sahni, Jit and Suri, 1998). The spheno-occipital synchondrosis is a good indicator of age, as it reaches the complete fusion in females around the age of 16 and males around the age of 18 (Sahni, Jit and Suri, 1998; Schaefer, Black and Scheuer, 2009; Cunningham, Scheuer and Black, 2016). For this reason, this method was used as a discriminant between adults and non-adults individuals.

The ectocranial sutures closure have been extensively explained by Meindl and Lovejoy (1985). A series of 1 cm segments of ten sutures on cranial vault and lateral anterior skull have been chosen and scored with a scale from 0 (open) to 3 (complete obliteration). The sum of all the values given to each segment determines an age range that spans from <30 to 50+ years of age at death. This method can be applied to both sexes if preservation conditions are optimal. However, for each technique, pathological and occupational conditions, together with inter-population variation must be considered when using these methods.

## 3.3.4 Data Collection

Before starting the data recording, a preservation assessment was carried out. If post-mortem pressure or artificial modification have changed a whole region of the skull, this would be excluded from the analysis (Howells, 1973). All skeletal elements, in particular fragile parts such as the skull, may be affected by alteration during the life of the person or after the burial. Ante-mortem changes can be a result of intentional alterations (which have not been detected in these samples) or pathological conditions. Pathological conditions can affect the shape, size and surface morphology of the skull, but are also very easily detectable. For this reason, the specimens that showed these conditions were removed from the data analysis.

Modifications that occurred post-mortem may be caused by various taphonomical events. After the burial of the skeletal elements, warping can occur, especially on the skull. The relatively weak structure of the cranium, and the small amount of soft tissue that surrounds it, makes this element less stable than the other anatomical parts. Warping is a taphonomic alteration resulting from the collapse of a coffin lid or in non-coffin burials as a consequence of the soil pressure (Pokines and Baker, 2014a) (Fig 3.9). The skulls that show evidence of soil pressure warping were excluded from this study.

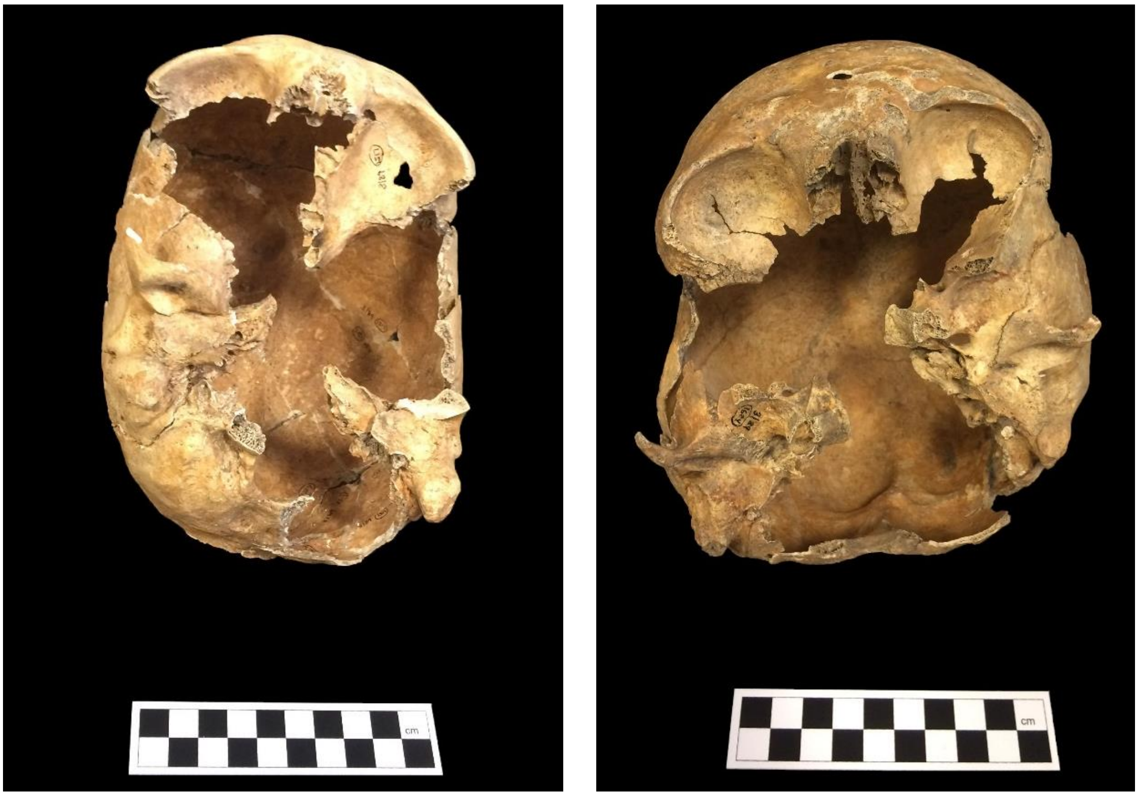


Figure 3.9: Warping effects on two skulls from Skeletons 66 and 133 from Gloucester

Working with archaeological material can be challenging as, oftentimes, recovered specimens are incomplete—even after reconstruction. For this reason, reasonable rules have been followed to maintain consistency in the data collection. First, the skulls were required to have a minimum presence of the frontal bone, right and left parietals, right and left temporals and occipital bone (calvarium). Their presence allowed the collection of most measurements essential for this research. The majority of skulls were recovered with a splanchnocranium. In most cases, due to the fragile nature of the splanchnocranium, they had to be reconstructed. In cases where just half of the facial bones were available, only one measurement for the extant side was recorded (i.e. orbital width and height). In cases where the landmark was located on a missing or damaged part of the skull, the measurement was excluded.

A remarkable number of skulls presented non-metric traits that could affect the measuring process. The most common was represented by wormian bones, which were found in several skulls and mostly located at bregma, lambda and between the sagittal and lambdoid sutures (Fig. 3.10).


Figure 3.10: Wormian bones on a reconstructed skull from Skeleton 131 from Poulton

The intra-sutural bones do not impede the measurement recording, but in cases where these occur at lambda, a judgement must be made by the person who is taking the measurement. In most of the cases, it was not difficult to locate the landmark, but if there were problems with the detection of the point, the measurement was not recorded.

Craniometric data were recorded on hand-written sheets with a table including all variables (See Appendix 1). Sex, age and anomalies (i.e. non-metric traits, pathologies and taphonomical changes) were also recorded. The same recording process was followed for each specimen included in this thesis. The anthropometric instruments used were the same for the entire study to allow the author to maintain consistency during the data collection. The equipment was also checked and calibrated before proceeding to the measurement of a skull to avoid any error in the data recording. All the measurements were recorded in millimetres with no decimal values.

In regard to the measurements not recorded by the author, it was not possible to monitor the data collection, as part of the sample was analysed at the beginning of the 20th century. However, it is assumed that experience and knowledge allowed the researchers to maintain a certain degree of consistency and logic during the data collection. The information provided by the other authors, when provided, is consistent with the data collection methods used for this study. Concerning craniometric data collection, standard methods were used for the published samples, which will be specified more in-depth in section 3.3.5.

### 3.3.5 Craniometric Measurements

The purpose of the craniometric analysis is description and comparison. In the past, craniologists and osteologists proposed up to 5000 measurements on an individual skull (Howells, 1969). Researchers such as Howells (1973) proposed instead a method with the intention of standardising the measurements. Yet, much work needs to be done to produce a protocol that can be a reference for all researchers.

For this study, the protocol developed by Borrini (2013) was adopted. The aim is to standardise the Martin and Saller procedure for data collection to yield reliability in measurements and minimise intra-observed error. The method has also been adopted by Florence, Pisa, Rome and Vatican Universities. Here, 45 measurements are proposed (Tables 3.3-3.7): 24 located on the neurocranium, eight for the facial skull, five for the orbital skeleton, four for the nasal skeleton and five for the maxilla (see Appendix 2).

A new coding system was proposed, to make more comprehensible the anatomical region where the measurements are being recorded. In this study, only craniometric measurements were analysed, but the protocol is proposed for the anthropometric analysis of the entire human skeleton. For this reason, numerical coding, differently from the previous alphabetical ones, was developed. The coding assigned to the cranium shows three numbers. The first number denoted the macro-area from where on the skeleton the measurement has been taken (for example, the skull has been allocated number 1). The second number refers to the bone where the set of measurements are recorded (i.e. 1.1 refers to neurocranium, 1.2 refers to facial measurements and so on). The third number refers to the single measurement that is being recorded. This method allows the researcher to locate the single measurement based on the numbers, instead of having to refer to a single code.

In anthropometry, the measurements are based on landmarks that have been defined by Martin and Saller (1957) and adopted in other recognised standards, such as Howells (1973), Buikstra and Ubelaker (1994), Bass (1995) and Langley *et al*. (2016). Furthermore, craniometric landmarks can be paired or unpaired. Paired landmarks include two points that are equidistant on either side of the midsagittal plane. Unpaired landmarks are single points that fall on the midsagittal plane (Bass, 1995). For the location of the cranial landmarks, please refer to Fig. 3.11-3.14 and for the description of the landmarks to Appendix 3.

All measurements were recorded with the instruments described in section 3.2.3. Each measurement requires a specific instrument, and a summary regarding the tools that were used for each variable can be found in Appendix 4.

| Measurement | Code | Landmarks |
|---|---|---|
| Maximum length of the neural skull | 1.1.1 | Glabella-opisthocranium |
| Glabella-inion length | 1.1.2 | Glabella-inion |
| Glabella-lambda length | 1.1.3 | Glabella-lambda |
| Cranial base length | 1.1.4 | Nasion-endobasion |
| Maximum neurocranial breadth | 1.1.5 | Euryon-euryon |
| Biauricular breadth | 1.1.6 | Auricolare-auricolare |
| Biasterionic diameter | 1.1.7 | Asterio-asterion |
| Bimastoid breadth of the cranial base | 1.1.8 | Mastoidale-Mastoidale |
| Basion-bregma height | 1.1.9 | Esobasion-bregma |
| Total height | 1.1.10 | Esobasion-sagittal suture |
| Porion-bregma height | 1.1.11 | Porion-bregma |
| Porion-vertex height | 1.1.12 | Porion-vertex |
| Horizontal cranial circumference | 1.1.13 | Glabella-opisthocranion |
| Horizontal cranial circumference above ophrion | 1.1.14 | Ophryon-opisthocranion |
| Transverse curve | 1.1.15 | Auricolare-bregma-auricolare |
| Total longitudinal arch | 1.1.16 | Nasion-opisthion |
| Nasion-bregma arch | 1.1.17 | Nasion-bregma |
| Parietal-longitudinal arch | 1.1.18 | Bregma-lambda |
| Occipital arch | 1.1.19 | Lambda-opisthion |
| Nasion-bregma chord | 1.1.20 | Nasion-bregma |
| Bregma-lambda chord | 1.1.21 | Bregma-lambda |
| Lambda-opisthion chord | 1.1.22 | Lambdaopisthion |
| Foramen magnum length | 1.1.23 | Endobasion-opisthion |
| Foramen magnum breadth | 1.1.24 | Lateral margion-lateral margin of the foramen |

Table 3.3: Neurocranial measurements (after Borrini, 2013)

| Measurement | Code | Landmarks |
|---|---|---|
| Length of the face | 1.2.1 | Endobasion-prosthion |
| Minimum frontal breadth | 1.2.2 | Frontotemporale-frontotemporale |
| Maximum frontal breadth | 1.2.3 | Coronale-Coronale |
| Upper facial breadth | 1.2.4 | Frontomalare temporale-frontomalare temporale |
| Bizygomatic facial breadth | 1.2.5 | Zygion-zygion |
| Maximum bimaxillary breadth of the midface | 1.2.6 | Zygomaxillare-zygomaxillare |
| Morphological height of the face | 1.2.7 | Nasion-gnathion |
| Height of the upper face | 1.2.8 | Nasion-alveolare |

Table 3.4: Facial measurements (after Borrini, 2013)

| Measurement | Code | Landmarks |
|---|---|---|
| Biorbital breadth | 1.3.1 | Ectoconchion-ectoconchion |
| Interorbital breadth from dacryon | 1.3.2 | Dakryon-dakryon |
| Interorbital breadth | 1.3.3 | Maxillofrontale-maxillofrontale |
| Orbital breadth | 1.3.4 | Maxillofrontale-ectoconchion |
| Orbital height | 1.3.5 | Supercilium-infracilium |

Table 3.5: Orbital measurements (after Borrini, 2013)

| Measurement | Code | Landmarks |
|---|---|---|
| Nasal breadth | 1.4.1 | Alare-alare |
| Nasal height | 1.4.2 | Nasion-nasospinale |
| Nose-malar chord | 1.4.3 | Orbital rim-orbital rim |
| Nose-malar breadth | 1.4.4 | Orbital rim-orbital rim |

Table 3.6: Nasal measurements (after Borrini, 2013)

| Measurement | Code | Landmarks |
|---|---|---|
| Maxilla-alveolar length | 1.5.1 | Prosthion-alveolon |
| Maxillo-alveolar breadth | 1.5.2 | Ectomolare-ectomolare |
| Palate length | 1.5.3 | Orale-staphylion |
| Palate breadth | 1.5.4 | Endomolare-endomolare |

Table 3.7: Maxillary measurements (after Borrini, 2013)

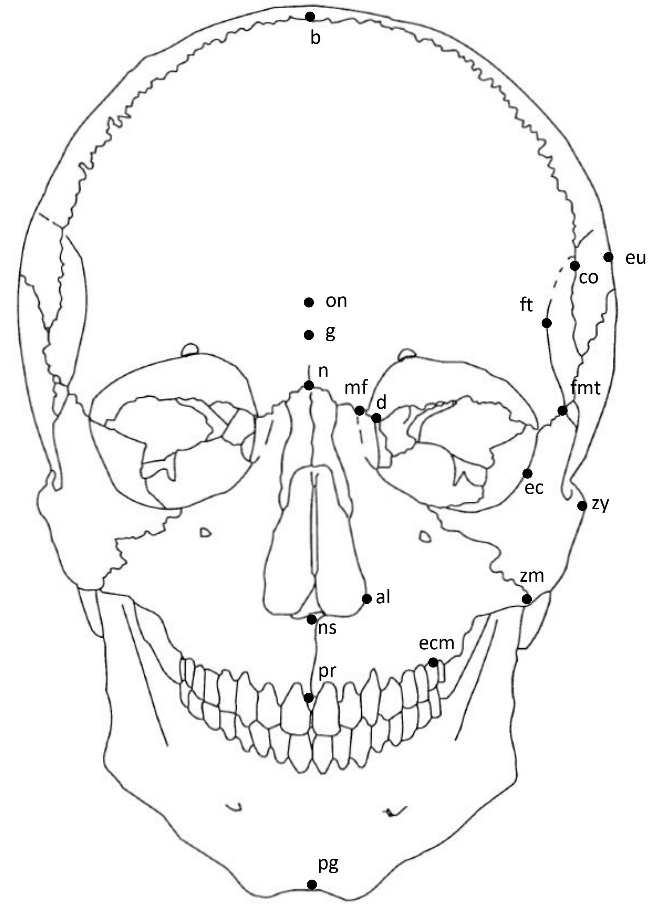


Figure 3.11: Frontal view of skull landmarks (adapted from Buikstra and Ubelaker, 1994)

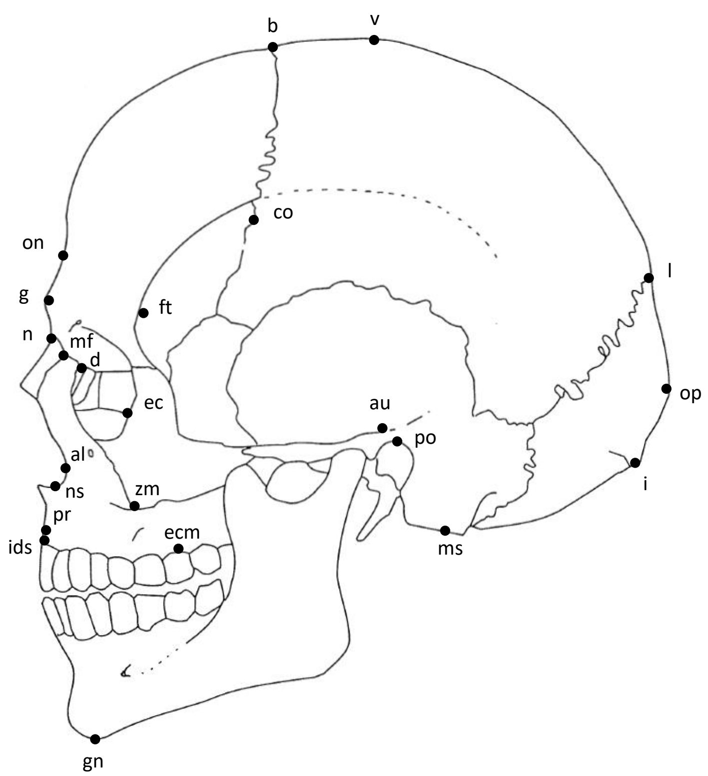


Figure 3.12: Lateral view of skull landmarks (adapted from Buikstra and Ubelaker, 1994)

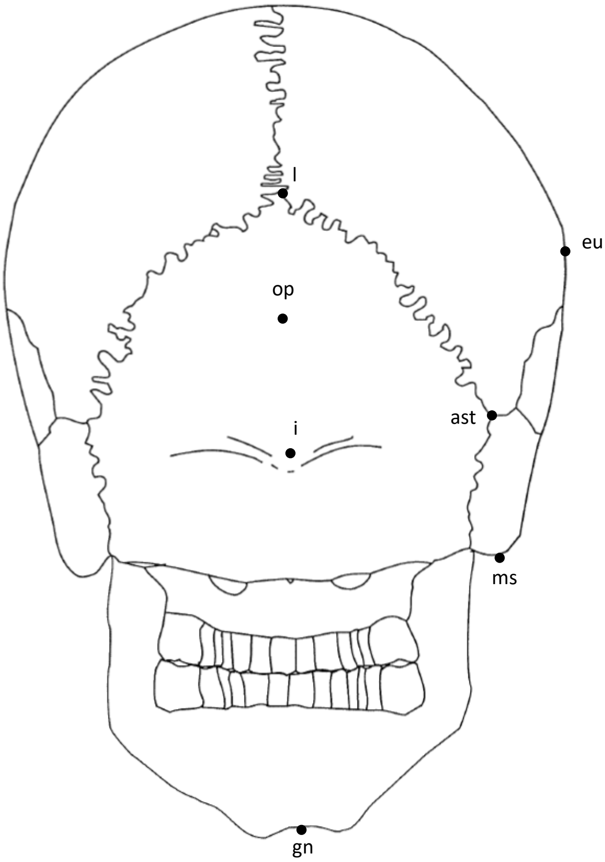

Figure 3.13: Occipital view of skull landmarks (adapted from Buikstra and Ubelaker, 1994)

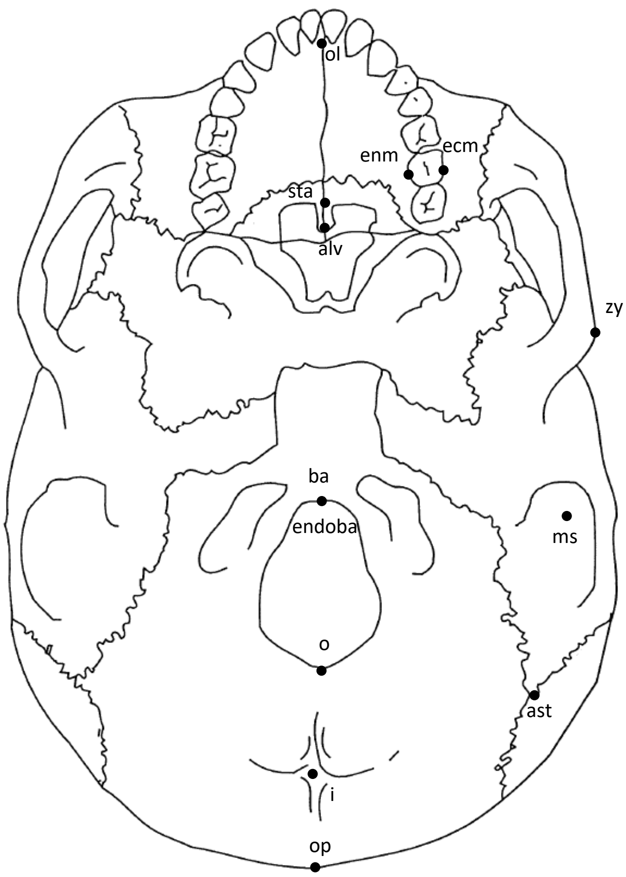

Figure 3.14: Basal view of skull landmarks (adapted from Buikstra and Ubelaker, 1994)

The measurements listed in Tables 3.3-3.7 were recorded by the author for the collections. For the data collected by other researchers, different methods were adopted. Even if the craniometric data recording involves mostly the same measurements, it is essential to specify the standards followed for published data in this study.

The samples located at the Museum of London Archaeology were analysed at the Centre for Human Bioarchaeology. After having developed the Wellcome Osteological Research Database (WORD), the osteologists working for the Museum uploaded the data online to make it available for other researchers. The data acquisition has been made on the base of a specialist recording form with the aim of standardising the recording of all the metric and morphological variability expressed by the human remains stored at the Museum (Connell, 2012). For the craniometric data, a maximum of 37 measurements were taken from the adult skulls (31 unpaired and 3 paired left and right). The reference procedures for the recording of the data were carried out following the guidelines published by Bass (1987), Buikstra and Ubelaker (1994) and Brothwell (1981) (Mikulski, 2012).

The sample from the site of St Nicholas Shambles was analysed by White (1988) for a total of 23 measurements for each skull. The standards used for his data collections are not listed, but it is stated that "*individual skeletal measurements were determined by standard techniques using conventional equipment*" (White, 1988: 29). However, the codes for the measurements listed in the publication were checked for conformity to this study.

The data for the skulls at St Leonard church in Hythe were collected and published by Stoessinger and Morant (1932). There is no reference to the methods used for the craniometric measurements. However, it is specified that the methods refer to a previous technique published by one of the authors and these were "*used normally by workers in the Biometric Laboratory*" (Morant, 1929: 82). The Biometric Laboratory used a code approved by the Frankfort Agreement to produce a standard data collection method for anthropometry. The code consists of different categories of symbols for different measurements and comprises single capitals, double capitals, lower case letters, primes (single and double), angle signs, subscripts and Greek letters. Before including the data in this study, the description of the measurements used in this paper was checked, and they are consistent with those adopted in the anthropometric literature.

Little (1943) carried out the craniometric analysis for the sample from Castle Hill, Scarborough. As for the sample from St Leonard church, it has not been possible to determine the method used for data collection due to the dated publication of the results. In this case, the author states that "*the measurements were taken in accordance with the customary biometric technique*" (Little, 1943:34). As well as for the previously cited sample, the definitions were checked for consistency with the craniometric measurements published in the anthropometric literature.

The data for the remains excavated in Guisborough were analysed and published by Anderson (1994). For the recording of the craniometric measurements from this sample, the author referred to the methods described by Brothwell (1981), Bass (1971) and Krogman (1978). Even if the measurements used by this author are the ones adopted in anthropological research, they were checked for consistency in this thesis.

For a more complete examination of the British archaeological samples analysed in this thesis, the data were compared with the W.W. Howells dataset. In the publications for this research (Howells, 1973; 1989), the author specifies exactly the measurements he included. Howells developed a coding system using a set of abbreviations for the measurements. They correspond to ones used in the previously most recognised systems, such as Martin and Saller (1957) and the one developed by the Biometric Laboratory. However, both of these methods used different coding systems, which the Howells criticises for different reasons. In his opinion, these cannot be used in computer language, as they use numbers or symbols (i.e. parentheses are used for specific operating functions in computer languages). Secondly, he states that the systems are not open for the introduction of new measurements used for his research, whereas three letters coding is more appropriate and more quickly recognisable.

The system developed by W.W. Howells is widely accepted in the Anthropometric field. It has also been adopted for the CRANID worldwide craniometric database, and it is familiar to most of the researchers. Even if Howells' system has been used for the development of the code used for this research, a second check for conformity was carried out by the author for consistency in this thesis.

### 3.3.6 Cranial and facial Indices

Neurocranial and facial indices were calculated, where allowed by the availability of the data. Indices are used to analyse shape differences independent of size and are used to quantify differences between morphological features. Skulls are classified into broad categories on the basis of shape variation derived from the indices (Liebenberg *et al*., 2015). It is fundamental to underline that cranial indices do not give a full description of the cranial shape in a whole of its measurements but only takes into consideration two measurements at a time. For this reason, it is merely considered descriptive of the shape. For the comparison of the overall cranial shape and the determination of the differences within and between the samples analysed, multivariate analyses were used, as is described in section 3.3.9.

The formulae for the calculation of the indices refer to the ones published by Bass (1995) and are listed in Table 3.8 below. The variable codes were adapted to calculate the indices based on the coding system used for this thesis. The ranges that result from the calculation of each index and their description can be found in Appendix 5.

| Index | Bass Code | Formula |
|---|---|---|
| Cranial Index | A | (1.1.5 x 100)/1.1.1 |
| Cranial length/Height Index | C | (1.1.9 x 100)/1.1.1 |
| Cranial Breadth/Height Index | D | (1.1.9 x 100)/1.1.5 |
| Nasal Index | K | (1.4.1 x 100)/1.4.2 |
| Orbital Index | L | (1.3.5 x 100)/1.3.4 |

Table 3.8: Formulae for neurocranial and facial indices adopted for this study

## 3.3.7 Data Handling

The total number of craniometric measurements that were collected on each cranium amounts to 45 variables (see section 3.3.5), which were recorded for completeness of the information (for a complete data set of the measurements collected by the author, see Appendix 6). Some of these variables are recorded spatially adjacent to one another, yielding analogous measurements.

For this reason, to allow an easier analysis of the data, a Pearson's product-moment correlation test was carried out. The test allowed the selection of a set of measurements, excluding the values that had a correlation of $r > .500$ (Emerson, 2015). The resulting dataset was then composed of 21 variables. The measurements were consequently checked for correspondence with those recorded by the other authors and reduced to 18 variables for improved data analysis. The final set of cranial measurements for this research can be seen in Table 3.9 below.

After recording the craniometric measurements, the data were transferred into an Excel file to create a complete dataset for each site. The measurements recorded for samples in the London area were considered a single dataset. The reason for this approach is to create a statistically valid sample for analysis from the same location. The dataset was then transferred into an SPSS v.24 database for the statistical analysis

| Cranial Measurement | Code |
|---|---|
| Maximum length of the neural skull | 1.1.1 |
| Cranial base length | 1.1.4 |
| Maximum neurocranial breadth | 1.1.5 |
| Basion-bregma height | 1.1.9 |
| Nasion-bregma arch | 1.1.17 |
| Parietal longitudinal arch | 1.1.18 |
| Occipital arch | 1.1.19 |
| Nasion-bregma chord | 1.1.20 |
| Bregma-lambda chord | 1.1.21 |
| Lambda-opisthion chord | 1.1.22 |
| Foramen magnum length | 1.1.23 |
| Length of the face | 1.2.1 |
| Maximum bimaxillary breadth of the midface | 1.2.6 |
| Height of the upper face | 1.2.8 |
| Orbital breadth | 1.3.4 |
| Orbital height | 1.3.5 |
| Nasal breadth | 1.4.1 |
| Nasal height | 1.4.2 |

Table 3.9: Measurements used for data collection in this study

First, all individuals that were assigned unknown sex were removed from the database. The individuals that had a sex estimation of “probable male” or “probable female” were included to maximise sample sizes. Second, missing value analysis was carried out to exclude individuals with >50% of the measurements missing. Finally, any individual that showed extremely low or high values in the statistical analysis was checked with the original data file for accuracy. If no inputting error could be identified, the individual was left in the dataset.

The recovered archaeological skeletal material is usually fragmentary, so some of the metric data cannot be recorded. Furthermore, the analysis used for this study does not permit missing values in the dataset. It was then necessary to carry out a replacement of the missing data. The procedure was carried out in SPSS v.24 using the “replace missing value” tool, and the “series mean” method. The result was replacement of the missing values with the means for each craniometric variable. The process was carried out for each site independently to obtain the mean values for each dataset included in the analysis.

In conclusion, the dataset resulting from the data preparation consisted of 670 individuals with less than 50% missing data. The final dataset was the one used for the statistical analyses described in section 3.3.9.

## 3.3.8 Inter- and Intra-observer Error

Accuracy and precision are essential for the results of a study. Accuracy refers to how correct the data are and indicates the closeness of a given measurement to the actual value of the variable. Precision is instead referred to as consistency, and can be defined in terms of measurement error, i.e. the deviation of a set of repeated measurements from a value (Pérez-Pérez, Alesan and Roca, 1990). Reproducibility refers to measurements taken by different researchers, also called inter-observer error. Repeatability is the similarity of repeating the measurements taken by the same investigator, i.e. intra-observer error (Fancourt and Stephan, 2018).

The sources of error in anthropometric measurements can be varied, including mistakes made by the observer in reading the instrument and/or uncertainty in locating the landmark. The definition of a measurement may not be read exactly in the same way by all observers, and their method of measuring a skull could affect reading of the value (for example difference in holding a skull or an instrument). Furthermore, re-measuring a skull could produce an error of 1 mm from the first set. The difference could be a result of the difficulty of some measurements, as they are extremely precise, and the indeterminacy of a reading that falls between two numbers on the instrument (Howells, 1973). For this reason, it is essential to test whether there is an error in the measuring system of the researcher.

For this study, an inter- and intra-observer error was carried out to test the degree of error in the craniometric measurements. First, a set of variables was selected based on the instruments used for this project. Three measurements were selected for each instrument, apart from the Mollison's craniophor and the auricular headspanner that are used to record just two measurements. The selection of measurements can be seen in the following Table 3.10.

The measurements were collected by two independent observers (Master students in Forensic Anthropology at Liverpool John Moores University) and the author on a sample of 30 crania and recorded on measuring sheets. Subsequently, the craniometric measurements were transferred on an SPSS v.24 database for the statistical analysis. Before carrying out the inter-observer error test, the dataset was tested to check whether the data were normally distributed. A Kolmogorov-Smirnov test for goodness of fit was carried out, and the results indicated that most values had a normal distribution, apart from measurements 1.1.5 and 1.1.21 with values of .000 and .001, respectively.

As a result, two different inter-observer tests were carried out. For variables with a normal distribution, a Pearson product-moment correlation was used, while for non-normally distributed data a Spearman's rank-order correlation test was applied. Measurements collected by the author were compared to the first and the second observers, resulting in the correlation coefficients $r$ =.992 and r=.993 for the normally distributed data ($P$ values <0.05). The $r_s$ value for non-normally distributed data yielded values of .963 and .969 ($P$ values <0.05). The test indicated a significant correlation between both observers and the author, as a value of >.8 reflects high reliability (Atkinson and Nevill, 1998). Detailed results for the inter-observer error analysis can be found in Appendix 7.

The same procedures were applied for intra-observer error. The set of measurements described in Table 3.10 was recorded on three crania one year apart from the first recordings. The results showed a correlation coefficient of $r$ =.964, which indicates high reliability. More detailed results from the intra-observer error can be found in Appendix 8.

It was, of course, not possible to carry out error tests for collections previously recorded by other authors, other than checking the methods adopted for measurements of the crania. As Utermohle and Zeruga (1982) state, significant inter- and intra-observer variation exists, and it is essential to account for this error when carrying out anthropometric investigations.

| Measurement | Instrument |
|---|---|
| 1.1.1 | Spreading calliper |
| 1.1.5 | Spreading calliper |
| 1.1.11 | Mollison's craniophor and headspanner |
| 1.1.12 | Mollison's craniophor and headspanner |
| 1.1.17 | Measuring tape |
| 1.1.18 | Measuring tape |
| 1.1.19 | Measuring tape |
| 1.1.20 | Sliding calliper |
| 1.1.21 | Sliding calliper |
| 1.1.22 | Sliding calliper |
| 1.2.2 | Spreading calliper |

Table 3.10: Measurements and instruments used for the inter- and intra-observer error

### 3.3.9 Statistical Analysis

In this study, three statistical methods were employed for the analysis of the data: discriminant function analysis, principal component analysis and hierarchical cluster analysis. The application of the three methods are described in the following sections.

**Discriminant Function Analysis**

Discriminant function analysis provides a set of weightings that allow the groups to be distinguished (Fisher, 1936b). The weightings can then be used to give a probability of assigning unknown individuals to each possible group. If the probability is high, the individual is consequently assigned to a group (Dytham, 2011). The assumptions of the discriminant function analysis are: the observations (or values) are collected from a random sample; each predictor variable is normally distributed; there are at least two groups of categories, with each individual belonging to only one group; the number of individuals belonging to each group should be equal or approximately of the same amount (Burns and Burns, 2008).

Before carrying out the multivariate analyses for the comparison between the samples, a normality test was carried out to find out whether the osteometric data were normally distributed. The test was carried out as the DFA performs better when the observations are normally distributed, and the sample size is equal or nearly equal in all the groups. However, in archaeology, these assumptions are frequently violated, because at least one of the groups may have a smaller sample size (Kovarovic *et al.*, 2011). For this reason, a DFA was realised with both raw data and log transformation in SPSS v24, to determine whether the results were affected by the non-normal distribution of the data.

A stepwise discriminant function analysis was applied using the Mahalanobis distance method to test whether the analysis would give a better classification of the individuals in the different groups. The stepwise analysis enters or removes all the predictors one at a time, evaluating the contribution of the variables to the overall discrimination. At each step of the analysis, the resulting model includes only the variables that have contributed most to the discrimination between individuals. As a result, a set of best predictors should be identified, removing the ones that less contribute to the discrimination in the comparison. The stepwise method is driven by $F$ to enter and $F$ to remove values. $F$ value indicates the statistical significance in the discrimination between samples, i.e. it is a value for how much a variable is contributing to the correct classification of the individuals in a group (Hill, Lewicki and Lewicki, 2006).

The DFA analysis was used in this study to assess the differences between British populations in relation to single measurements. First, for both the analyses, the statistical test was carried out comparing the non-pooled British samples comprising both males and females. Secondly, the samples were pooled by sex to compare the variability between British males and British females.

A further comparison, with regard to the single craniometric measurements, was made with the Howells dataset, both comparing the non-pooled and pooled samples. For a better performance of the analysis, the Howells dataset was reduced to 12 main populations. However, the analysis of the complete Howells' dataset can be found in Appendix 9. Finally, the comparison was made among British males and females respectively to Howells' males and females. Another comparison was made between the British sample and the Howells' European Norse, Berg and Zalavar populations to detect whether there are significant differences between the samples. For all these comparisons, the analysis has been first carried out with discriminant function analysis and with the stepwise method, to see whether there is a difference in the results following the reduction of the variables.

### Principal Component Analysis

Principal component analysis aims to reduce a dataset composed of a large number of interrelated variables in order to explain as much as possible of the variation present in the sample. The method transforms the set of data into new non-correlated variables, called principal components. It then orders them so that the first explains the greatest variability in the sample, the second explains the most variability not accounted for by the first, and so on (Jolliffe, 2002).

The first principal component is represented by the line through the points that passes through the long axis of the cloud. A second line that passes through the cloud of points and perpendicularly to the first component represents the second principal component instead (Dytham, 2011). In this case, the analysis was carried out in SPSS v24, where a set of factors (or PCs) were retained by the program to determine the variability of the sample. SPSS v24 uses Kaiser's criterion (Kaiser, 1960) to extract these factors, i.e. only the factors with Eigenvalues greater than 1 are retained. The factor scores were then used to produce three-dimensional scatterplots to comprehend the results of the analysis better.

For this study, unlike for the discriminant function analysis, the means for each measurement were used. The means were calculated for each population separately and then analysed. The aim of the PCA, in this case, was to determine which cranial measurements determine the greatest variability between the populations included in the analysis. As for the discriminant function analysis, the first step was to analyse the means of the British populations. Firstly, the non-pooled samples were compared. Secondly, the pooled samples were analysed.

A further analysis was made comparing the British populations with the Howells' European samples (Norse, Zalavar and Berg). The first comparison was made between the non-pooled samples, and subsequently, the males were compared and lastly the males. Finally, the same method was used to compare the selected major Howells' samples. The selected samples used for this final analysis are the same that were used previously for the discriminant function analysis.

### Hierarchical Cluster Analysis

Cluster analysis is a data exploratory analysis tool, which separates data into groups whose identities are unknown in advance. To define the groups and to assign group membership, the degree of similarity and difference between individual observations is used (Wilks, 2011). Cluster analysis is also used to generate dendrograms that show putative phylogenetic relationships or to divide individuals into groups that might have taxonomic meaning. Differently from discriminant function analysis, the procedure does not require any assumptions before assigning memberships to a group.

Cluster analysis works as a systematic process. The individuals are first depicted as a scattering of points, then the two closest individuals are identified, and their similarity is recorded as the distance between them (Dytham, 2011). The most commonly used distance measure is the squared Euclidean distance, which was also used for the analysis in this thesis. The distance between clusters can vary in methodology, but the one chosen for this analysis is based on the distance between the sample means of the points contained in each group. Based on this distance, the first step is to find two data vectors that are the closest ones in a dimensional space, combining them into a new group. In each subsequent step, the two closest are merged to form a broader group. The process is repeated until all the individuals are assigned to a single group. The final aim is to minimise the differences within groups of individuals and to maximise the differences between clusters (Wilks, 2011).

In this thesis, similarly to discriminant function analysis and principal component analysis, the British non-pooled samples were first analysed, and later male and female groups were compared. This method was also used in the comparison between British and Howells' European samples (Norse, Berg and Zalavar). Finally, the same procedure was carried out on a selection of Howells' populations, as for the previous statistical analyses. For a more comprehensive exploration of the data, the functions extracted from the principal component analysis were used in the production of the dendrograms. Furthermore, more than one method was applied (between groups, within groups, single linkage, Ward linkage), to understand whether the results were consistent in each methodology, but only the results of the analysis between groups and Ward's minimum variance method are included in this thesis.

# 4. Results

## 4.1 Introduction

Chapter 4 explains the results for the statistical analyses that were carried out for this study. Section 4.2 describes the five cranial indices calculated, based on the availability of the measurements. The results derived from the indices for each British sample are explained, comparing the male and the female groups. Then, the means of the indices calculated for each group are compared with the mean indices of the Howells' European samples.

Section 4.3 describes the results for the discriminant function analysis. The DFA allowed discriminating between the samples included in this study based on the craniometric measurements.

Section 4.4 comprises an explanation of the results for the principal component analysis. Differently from the previous discriminant function analysis, the means resulting from each variable in the different samples were employed for the data analysis. This procedure allowed to determine which variables were more significant in discriminating between groups.

In section 4.5, the results for the hierarchical cluster analysis are presented. This descriptive method was used to show better the similarities between the samples and to create dendrograms to illustrate the clustering of the groups. Only two methods were included, the between-groups linkage and Ward's method, to show that both the approaches give equal results and to confirm the validity of the analysis.

Every chapter has a standard outline, to maintain consistency throughout the thesis. First, the non-pooled British samples data analysis is described, with no differentiation between males and females. In the second part of the analyses, the samples were pooled, and male data were compared for all the British groups, as well as female data. Then, the pooled and non-pooled British samples are compared to the Howells' European groups (Norse, Zalavar and Berg). Finally, for a more comprehensive analysis, the results for Howells' dataset analyses are described to see how the major human groups differentiate and if the different samples cluster together based on geographical affinity.

## 4.2 Indices

Cranial indices were calculated for descriptive purposes. Five cranial indices were calculated: cranial index, cranial length/height index, cranial breadth/height index, nasal index and orbital index. First, a comparison was carried out between males and females within each British sample. Second, the indices were calculated using the means of the measurements for the non-pooled samples, comprising both males and females, and a comparison was made between British and the European samples from Howells' dataset (Norse, Zalavar and Berg).

### 4.2.1 Poulton

The sample from Poulton shows relatively small differences between males and females (Fig. 4.1). The cranial index for both sexes falls in the mesocrany range, which means that both samples have an average or medium skull shape, tending to round-headed, as the values are close to brachycrany. Similarly to the ratio of height to length, both tend to be average or medium (orthocrany), with an inclination to a low skull. When comparing cranial breadth and height instead, both fall into the low skull range (tapeinocrany).

Different results are obtained when analysing the facial skull. Even though values are close, the nasal index for the females shows a narrow nasal aperture (leptorrhiny), while men seem to have a higher value that falls into the mesorrhiny range (average or medium). For the orbital index, females tend to have wider orbits (chameoconchy) compared to men, that fall into the mesoconchy range (average or medium).

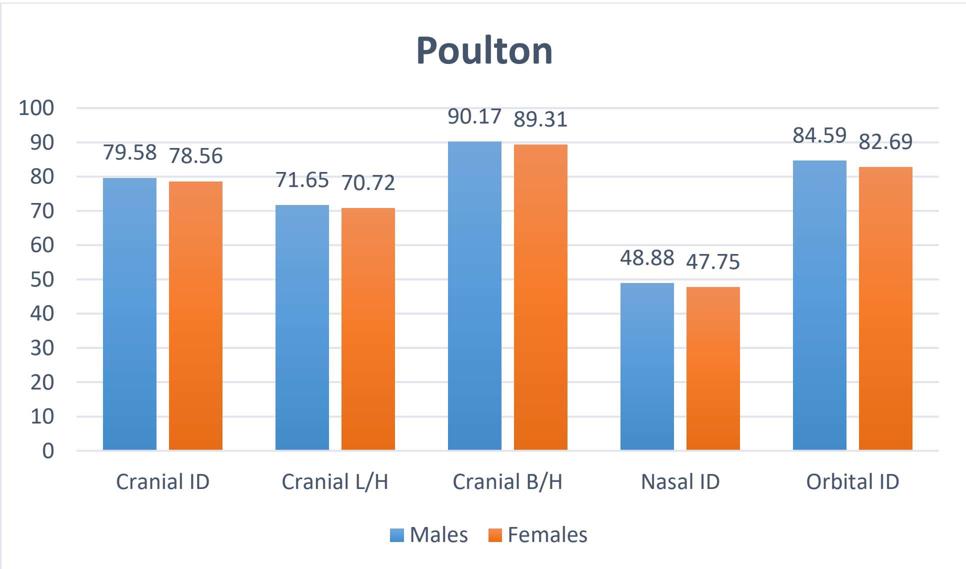


Figure 4.1: Comparison between female and males indices in the Poulton sample

## 4.2.2 Linenhall

The indices for the Linenhall sample seem to follow the same pattern for males and females (Fig. 4.2). Both sexes show an average skull shape for the cranial index (mesocrany) and the cranial height/length index (orthocrany). In the first case, females tend more to a broad/round head, while in the second case this sample is closer to chamaecrany. A slight difference is encountered in the ratio between cranial breadth and height. In fact, females fall into the tapeinocrany range, and males have a bigger value that falls into an average/medium skull. Regarding the facial skeleton, both the samples show an average or medium nasal index and wide orbits. In the last case, females have wider orbits than males, but still falling into mesoconchy.

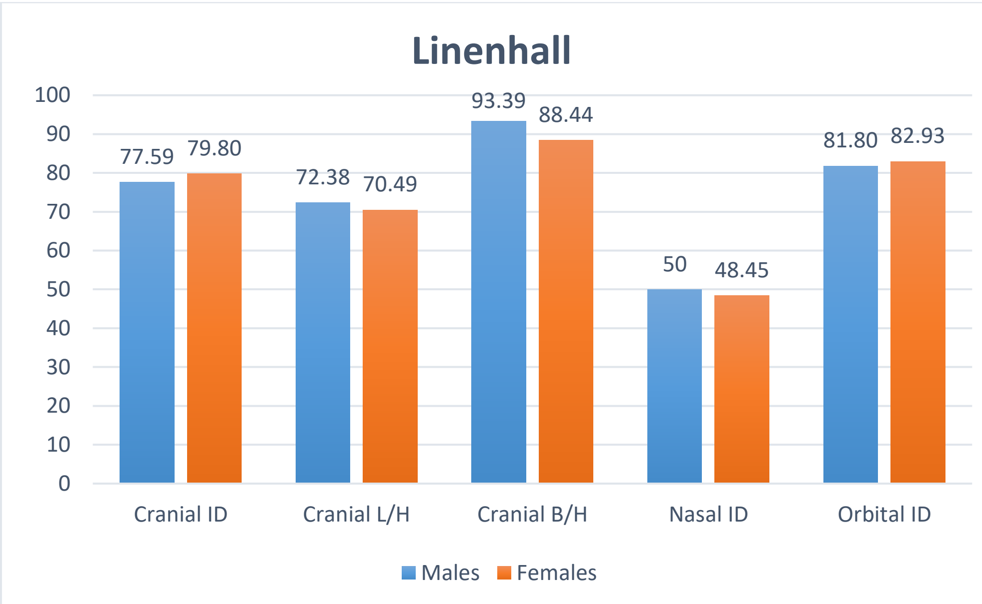


Figure 4.2: Comparison between females and males indices in the Linenhall sample

## 4.2.3 St Owen

The histogram in Fig. 4.3 shows that the values for the Gloucester sample are reasonably similar for both sexes. Both sexes show an average or medium skull for the first two indices. When comparing the cranial breadth with the height instead, both result as tapeinocranic (low skull).

The facial skeleton results in very similar values, especially the shape of the orbits, which shows mesoconchy for both sexes. The only difference is encountered in the nasal index where the females have a narrow nasal aperture, while men fall into an average range.

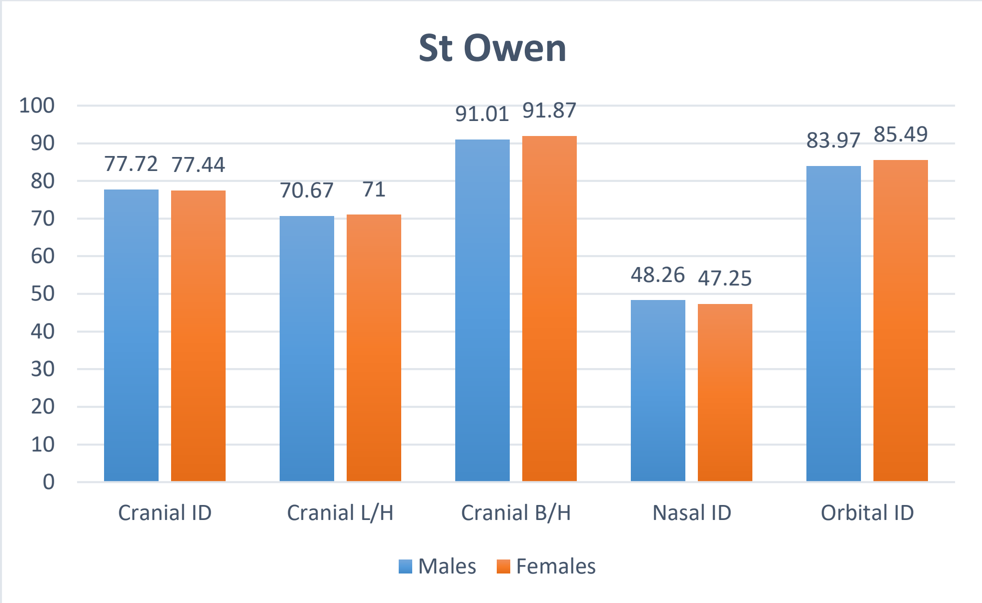


Figure 4.3: Comparison between females and males indices in the St Owen sample

## 4.2.4 London

The London sample is fairly homogeneous as the sexual dimorphism is minimal (Fig. 4.4). The cranial index has a higher value for females, which show a broad/rounded head, while males fall in the medium range. The other indices are higher in the males, showing orthocrany for the cranial length/height. When comparing the breadth and the height instead, females fall in the tapeinocrany class (low skull), while males still fall in the average value (metriocrany). The indices for the facial skull show average values both for nasal aperture and orbits' size.

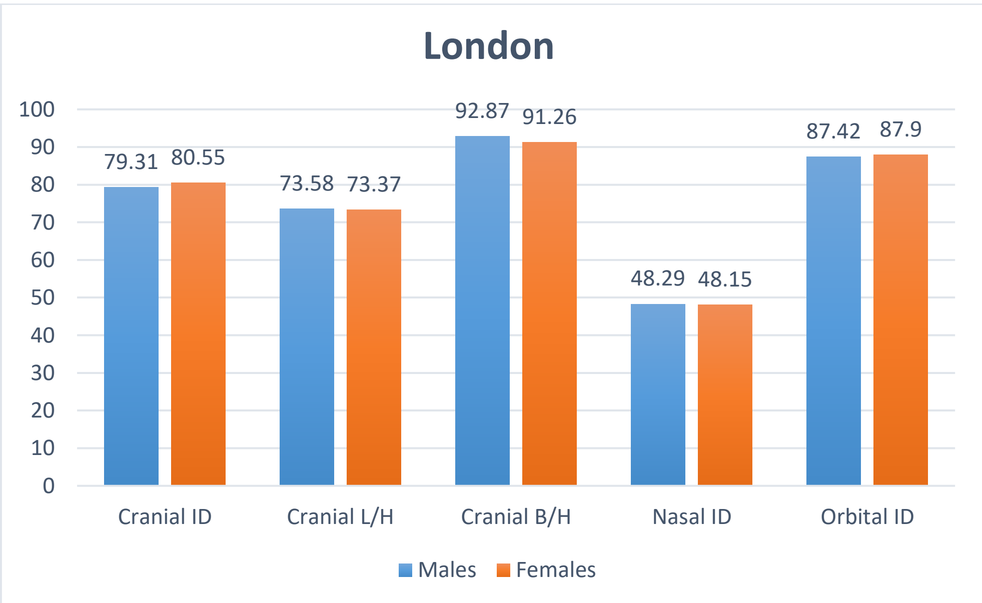


Figure 4.4: Comparison between females and males indices in the London sample

## 4.2.5 St Gregory

The sample from Canterbury shows minimal differences between sexes (Fig. 4.5). The cranial index indicates an average skull, tending to brachichrany, with a higher value for the females. The same average value can be seen for the cranial length/height ratio, while for the cranial breadth/length females have a low skull (tapeinocrany). The facial skeleton indices fall into the average/medium sizes, even though males show a significant tendency to cameoconchy.

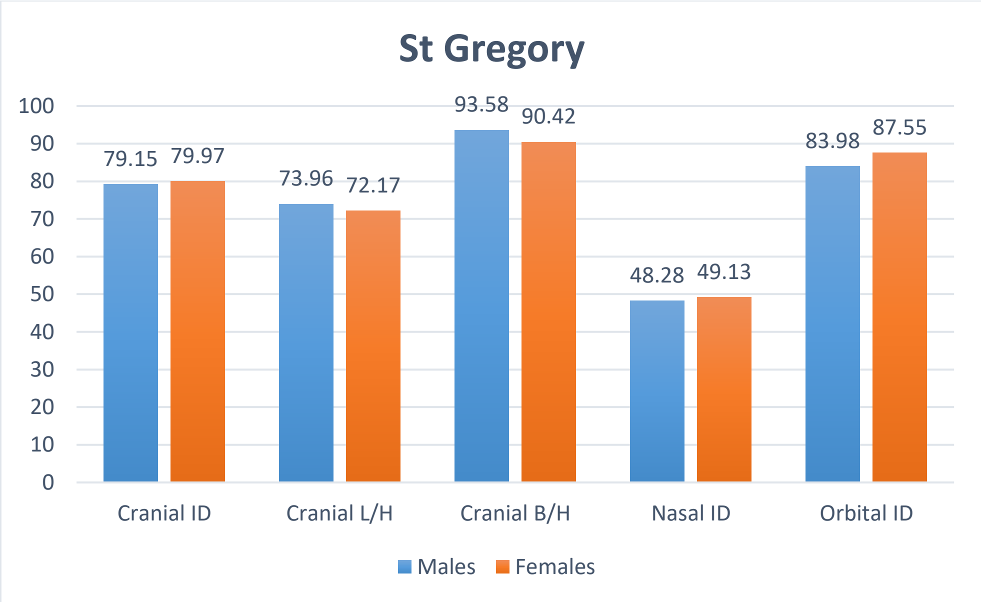


Figure 4.5: Comparison between females and males indices in the St Gregory sample

## 4.2.6 St Leonard

The Hythe sample follows the same pattern for both females and males (Fig. 4.6). For both the sexes, the cranial index falls well above the brachycrany category and is characterised by broad or round skulls. In the comparison between cranial length and height, females show an average or medium skull, whereas males have a high skull. However, regarding the breadth/height ratio, both the samples show a low skull, even though the value is borderline with metriocrany for male individuals.

The values for the facial skeleton seem to be higher for females, but both the samples fall into the same categories. The nasal index indicates mesorrhiny in both sexes, with an average or medium nasal aperture. The orbital index instead indicates that this sample has wide orbits, (cameoconchy).

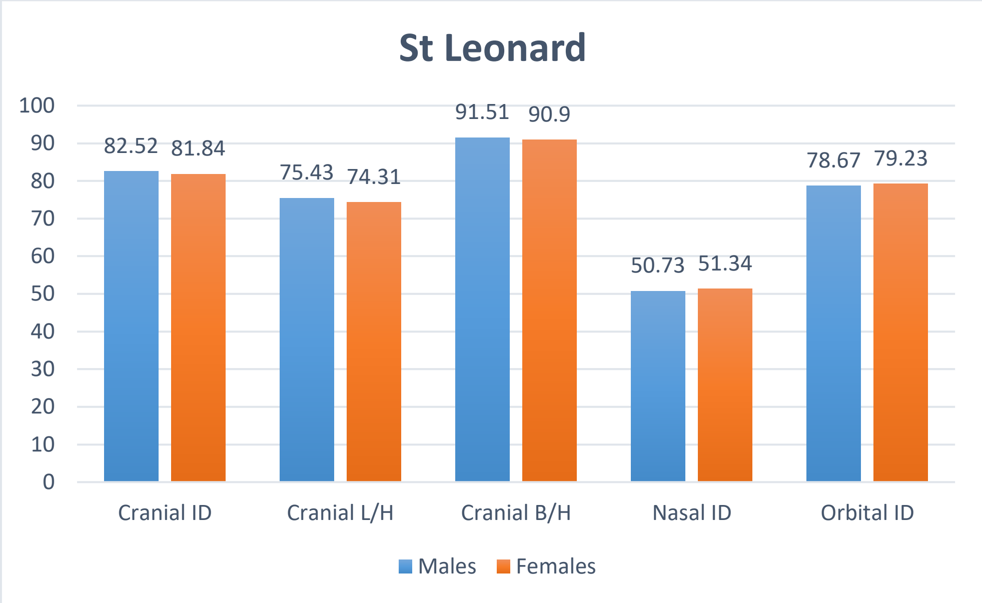


Figure 4.6: Comparison between females and males indices in the St Leonard sample

## 4.2.7 Castle Hill

Male and female samples from Scarborough are reasonably similar in their cranial indices (Fig. 4.7). Female skulls are overall smaller than the male ones. Both the cranial and the length/height indices show an average value. When comparing the breadth with the height instead, the skulls are classified as tapeinocranic (low skull).

The facial skull is similar, showing that both the sexes have an average nasal aperture. The highest difference between the sexes is shown in the orbital index where females show a higher value that locates them into the mesoconchy class. Males instead have wide orbits and fall in the chameoconchy class.

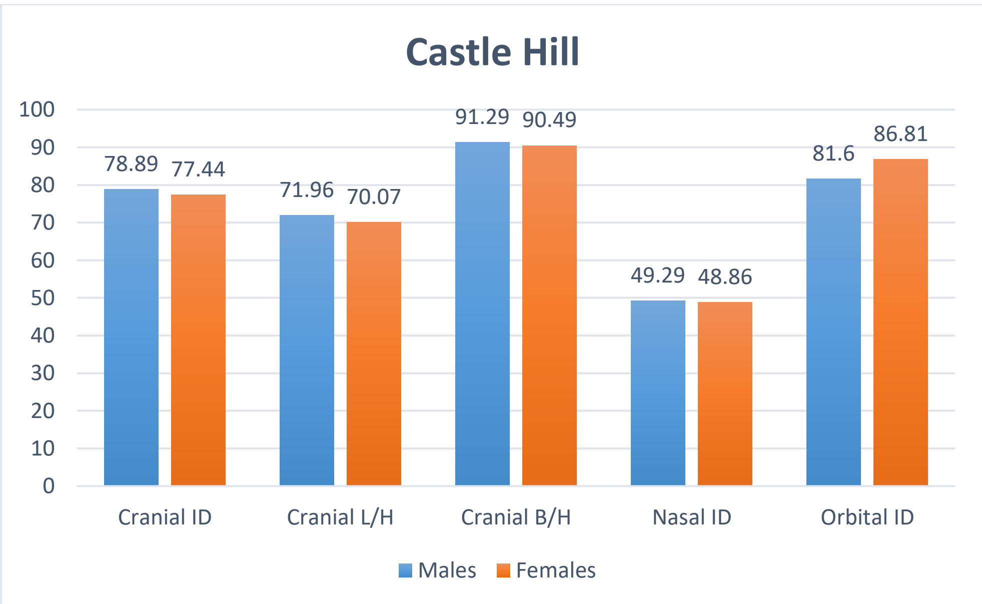


Figure 4.32: Comparison between females and males indices in the Castle Hill sample

## 4.2.8 Guisborough

The indices for the Guisborough sample were calculated depending on the availability of measurements. As it can be seen in Fig. 4.8, because of missing data, it was not possible to calculate facial indices on the female sample.  However, it was possible to determine the cranial indices.

Overall, there is a substantial similarity between the two sexes, with lower values encountered for the female sample. The cranial and the length/height indices classify the two samples in the average or medium categories (mesocrany and orthocrany). Cranial breadth and length ratio classifies both samples in the tapeinocranic group, showing that both the sexes are characterised by low skulls.

The facial skull indices for the males show that the nasal aperture was of an average type, with a tendency to a narrow shape. The orbits instead fall well into the hypsiconchy category, showing that this sample had narrow orbits.

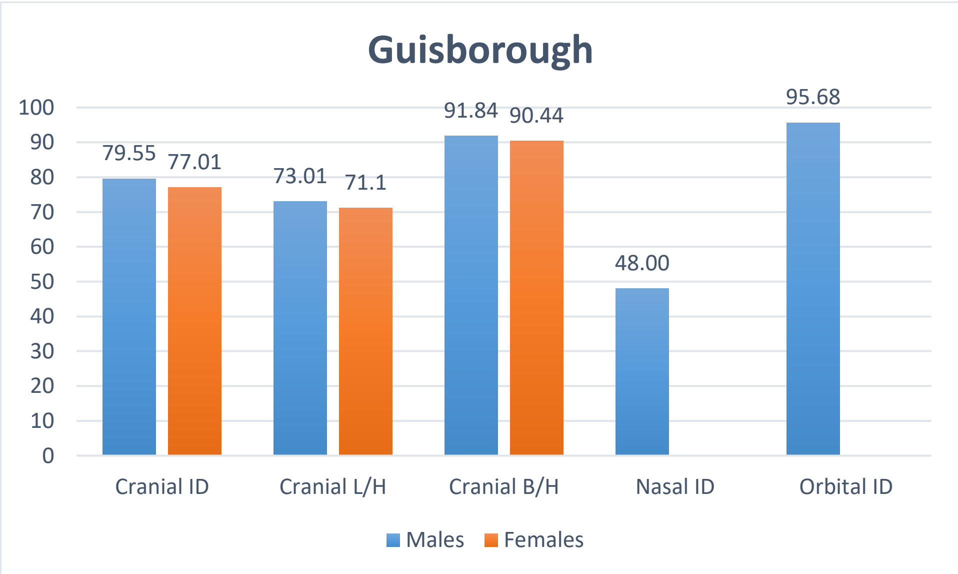


Figure 4.33: Comparison between females and males indices in the Guisborough sample

## 4.2.9 Ballumbie

The sample from Ballumbie shows a similar overall trend in the indices for both sexes (Fig. 4.9). The cranial index for the males seems to have a lower value than the females, but both are in the brachycrany group (broad or rounded head). The values for the length/breadth index show an average skull (orthocrany). The breadth/length index instead, classifies both sexes into the tapeinocrany class, with a higher value showed by males.

For both the samples, the nasal aperture is similar, with an average size falling into mesorriny. However, there is a difference in the orbital index where females seem to have narrower orbits (hypsiconchy) than men (mesoconchy).

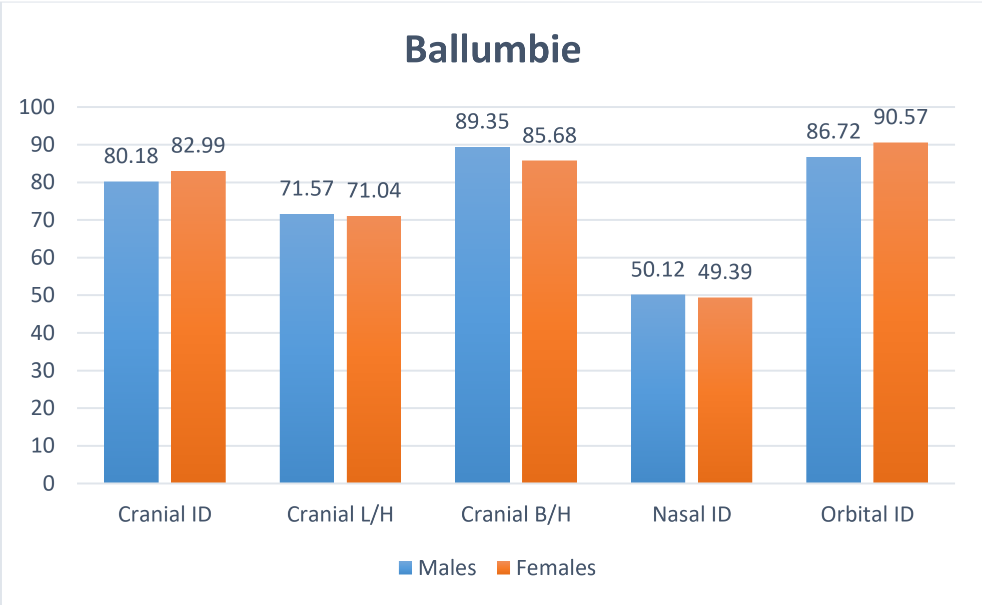


Figure 4.9: Comparison between females and males indices in the Ballumbie sample

## 4.2.10 Between population analysis

A variation in the cranial indices can be seen among the British groups, but also in comparison with the Howells' European samples (Fig. 4.10). Overall, the majority of the samples are classified in the average or medium group. The only three groups that fall into another class are St Leonard (number 6), Ballumbie (number 9) and the Berg group (number 12). These samples fall in the broad or rounded headed individuals category (brachycrany).

The lowest values for the cranial indices are shown by Norse group (75.53), Zalavar sample (76.98) and St Owen (77.63). The highest values are indicated by St Leonard (82.22), Berg sample (82.19) and Ballumbie (81.04). Even though there is disparity in the British cranial indices, they fall into the same class and it does not seem that they cluster together based on geographic proximity. St Leonard (number 6) and St Gregory (number 5) are both in Kent, but they seem to belong to two different morphological groups. The same cannot be said for Guisborough (number 7) and Castle Hill (number 8), that show a minimal difference between each other and are both classified as average headed.

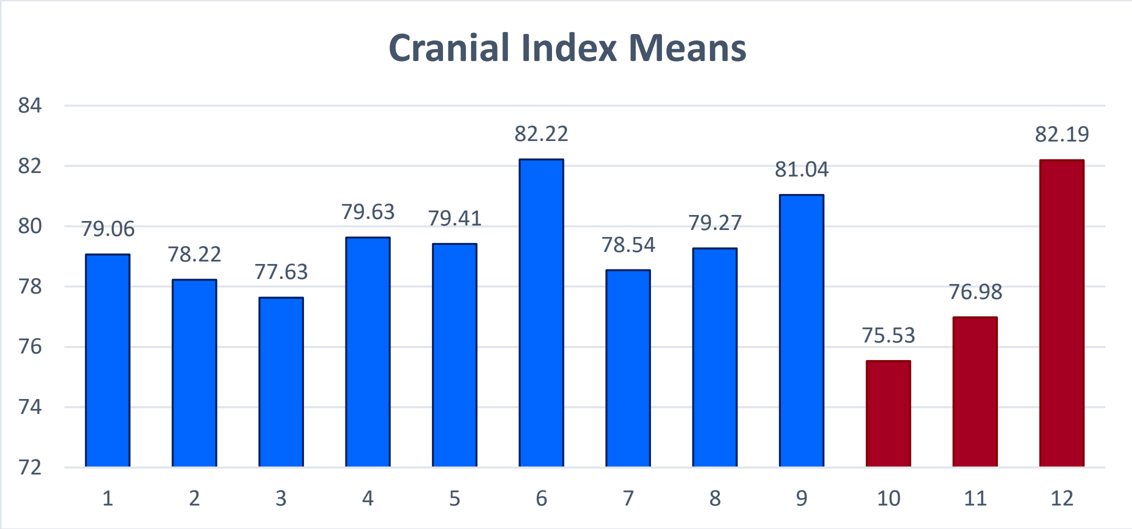


Figure 4.340: Cranial indices means for British (1-9) and Howells' European (10-12) samples

Cranial length/height ratio seems to follow the same pattern shown by the cranial index (Fig. 4.11). All the samples fall into the average or medium class, apart from Norse group, which is located in the chamaecrany class, with a strong tendency to an average skull.

The lowest values are given by Norse sample (69.99), St Owen (70.18) and Poulton (71.18). The highest values instead are given by St Leonard (74.94), London (73.53) and St Gregory (73.4). St Leonard falls into the average class, but with a tendency to a higher skull (hypsicrany). Here, there seems to be a similarity that follows the geographical proximity. The groups from the Southern part of Britain show higher values compared to the ones located in the North. The only exception for the southern groups is represented by Gloucester that is located on the western coast.

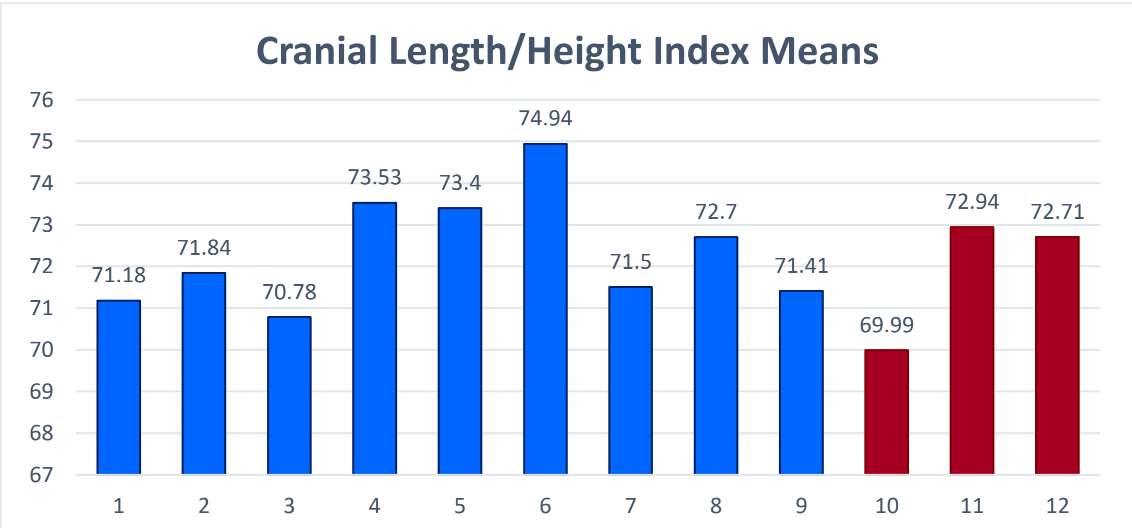


Figure 4.11: Cranial length/height indices means for British (1-9) and Howells' European (10-12) samples

The trend for the cranial breadth/height ratio changes compared to the previous indices. The majority cluster together in the tapeinocrany class, with values that show a low skull. Although, London, St Gregory, Norse sample and Zalavar fall into the metriocrany class (Fig. 4.12).

The lowest values are shown by Ballumbie (88.25), Berg sample (88.56) and Poulton (90.19). In contrast, the highest values are recorded by Zalavar (94.84) and Norse samples (92.71), followed by London (91.81). Even if the samples are divided into two different classes, there seems to be an increased homogeneity in the indices, especially for the British samples. The only different value is related to Ballumbie, which is well located in the tapeinocranic group.

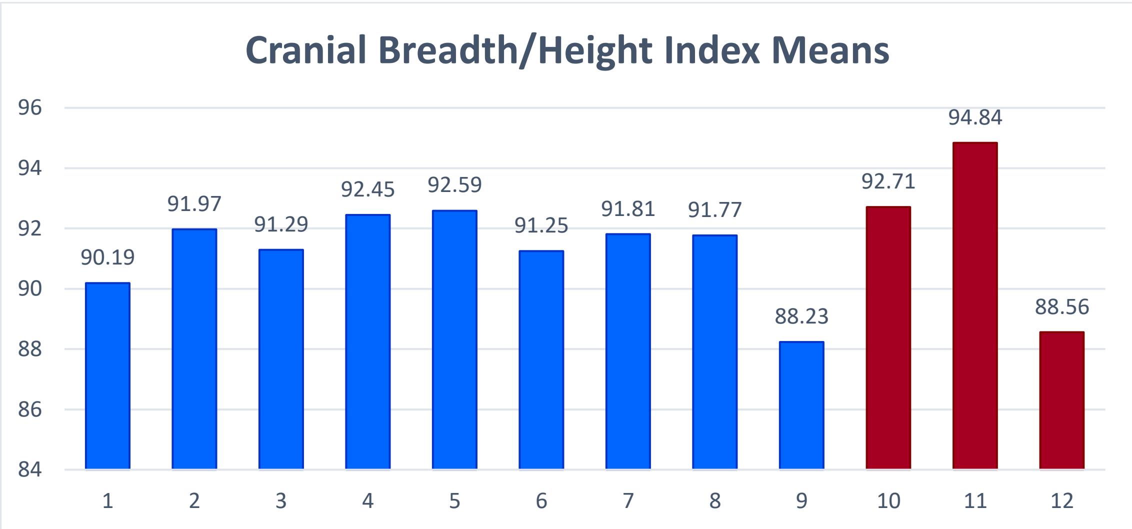


Figure 4.12: Cranial breadth/height indices means for British (1-9) and Howells' European (10-12) samples

The nasal indices place all the samples, both British and European, in the average or medium category. Only Gloucester sample has a narrow nasal aperture even though it is close to the average value (Fig. 4.13). The lowest values are represented by St Owen (47.93), Guisborough (48.01) and London (48.55). The highest values instead are given by St Leonard (51), Berg (50.55) and Zalavar (50.16) samples.

The sample from St Leonard is similar to the groups from mainland Europe, as they show similar values for the nasal shape. Close values are also shared by Gloucester and Guisborough. The last sample is classified in the average group, but it shows a tendency towards a narrow nasal aperture.

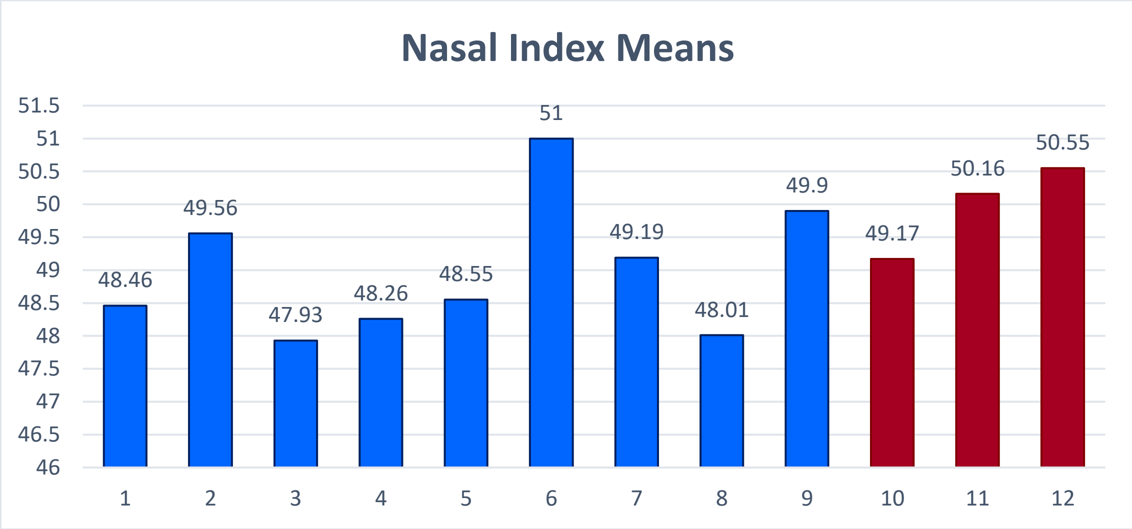


Figure 4.13: Nasal indices means for British (1-9) and Howells' European (10-12) samples

In Fig. 4.14, the orbital index is shown. There is a clear homogeneity between the groups as the values do not cover a wide range. Linenhall, St Leonard, Castle Hill and Zalavar samples are characterised by wide orbits (chameoconchy). The others fall into the average or medium class, apart from Guisborough that seems to be part of the hypsiconchy group.

The lowest values are given by St Leonard (78.91), Linenhall (82.12) and Zalavar (82.42). The highest values were instead reached by Guisborough (95.58), Ballumbie (87.89) and London (87.54). The only samples that seem to differ significantly from the others are Guisborough and St Leonard while the rest of the samples seem to show the same distribution.

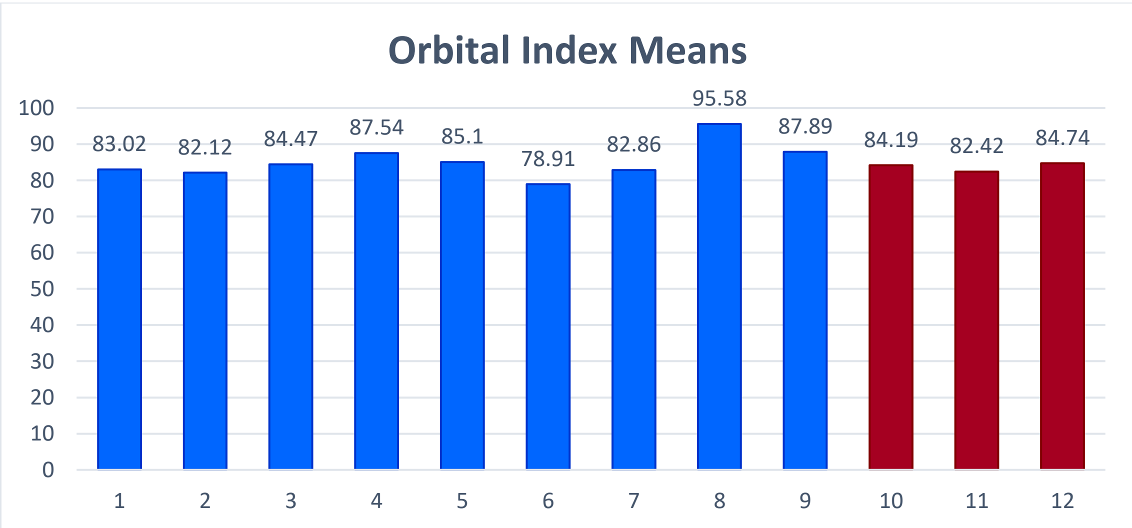


Figure 4.14: Orbital indices means for British (1-9) and Howells' European (10-12) samples

## 4.3 Discriminant Function Analysis

Discriminant function analysis was carried out for the first part of this study. First, the data were analysed with no differentiation between males and females. The British samples were first compared to each other to see whether there are statistically significant differences among the data.  In the second part, the samples were pooled, and male data were compared for all the British groups, as well as female data.

For a more comprehensive analysis, Howells' data set was used to see how the major human groups differentiate and if the British samples cluster together based on geographical affinity. First, the comparison was carried out with just the Howells' European samples. Second, Howells' dataset was used for discriminant analysis. However, because it is a conspicuous sample, the major human groups were selected to perform the statistical analysis better. The scatter plots and results for the initial comparison with the complete Howells' dataset can be seen in Appendix 9.

The analysis was first carried out using the raw data. Then, a log transformation of the variables was carried out, to see whether the analysis was better performed with normally distributed data. The results did not differ significantly from the ones resulting from the raw data. In the analysis regarding the non-pooled sample, the correct classification of the individuals was 58.2%, while after the data was log transformed was 58.4%. For the pooled sample, the results had a classification accuracy of respectively 67.4% and 65.6% for females and 58.8% and 60.6% for males. For this reason, only the results for the raw data analysis are discussed.

A stepwise discriminant function with Mahalanobis distance procedure was also applied to test the accurate classification of the individuals. Once again, the results were compared to the ones from the DFA. Here, the difference between the correct classifications for the two methods was high. In the non-pooled British sample analysis, the classification accuracy was 55.1% using the stepwise method. For the pooled sample, the results were 49.3% for females and 53% for males. The standard discriminant method was therefore used as the classification accuracy is better performed using this procedure.

## 4.3.1 Inter-population Analysis: Non-pooled British Samples

Discriminant function analysis allowed to discriminate between British non-pooled samples. As seen in Table 4.1, the classification accuracy for this test was 58.2%. The scatterplot in Fig. 4.15 shows how the British samples cluster based on the first two discriminant functions. As showed by the results of the Eigenvalues (see Appendix 10), which represent the amount of variance accounted for by each discriminant function, the first two account for 80.5% of the total variation (Function 1 = 56.3% and Function 2 = 24.1).

It is clear Table 4.1 and Fig. 4.15 that some samples share similarities. In fact, Poulton shows a classification accuracy of just 39.4%, with 12.1% of the individuals clustering in St Owen and 11.4% respectively into Castle Hill and Ballumbie. A smaller percentage of the sample (8.3%) appears to classify in Linenhall and London groups. Gloucester is the most homogeneous sample, as 48.3% are correctly classified. Instead, 17.2% are classified under the Poulton sample, and 12.1% is misclassified into Linenhall. A further 6.9% is classified respectively into London, St Gregory and Ballumbie. The poorest classification results are represented by St Gregory, which shows 17.1% of misclassification respectively in Poulton and Ballumbie. Castle Hill and Ballumbie show a good sample classification (61.1% and 58.3%), but still lower compared to the other groups. In fact, Linenhall, London, St Leonard and Guisborough represent the samples with the highest classification accuracy. Linenhall shows 71.4% correctly classified individuals, while 14.3% of the sample classified respectively in St Owen and St Leonard. The results could be due to the small sample size (7 individuals), compared to the others. London has a very good classification accuracy, resulting in 74% of the individuals being assigned to the original group. The major similarities are shared by this sample with Guisborough, St Owen and Castle Hill. Similarly, St Leonard reaches an accuracy of 72.4%, with 7.5% of the individuals misclassified in St Gregory and 5.5% in St Owen groups. Finally, the highest percentage is shown by Guisborough (88.9 %), with a minimal misclassification corresponding to 5.6% in both London and Ballumbie. Also, in this case, the sample size, that is remarkably smaller than the others (18), could affect the results of the classification.

The results are better represented in the scatterplot shown in Fig. 4.15. The samples that had a higher correct classification percentage display a looser cluster compared to the other groups. In fact, it can be seen that Guisborough and St Leonard act as outliers, while the closest associations are represented by Ballumbie, St Gregory and St Owen. Further outlier samples, but with a less isolated position in the scatterplot, are represented by Castle Hill and Linenhall, which are closer to Poulton, and London.

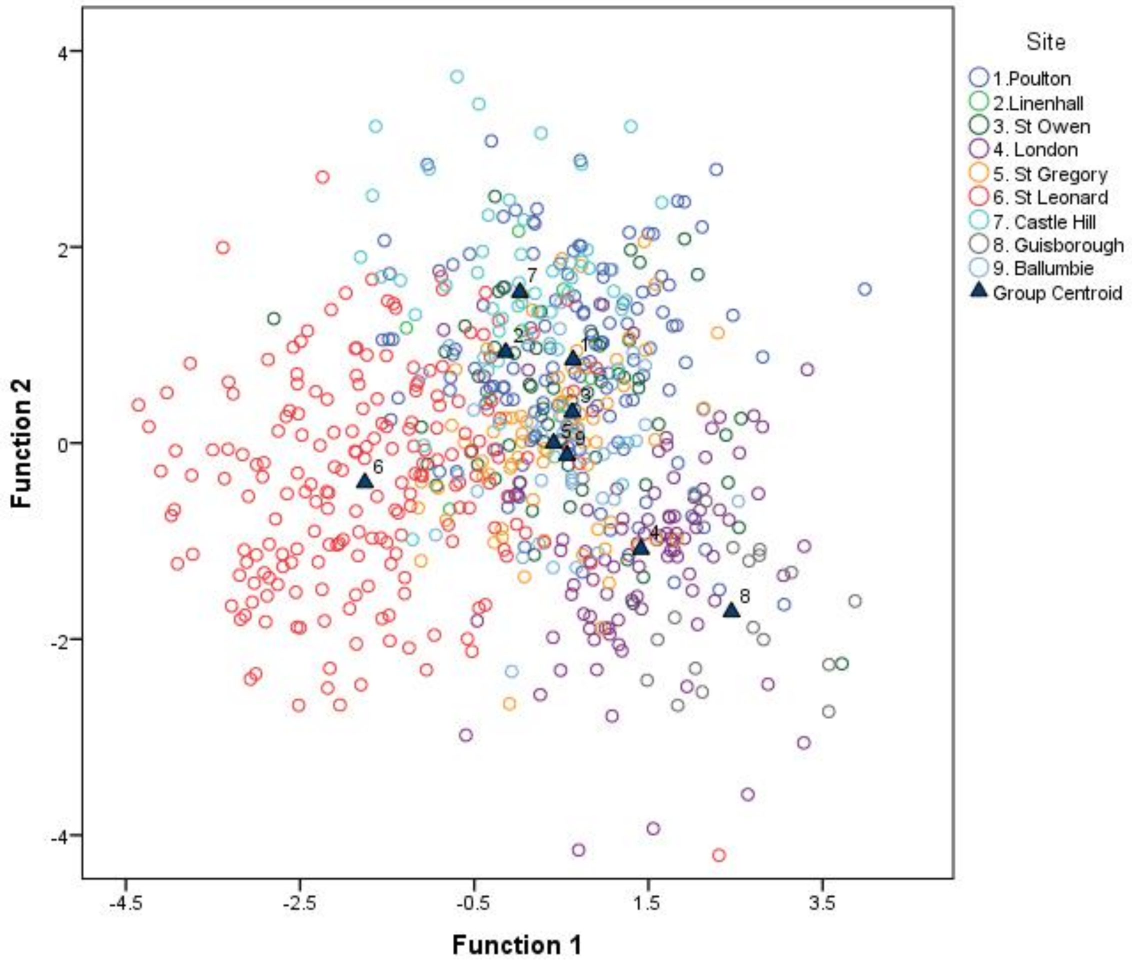


Figure 4.15: Scatterplot for the comparison between non-pooled British samples

**Classification Results**

| | | Predicted Group Membership | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
| % | 1 | 39.4 | 8.3 | 12.1 | 8.3 | 5.3 | 3.0 | 11.4 | .8 | 11.4 | 100.0 |
| | 2 | .0 | 71.4 | 14.3 | .0 | .0 | 14.3 | .0 | .0 | .0 | 100.0 |
| | 3 | 17.2 | 12.1 | 48.3 | 6.9 | 6.9 | 1.7 | .0 | .0 | 6.9 | 100.0 |
| | 4 | 2.1 | 1.0 | 5.2 | 74.0 | 4.2 | .0 | 5.2 | 6.3 | 2.1 | 100.0 |
| | 5 | 17.1 | 2.9 | 15.7 | 8.6 | 28.6 | 5.7 | 4.3 | .0 | 17.1 | 100.0 |
| | 6 | 1.0 | 3.5 | 5.5 | 1.5 | 7.5 | 72.4 | 4.5 | .0 | 4.0 | 100.0 |
| | 7 | 13.0 | 7.4 | 3.7 | .0 | .0 | 3.7 | 61.1 | 3.7 | 7.4 | 100.0 |
| | 8 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | 88.9 | 5.6 | 100.0 |
| | 9 | 5.6 | 2.8 | 5.6 | 11.1 | 5.6 | 2.8 | 5.6 | 2.8 | 58.3 | 100.0 |

58.2% of original grouped cases correctly classified.

Table 4.1: Non-pooled British samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie)

## 4.3.2 Pooled Samples Analysis

### British Males

The results for the British male sample mostly follow the same pattern of the non-pooled sample analysis. The percentage for the correct classification of the individuals amounts at 58.8%, which is very close, but more accurate than the non-pooled sample (Table 4.2). The Eigenvalues (see Appendix 10) demonstrate that the first two functions, which are used to generate the scatterplot in Fig. 4.16, account for 81.4% of the total variance (Function 1 = 51.6% and Function 2 = 29.9%).

Table 4.2 shows how the groups were classified following the discriminant function analysis. The belonging of the individuals to the original groups is more varied than the classification of the non-pooled sample. Poulton shows the poorest classification results, with 40.2% of its sample classified in the original group, while 19.6% clusters with St Owen, 15.2 % with Castle Hill and 10.9% with Ballumbie. The other two groups that show the highest misclassification of the individuals are St Gregory (45.8%) and St Owen (48.7%). St Gregory seems to share similarities with Poulton (14.6%), St Owen (12.5%) and London (10.4%), while St Owens had 15.4% of misclassified cases in Poulton and 10.3% respectively in London and Ballumbie. A higher percentage of correct classification is shown by Castle Hill (61%), Ballumbie (64%) and St Gregory (67%). Ballumbie exhibits a lower misclassification rate than the non-pooled sample analysed in section 4.3.1, locating the higher amount of misclassified individuals in the London sample. The similarities remain equal for Castle Hill but change for the sample from St Leonard, which seems that the misclassification is mostly present in St Gregory. Finally, the highest degrees of correct classification is shown by London, Linenhall and Guisborough. Again, the results obtained for Linenhall (80%) and Guisborough (87.5%) can be a result of the small sample included in the analysis. London instead seems to share similarities with St Owens and Guisborough.

The results are well evident in Fig. 4.16, where it is noticeable a distribution similar to the non-pooled sample. Again, St Owen, St Gregory and Ballumbie form a cluster in the centre of the scatterplot. Linenhall and Poulton seem to have a closer association with this group, while Castle Hill tends to differentiate from it. Equally to the previous analysis, London forms a loose association with the main group and tends towards Guisborough that still highly discriminates from the rest of the samples. The sample from St Leonard shows remarkable discrimination. In fact, its individuals cluster in a nearly completely different group compared to the others and this is also confirmed by Table 4.2, reiterating the non-pooled sample analysis.

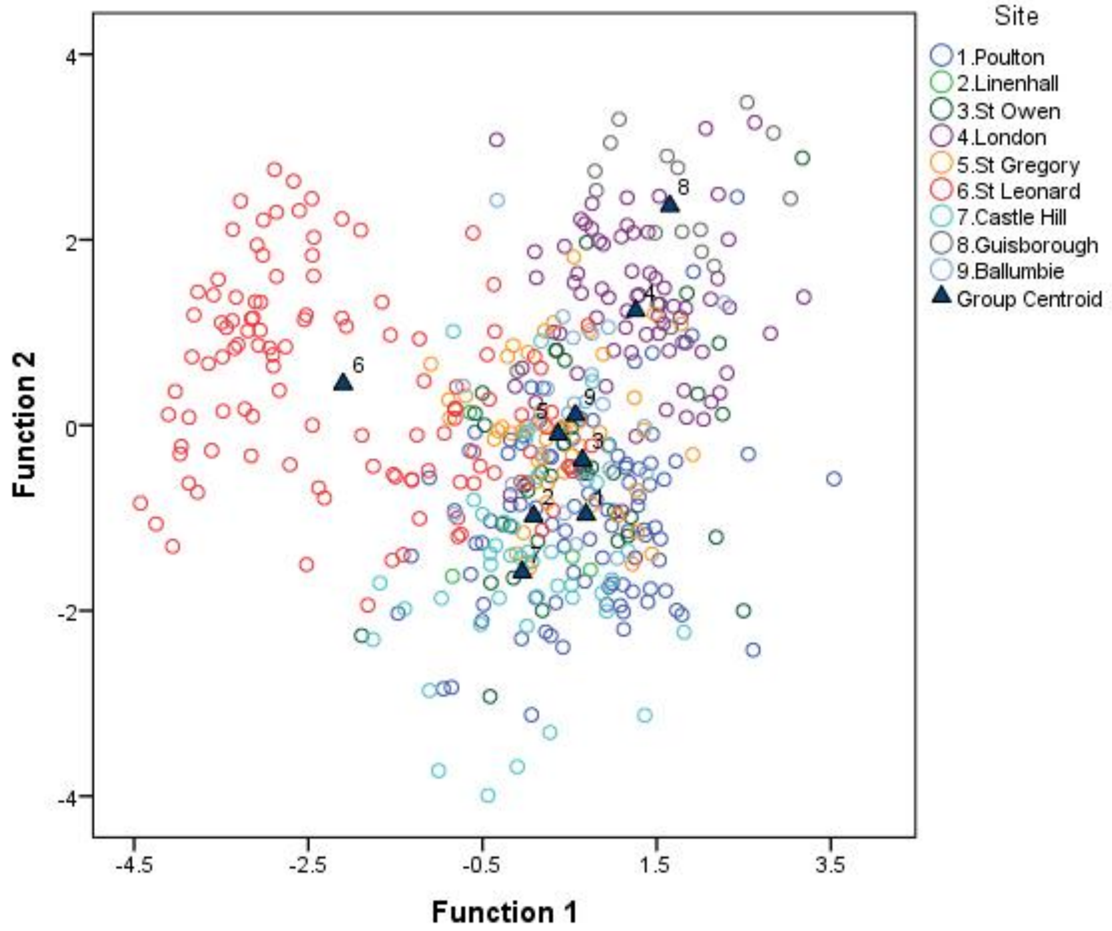


Figure 4.16: Scatterplot for the comparison between British male samples

**Classification Results**

| | Sample | Predicted Group Membership 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 1 | 40.2 | 4.3 | 19.6 | 4.3 | 3.3 | 1.1 | 15.2 | 1.1 | 10.9 | 100.0 |
| | 2 | .0 | 80.0 | .0 | .0 | 20.0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 15.4 | 7.7 | 48.7 | 10.3 | 5.1 | .0 | 2.6 | .0 | 10.3 | 100.0 |
| | 4 | 1.4 | .0 | 7.0 | 73.2 | 5.6 | .0 | 1.4 | 7.0 | 4.2 | 100.0 |
| | 5 | 14.6 | 2.1 | 12.5 | 10.4 | 45.8 | .0 | 6.3 | .0 | 8.3 | 100.0 |
| | 6 | 1.8 | .9 | 3.6 | 1.8 | 17.0 | 67.0 | 4.5 | .0 | 3.6 | 100.0 |
| | 7 | 7.3 | 9.8 | 2.4 | .0 | 4.9 | 2.4 | 61.0 | 2.4 | 9.8 | 100.0 |
| | 8 | .0 | .0 | .0 | 6.3 | .0 | .0 | .0 | 87.5 | 6.3 | 100.0 |
| | 9 | 8.0 | .0 | 8.0 | 12.0 | .0 | 4.0 | .0 | 4.0 | 64.0 | 100.0 |

58.8% of original grouped cases correctly classified.

Table 4.2: British male samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie)

### British Females

The results for the analysis of the female sample show a classification accuracy of 67.4%, which is higher than the previous results discussed in this study (Table 4.3). The samples are plotted on the first two discriminant functions in Fig. 4.17 and the distribution is consistent with the non-pooled sample, with slight differences if comparing the results with the male group. The first two functions account for 71.9% of the total variance (Function 1 = 55% and Function 2 = 16.9%) (see Appendix 10), which is lower than the previous two analyses.

The samples analysed for the female sample are much smaller than the male ones, and this could affect the classification of the individuals, especially for Linenhall and Guisborough, which have just two individuals available for the analysis. In fact, the two samples show a correctly classified percentage of 100%. London and Ballumbie show a very high percentage, with results of respectively 80% and 81.8%. Although the sample size of females is substantially smaller than that of males, the total sample number was still large enough to be considered for the analysis. Ballumbie shows the only misclassification in St Gregory sample (18.2%), while the 8% of the individuals from London were misclassified into Ballumbie and 4% into St Owen and St Gregory. A 76.9% of correctly classified cases results for the group from Castle Hill, with a 23.1% assigned to Poulton. St Leonard as well has a good classification rate (74.7%), with a 5.7% of the cases misclassified in St Gregory's sample and 4.6% respectively into Poulton and Linenhall. St Owen has a reasonably good classification percentage (68.4%), with 10.5% of the individuals being classified both into Poulton and Linenhall. Finally, the poorest classification rates are shown for the Poulton sample (50%) and St Gregory (36.4%). The first sample shares most of the similarities with London (15%), while the second saw the 22.7% of the individuals assigned to Poulton and 18.5% with Gloucester.

The scatterplot in Fig. 4.17 shows a tight cluster formed by St Gregory, St Owen and Ballumbie. Poulton seems to get closer to this central cluster if compared to the analysis carried out for the male individuals, while Linenhall seems still to keep the same distance from the other centroids. There are evident changes for Castle Hill, which appears to be more isolated in the females comparison and this is also confirmed from the percentages shown in Table 4.3. The samples of London and Guisborough maintain the same position in the cluster, similarly to St Leonard. The only difference regarding this last group is that the individuals appear more spread in the scatterplot, compared to the male sample. In fact, the male sample tended to form a highly loose cluster on the side of the scatterplot, while the females show a broader spatial distribution.

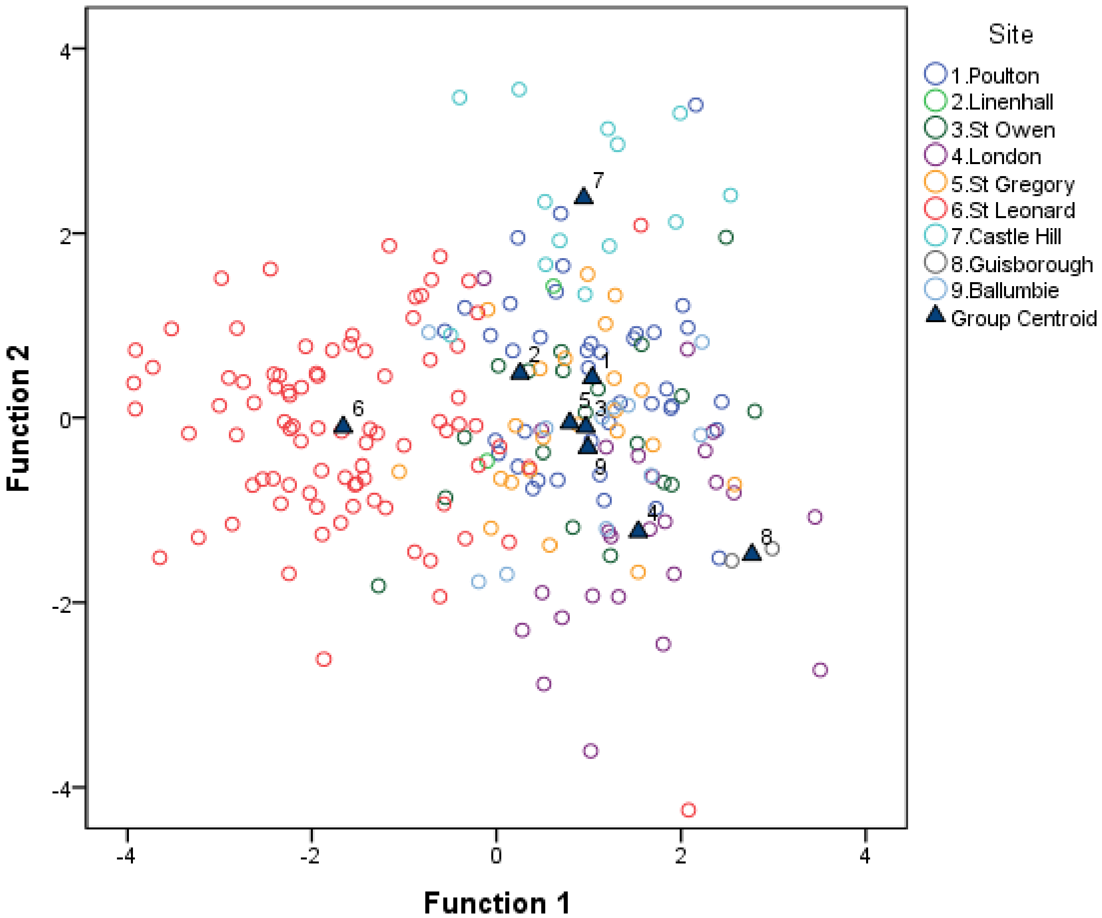


Figure 4.17: Scatterplot for the comparison between British female samples

**Classification Results**

| | Sample | Predicted Group Membership 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 1 | 50.0 | 2.5 | 7.5 | 15.0 | 7.5 | 2.5 | 7.5 | .0 | 7.5 | 100.0 |
| | 2 | .0 | 100.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 10.5 | 10.5 | 68.4 | .0 | 5.3 | 5.3 | .0 | .0 | .0 | 100.0 |
| | 4 | .0 | .0 | 4.0 | 80.0 | 4.0 | .0 | 4.0 | .0 | 8.0 | 100.0 |
| | 5 | 22.7 | 4.5 | 18.2 | 4.5 | 36.4 | 4.5 | .0 | .0 | 9.1 | 100.0 |
| | 6 | 4.6 | 4.6 | 2.3 | 1.1 | 5.7 | 74.7 | 3.4 | .0 | 3.4 | 100.0 |
| | 7 | 23.1 | .0 | .0 | .0 | .0 | .0 | 76.9 | .0 | .0 | 100.0 |
| | 8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 | .0 | 100.0 |
| | 9 | .0 | .0 | .0 | .0 | 18.2 | .0 | .0 | .0 | 81.8 | 100.0 |

67.4% of original grouped cases correctly classified.

Table 4.3: British female samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie)

## 4.3.3 Comparison with W.W. Howells data set

### British and Howells European Non-pooled Samples

This stage of the analysis compares the non-pooled British samples with Howells European groups to test whether there are any similarities between groups of individuals. The classification was carried out with an accuracy of 51.3% (Table 4.4), with Eigenvalues (see Appendix 11) showing that the first two discriminant functions account for 65.6% of the total variance (Function 1 = 47.2% and Function 2 = 18.4%).

The overall distribution of the individuals in the scatterplot tends to remain stable if compared to the ones discussed in the previous sections. However, the correct classification percentages diminish as the sample analysed is bigger and therefore there is an increased chance for the individuals to be misclassified. The highest classification accuracy is shown by Linenhall (71.4%) and Guisborough (88.9%). Again, this could be the result of the small sample sizes of these two collections, but it is worthy of attention that none of the individuals from these groups has been misclassified in the ones from mainland Europe. Good classification results are shown by St Leonard (69.8%) and London (62.5%), which both seem to have a misclassification mainly into the other British groups. London though shows six individuals (6.3%) that have been misclassified in the Zalavar group. Castle Hill reports some individuals that have been assigned to the Europe mainland groups, but the percentages are not significant (5.6% and 3.7%). St Owen seems to be the sample that shares more characteristics with the Norse sample (10.3%), but the same percentage of misclassified individuals can also be seen in the samples of Linenhall and Poulton. Finally, the poorest classification rates are represented by Poulton (28.8%) and St Gregory (24.3%). Poulton shares many of its individuals with the European groups: six were classified as Norse, eight as Zalavar and 11 into the Berg group. Even though, most of the classification percentage is still between the British samples. St Gregory instead seems more similar to the British than the ones from the Howells sample.

The scatterplot in Fig. 4.17 shows a tight cluster that is formed by Poulton and St Owen in the middle. A second, but looser cluster is formed by St Gregory, Ballumbie and the Berg sample. Slightly detached from the groups clustered in the middle are the Norse and Zalavar samples. Linenhall and Castle Hill seem to differentiate from the other samples, but still not isolated. Similarly, London seems to reiterate the classification given by the previous analyses, resulting as a separate group. Finally, Guisborough and St Gregory seem to not share any similarities with the other British and European groups, as they result as two isolated samples far removed from any of the other groups.

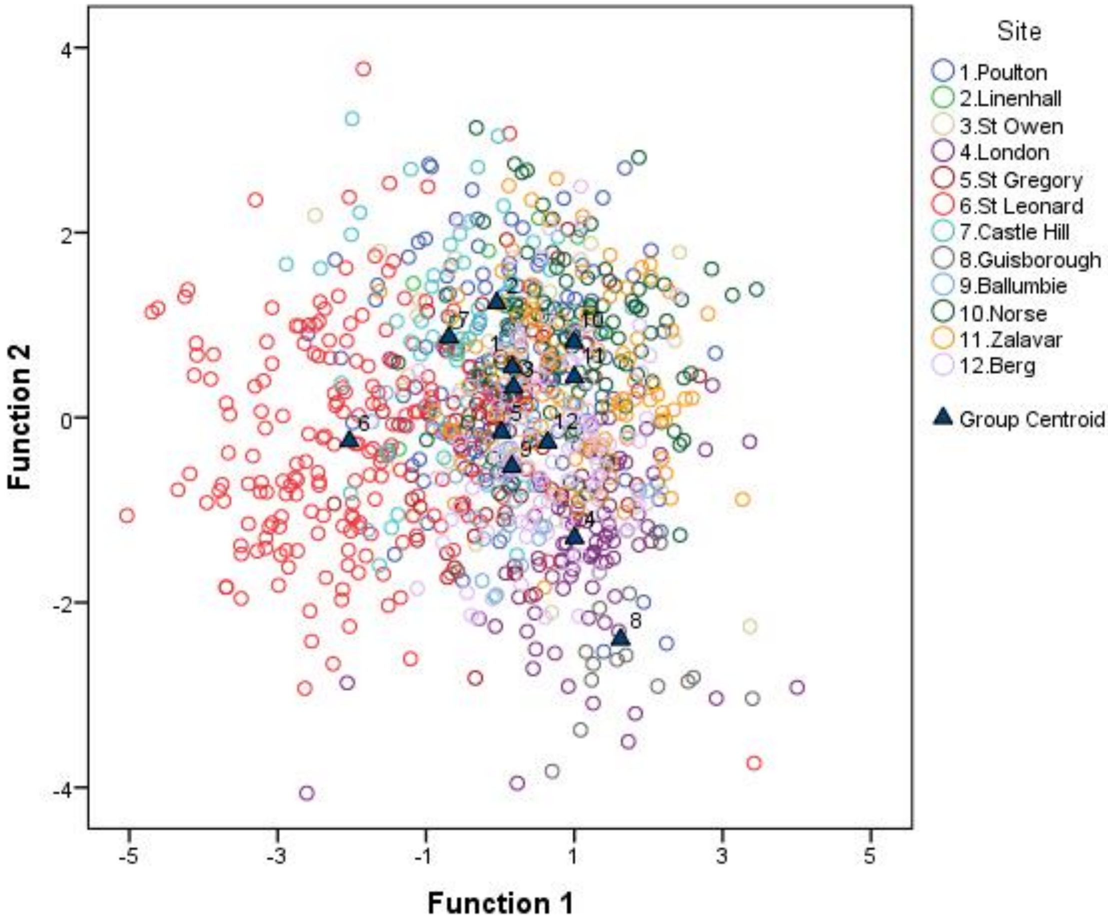


Figure 4.18: Scatterplot for the comparison between British and Howells' European non-pooled samples

**Classification Results**

| | Sample | Predicted Group Membership 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 1 | 28.8 | 7.6 | 10.6 | 4.5 | 3.8 | 4.5 | 11.4 | .8 | 9.1 | 4.5 | 6.1 | 8.3 | 100.0 |
| | 2 | .0 | 71.4 | 14.3 | .0 | .0 | 14.3 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 10.3 | 10.3 | 46.6 | 5.2 | 6.9 | 1.7 | .0 | .0 | 6.9 | 10.3 | 1.7 | .0 | 100.0 |
| | 4 | 1.0 | .0 | 5.2 | 62.5 | 4.2 | 3.1 | 2.1 | 8.3 | 2.1 | 2.1 | 6.3 | 3.1 | 100.0 |
| | 5 | 10.0 | 2.9 | 14.3 | 10.0 | 24.3 | 5.7 | 4.3 | 1.4 | 11.4 | 5.7 | 5.7 | 4.3 | 100.0 |
| | 6 | 1.0 | 3.5 | 4.0 | 1.0 | 4.0 | 69.8 | 6.5 | .0 | 2.5 | .5 | 2.0 | 5.0 | 100.0 |
| | 7 | 14.8 | 3.7 | 3.7 | .0 | 1.9 | 5.6 | 51.9 | 3.7 | 5.6 | 5.6 | .0 | 3.7 | 100.0 |
| | 8 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | 88.9 | 5.6 | .0 | .0 | .0 | 100.0 |
| | 9 | 2.8 | 2.8 | 5.6 | 13.9 | 5.6 | 2.8 | 8.3 | .0 | 44.4 | 2.8 | .0 | 11.1 | 100.0 |
| | 10 | 4.5 | 7.3 | 8.2 | 4.5 | 6.4 | .0 | 4.5 | .0 | 3.6 | 43.6 | 15.5 | 1.8 | 100.0 |
| | 11 | 2.0 | 4.1 | 3.1 | 5.1 | 7.1 | 1.0 | 1.0 | 3.1 | 1.0 | 16.3 | 43.9 | 12.2 | 100.0 |
| | 12 | 6.4 | .9 | .0 | 6.4 | 1.8 | 1.8 | 1.8 | .9 | 4.6 | 5.5 | 6.4 | 63.3 | 100.0 |

51.3% of original grouped cases correctly classified.

Table 4.4: British and Howells' European non-pooled samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie)

### British and Howells European Male Samples

The comparison between the British and Howells' European males are shown in Fig. 4.18 and Table 4.5. The scatterplot confirms the results both given by the analyses of the non-pooled sample and the British samples. The correctly classified individuals amount at 52% and the Eigenvalues (see Appendix 11) show that the first two Functions account for 68.7% of the variability (Function 1 = 46.3% and Function 2 = 22.5%).

The correct classification rates rise when the samples are pooled, and they remain similar to the previous classification. Still can be seen a high classification rate for the samples of Linenhall (80%) and Guisborough (87.5%). Fairly good classification rates are shown for St Leonard (67.9%), London (62%) and the Berg group (62.5%). Overall the British samples tend to misclassify their individuals in the British groups. The poorest classification percentage is shown by Poulton (34.8%) and the Norse sample (36.4%). The only British samples that had a more significant amount of individuals misclassified in Howells' European sample are Poulton and Castle Hill, with respectively eight individuals assigned to the Norse group and four individuals to the Berg sample. The European samples seem to be share more similarities between them, apart from an 11.3% of the Zalavar sample classified into the St Gregory group and 9.1% of the Norse sample classified in the St Owen group.

The scatterplot in Figure 4.18 shows the distribution of the samples according to Function 1 and Function 2. It is clear that there are three main clusters. The first is represented by St Owen, St Gregory and Ballumbie that are plotted very closely together. This association remains constant over all the analyses carried out for this study. The second cluster is formed by Linenhall and Poulton. Close to this group is the third cluster formed by the European samples, which seem to differentiate from the British ones. London and Guisborough seem to be isolated from the rest of the samples in the same quadrant, but they do not form a cluster together as they seem quite far away from each other. Finally, St Leonard is the sample that seems to show the higher discrimination from the other groups. In fact, even if its individuals are fairly spread on the right side of the plot, most of them seem inclined to the opposite direction from the main clusters, both British and European.

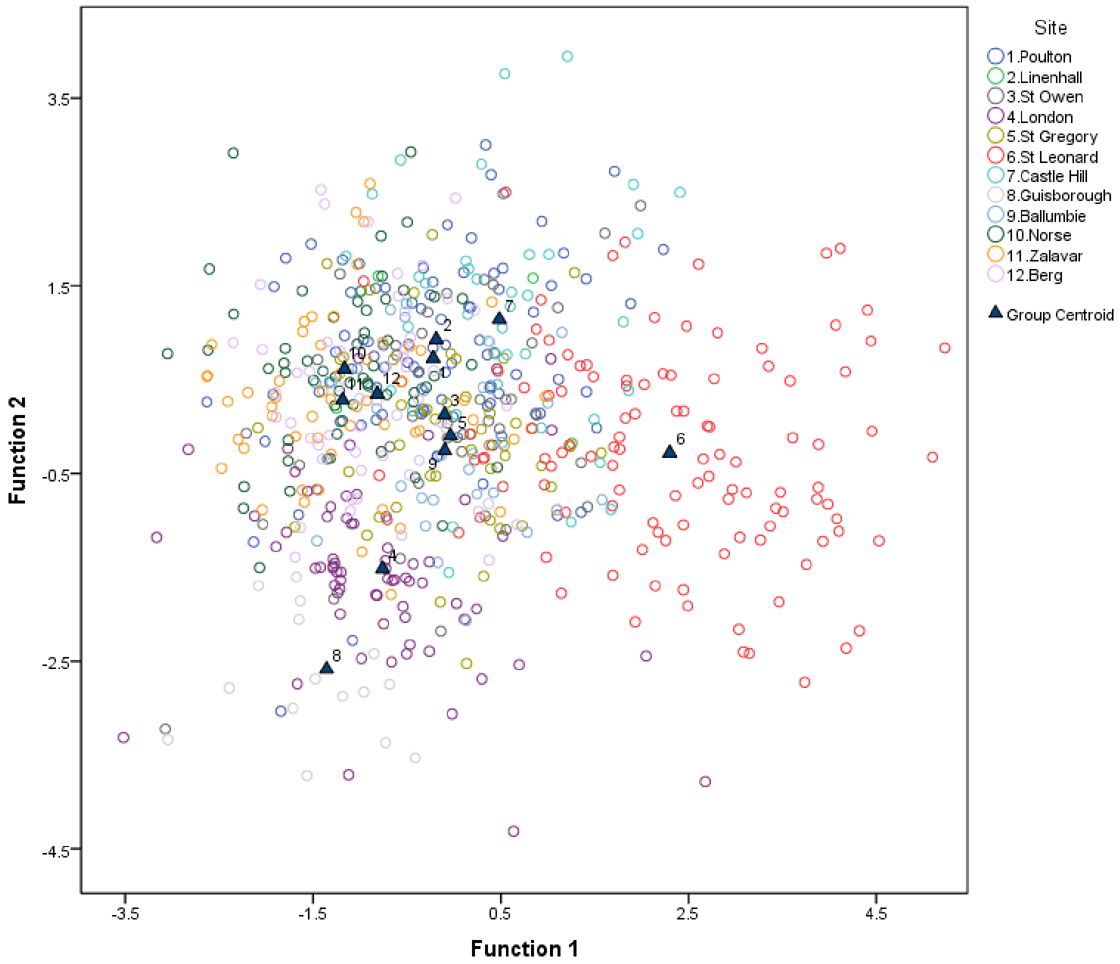


Figure 4.18: Scatterplot for the comparison between British and Howells' European male samples

**Classification Results**

| | | Predicted Group Membership | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
| % | 1 | 34.8 | 6.5 | 10.9 | 2.2 | 1.1 | 1.1 | 13.0 | 1.1 | 8.7 | 8.7 | 4.3 | 7.6 | 100.0 |
| | 2 | .0 | 80.0 | .0 | .0 | .0 | 20.0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 15.4 | 7.7 | 43.6 | 7.7 | 10.3 | 2.6 | .0 | .0 | 5.1 | 7.7 | .0 | .0 | 100.0 |
| | 4 | 1.4 | .0 | 4.2 | 62.0 | 5.6 | 2.8 | 1.4 | 11.3 | 7.0 | .0 | 1.4 | 2.8 | 100.0 |
| | 5 | 4.2 | 4.2 | 10.4 | 12.5 | 39.6 | 2.1 | 4.2 | .0 | 8.3 | 4.2 | 6.3 | 4.2 | 100.0 |
| | 6 | .0 | 1.8 | 1.8 | .9 | 13.4 | 67.9 | 7.1 | .0 | 2.7 | .9 | .9 | 2.7 | 100.0 |
| | 7 | 9.8 | 9.8 | 4.9 | .0 | 4.9 | 4.9 | 46.3 | 2.4 | 2.4 | 4.9 | .0 | 9.8 | 100.0 |
| | 8 | .0 | .0 | .0 | 6.3 | .0 | .0 | .0 | 87.5 | 6.3 | .0 | .0 | .0 | 100.0 |
| | 9 | 4.0 | .0 | 12.0 | 16.0 | 8.0 | 4.0 | 8.0 | .0 | 44.0 | .0 | .0 | 4.0 | 100.0 |
| | 10 | 5.5 | 1.8 | 9.1 | 7.3 | 5.5 | .0 | 9.1 | .0 | 1.8 | 36.4 | 20.0 | 3.6 | 100.0 |
| | 11 | .0 | 3.8 | .0 | 1.9 | 11.3 | .0 | 1.9 | 5.7 | .0 | 13.2 | 52.8 | 9.4 | 100.0 |
| | 12 | 5.4 | 3.6 | 1.8 | 3.6 | 3.6 | .0 | 1.8 | .0 | 5.4 | 7.1 | 5.4 | 62.5 | 100.0 |

52.0% of original grouped cases correctly classified.

Table 4.5: British and Howells' European male samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie; 10. Norse; 11. Zalavar; 12. Berg)

## British and Howells European Female Samples

The comparison between British and Howells' European females show results that are slightly different from the comparisons between the male samples. The classification accuracy amounts at 53.9% (Table 4.6) and the Eigenvalues (see Appendix 11) show that the first two Discriminant Functions account for 64.1% of the variation (Function 1 = 42.1% and Function 2 = 21.9%).

In Table 4.6 are shown the classification percentages. The highest rates are shown by Ballumbie (80%) and St Leonard (71.3%). Guisborough reports a 100% correctness in the classification, but the sample is too small to be analysed, just as the one from Linenhall. Ballumbie shows no misclassifications of its individuals in the European groups, but just in the group of St Gregory. This time St Leonard shows that five elements of its sample are classified in the Berg group, while the rest are assigned to British groups. Castle Hill reports a fairly correct classification (69.2%), with no similarities with the European sample, apart from one individual belonging to the Norse group. The other British groups see a relatively poor classification percentage, with St Owen reporting 47.4% and just one individual assigned to the Zalavar group. London appears as the most similar to the European groups, with 12% of the cases classified respectively in the Zalavar and Berg samples. Poulton (40%) results more similar to the British samples, with just four individuals misclassified in the European groups. Finally, the Berg group sees a misclassification of six of its individuals instead into Ballumbie.

As it is clear from Figure 4.19, the samples appear more spread in the scatterplot, and the connections between groups are looser than the previous male samples. The division between the British and the European groups does not seem evident from the analysis of the female samples. Poulton, St Owen and St Gregory seem to be the closest ones, but still not as close as the male samples. Reasonably close to St Owen seems Linenhall, even if the variability of the sample cannot be determined by a very small group for this sample. Guisborough and the Norse sample are relatively close, as well as London and the Zalavar sample. Ballumbie results to be slightly isolated from the other groups, as well as Castle Hill. The clear difference between St Leonard and the other groups also persists in the female samples. It is worthy of attention the outlier from this group, which is completely isolated. The individual is Skeleton 804 from St Leonard, which shows remarkably smaller measurements compared to the other ones.

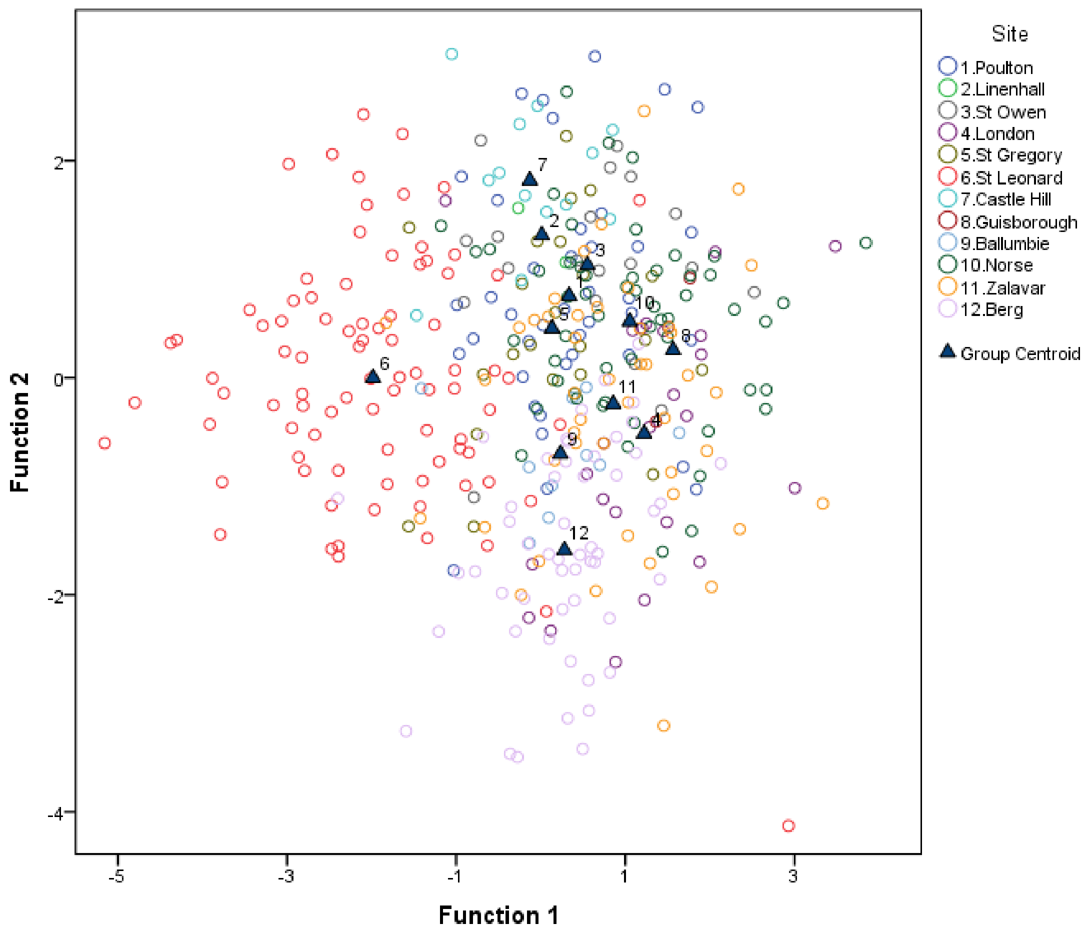


Figure 4.19: Scatterplot for the comparison between British and Howells' European female samples

**Classification Results**

| | Sample | Predicted Group Membership 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 1 | 40.0 | 5.0 | 7.5 | 12.5 | 12.5 | .0 | 7.5 | .0 | 5.0 | 2.5 | 5.0 | 2.5 | 100.0 |
| | 2 | .0 | 50.0 | 50.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 15.8 | 10.5 | 47.4 | .0 | 5.3 | 5.3 | 5.3 | .0 | .0 | 5.3 | 5.3 | .0 | 100.0 |
| | 4 | 4.0 | .0 | 8.0 | 44.0 | 4.0 | 4.0 | 4.0 | .0 | 8.0 | .0 | 12.0 | 12.0 | 100.0 |
| | 5 | 13.6 | 4.5 | 18.2 | 4.5 | 36.4 | 4.5 | .0 | 4.5 | 4.5 | 4.5 | 4.5 | .0 | 100.0 |
| | 6 | 3.4 | 4.6 | 2.3 | 1.1 | 4.6 | 71.3 | 1.1 | .0 | 2.3 | 2.3 | 1.1 | 5.7 | 100.0 |
| | 7 | 7.7 | 7.7 | 7.7 | .0 | .0 | .0 | 69.2 | .0 | .0 | 7.7 | .0 | .0 | 100.0 |
| | 8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 | .0 | .0 | .0 | .0 | 100.0 |
| | 9 | .0 | .0 | .0 | .0 | 20.0 | .0 | .0 | .0 | 80.0 | .0 | .0 | .0 | 100.0 |
| | 10 | 3.6 | 5.5 | 9.1 | 3.6 | 3.6 | 1.8 | 1.8 | .0 | 3.6 | 49.1 | 14.5 | 3.6 | 100.0 |
| | 11 | 8.9 | .0 | 8.9 | 8.9 | .0 | 4.4 | .0 | .0 | .0 | 15.6 | 37.8 | 15.6 | 100.0 |
| | 12 | 3.8 | .0 | .0 | 5.7 | 1.9 | 3.8 | .0 | .0 | 11.3 | 5.7 | 9.4 | 58.5 | 100.0 |

53.9% of original grouped cases correctly classified.

Table 4.6: British and Howells' European female samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie; 10. Norse; 11. Zalavar; 12. Berg)

### British and Howells Non-pooled Samples

The analysis was initially carried out on the complete Howells' sample. However, the number of crania comprising the British samples amounted at 3194 individuals and the results were difficult to interpret, especially the scatterplot. For this reason, the Howells sample was reduced in order to get a better performance of the statistical analysis. The number was reduced from 37 to 21 samples, which represent the major Howells' human groups, for a total of 1766 individuals.

The analysis of the non-pooled samples shows a classification accuracy of 57.8%. The Eigenvalues (see Appendix 12) indicate that the first two Functions account for 60.5% of the total variation (Function 1 = 39.5% and Function 2 = 21%). In Table 4.7 the results for the classification of the individuals can be observed. The first thing that can be noticed is that there is a very low misclassification between the European and the other Howells' groups. The misclassification regarding the British groups is mainly into the European samples and very low in the other samples. The most accurate classification for the British samples is once again seen for Guisborough (88.9%) and Linenhall (71.4%), which do not show any individuals assigned to the Howells groups. St Leonard shows a relatively good correct classification (68.3%). Most of the individuals are assigned to the British or European groups, while just three elements respectively to Hainan and Buriats groups and two individuals to Guam group. Castle Hill shows classification correctness of 51.9%, with the majority of its individuals assigned to the British and European groups. The poorest results are given by St Gregory (20%) and Poulton (25.8%). St Gregory shows six of its individuals assigned to the Yauyos group, while the majority is still comprised in the European sample. Poulton sees only three individuals assigned to the Buriats group and two to the Guam group. The rest of the misclassified skulls are spread between the European samples. Even though London has a good classification rate (47.9%), it is the group that has more similarities with the non-European groups. Seven individuals are assigned to Yauyos and six to Hainan samples.

Similarly, Howells' non-European groups report a very low misclassification in the European sample. The correct classification rates are more accurate than the European ones, showing results above 50% correctness. The highest results are given by Easter Island (89.5%), Buriats (87.2%) and Australian (83.2%) samples. The Shang Dynasty sample also shows a good classification rate (71.4%). A similar score is given by the Guam (66.7%) group, which show a misclassification into geographically close samples. The Yauyos group also has a reasonably good result (67.3%), but it appears as the group with the highest number of individuals assigned to the European samples (11.7%). Finally, the Hainan group shares similarities with the Shang Dynasty, according to their geographical proximity. The Zulu instead seems to show most of its affinity with the Australian group (9.9%).

The discrimination between samples can be better observed in the scatterplot in Fig. 4.20. The European sample is coloured in different shades of blue, while the non-European groups are represented by the other colours. There is a clear division between these two main groups. Most of the British samples form a cluster, where St Leonard, Castle Hill, Linenhall and London tend to be linked by looser associations. Guisborough is the British group that tends to differentiate more from this cluster, reiterating the previous analyses discussed in the sections above. This British sample is located very close to the Buriats, but as shown by the percentages of correctly classified individuals, there is no significant similarity between them. The Norse and Zalavar locate their centroids with a slightly increased distance from the British groups, differently from the Berg sample that is included in the main cluster. The Asian groups cluster together in the upper right side of the plot, confirming the similarities related to the geographical proximity. The Zulu and the Bushmen appear isolated, but both in the lower right side of the plot, close to the Australians. Finally, the Easter Island does not seem to cluster with any of the other groups, confirming the geographical isolation of this human group.

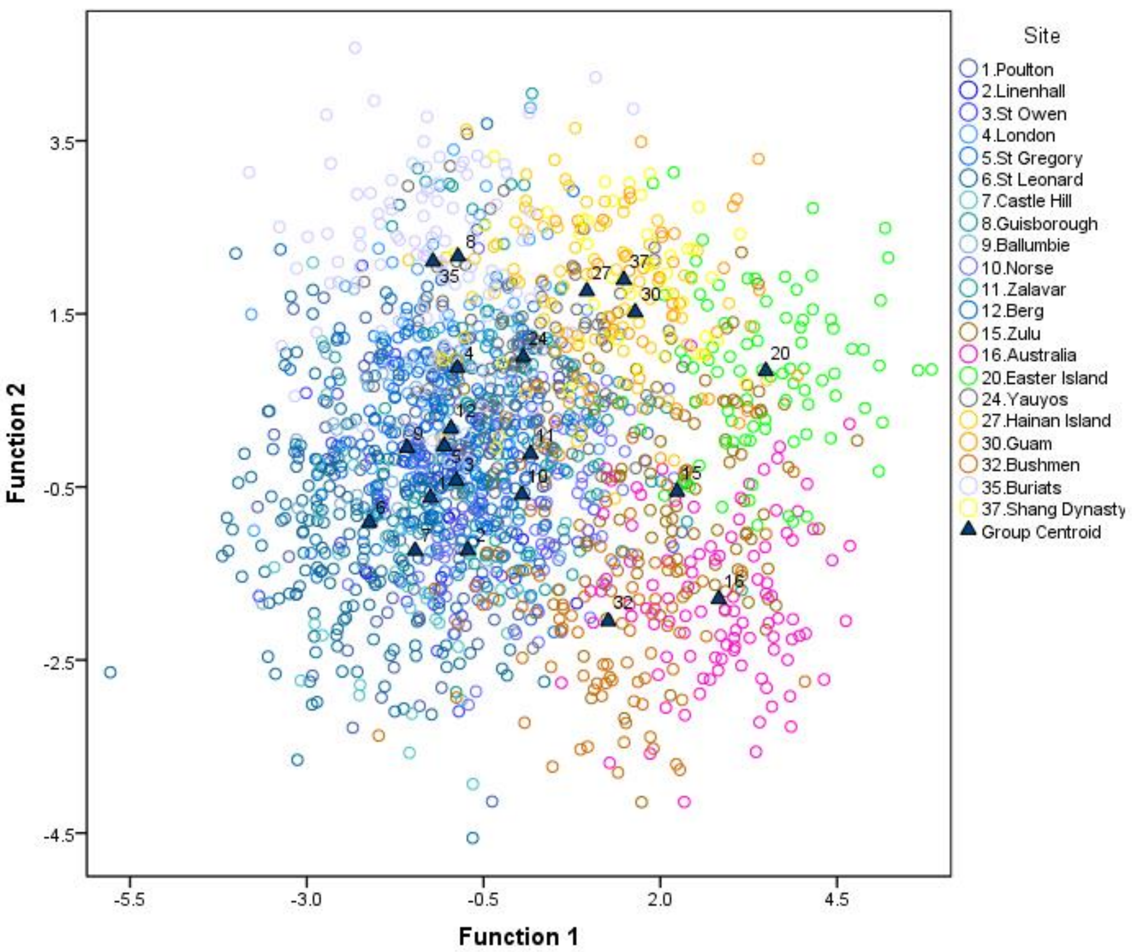


Figure 4.20: Scatterplot for the comparison between British and Howells' non-pooled samples

## Classification Results

| | Sample | Predicted Group Membership | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 15 | 16 | 20 | 24 | 27 | 30 | 32 | 35 | 37 | Total |
| % | 1 | 25.8 | 6.8 | 12.1 | 3.0 | 3.8 | 4.5 | 12.1 | .8 | 7.6 | 3.8 | 4.5 | 9.1 | .8 | .8 | .0 | .8 | .0 | 1.5 | .0 | 2.3 | .0 | 100.0 |
| | 2 | .0 | 71.4 | 14.3 | .0 | .0 | 14.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 6.9 | 15.5 | 36.2 | 5.2 | 8.6 | 1.7 | 1.7 | .0 | 6.9 | 12.1 | 1.7 | .0 | .0 | .0 | .0 | 3.4 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 4 | 1.0 | .0 | 6.3 | 47.9 | 2.1 | 4.2 | 2.1 | 8.3 | 3.1 | 2.1 | 3.1 | 4.2 | .0 | .0 | .0 | 7.3 | 6.3 | 1.0 | .0 | 1.0 | .0 | 100.0 |
| | 5 | 7.1 | 4.3 | 11.4 | 7.1 | 20.0 | 4.3 | 5.7 | 1.4 | 10.0 | 7.1 | 2.9 | 4.3 | .0 | .0 | .0 | 8.6 | .0 | .0 | 1.4 | 4.3 | .0 | 100.0 |
| | 6 | .5 | 2.5 | 4.0 | 1.0 | 4.0 | 68.3 | 6.0 | .0 | 3.0 | 1.0 | 1.0 | 4.0 | .0 | .0 | .0 | .0 | 1.5 | 1.0 | .5 | 1.5 | .0 | 100.0 |
| | 7 | 9.3 | 9.3 | 1.9 | .0 | 3.7 | 3.7 | 51.9 | 1.9 | 3.7 | 5.6 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | 1.9 | .0 | 100.0 |
| | 8 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | 88.9 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 9 | 2.8 | .0 | 5.6 | 13.9 | 5.6 | 2.8 | 8.3 | .0 | 36.1 | 5.6 | .0 | 5.6 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | 8.3 | .0 | 100.0 |
| | 10 | 6.4 | 5.5 | 8.2 | 4.5 | 4.5 | .0 | 4.5 | .0 | 3.6 | 35.5 | 14.5 | 1.8 | 1.8 | 2.7 | .9 | 2.7 | .0 | .0 | 2.7 | .0 | .0 | 100.0 |
| | 11 | 1.0 | 5.1 | 1.0 | 3.1 | 6.1 | 2.0 | 1.0 | 3.1 | .0 | 14.3 | 33.7 | 11.2 | 2.0 | 2.0 | 2.0 | 3.1 | 3.1 | 1.0 | 1.0 | 1.0 | 3.1 | 100.0 |
| | 12 | 4.6 | .0 | .0 | 6.4 | 2.8 | 1.8 | 1.8 | .9 | 5.5 | 4.6 | 3.7 | 52.3 | .0 | .0 | .0 | 4.6 | .9 | .0 | 1.8 | 8.3 | .0 | 100.0 |
| | 15 | .0 | 1.0 | .0 | 1.0 | .0 | .0 | 2.0 | .0 | 1.0 | 3.0 | 1.0 | .0 | 62.4 | 9.9 | 5.0 | .0 | 3.0 | 2.0 | 5.0 | .0 | 4.0 | 100.0 |
| | 16 | .0 | 1.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.9 | .0 | .0 | 5.0 | 83.2 | .0 | .0 | .0 | 1.0 | 3.0 | .0 | .0 | 100.0 |
| | 20 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.2 | .0 | .0 | 1.2 | 89.5 | 1.2 | 1.2 | 3.5 | .0 | .0 | 2.3 | 100.0 |
| | 24 | .0 | .0 | 1.8 | 7.3 | 1.8 | .0 | .0 | 2.7 | 1.8 | .0 | 1.8 | 1.8 | 1.8 | .0 | .0 | 67.3 | 7.3 | 2.7 | .9 | .0 | .9 | 100.0 |
| | 27 | .0 | .0 | .0 | 2.4 | 1.2 | .0 | .0 | 1.2 | .0 | .0 | 3.6 | 1.2 | 3.6 | .0 | .0 | 4.8 | 55.4 | 4.8 | .0 | 1.2 | 20.5 | 100.0 |
| | 30 | .0 | .0 | .0 | .0 | 3.5 | .0 | .0 | .0 | .0 | .0 | 3.5 | .0 | 1.8 | .0 | 5.3 | 1.8 | 12.3 | 66.7 | .0 | .0 | 5.3 | 100.0 |
| | 32 | 1.1 | 2.2 | 1.1 | .0 | .0 | .0 | 2.2 | .0 | 2.2 | .0 | 1.1 | .0 | 4.4 | 4.4 | .0 | 1.1 | .0 | .0 | 80.0 | .0 | .0 | 100.0 |
| | 35 | .9 | .0 | .0 | .0 | 2.8 | 1.8 | .0 | .9 | .9 | .0 | .0 | 3.7 | .0 | .0 | .0 | .9 | .0 | .9 | .0 | 87.2 | .0 | 100.0 |
| | 37 | .0 | .0 | .0 | 4.8 | .0 | .0 | .0 | .0 | .0 | .0 | 7.1 | 2.4 | 2.4 | .0 | 2.4 | .0 | 2.4 | 4.8 | .0 | 2.4 | 71.4 | 100.0 |

57.8% of original grouped cases correctly classified

Table 4.7: British and Howells' non-pooled samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie; 10. Norse; 11. Zalavar; 12. Berg; 15. Zulu; 16. Australia; 20. Easter Island; 24. Yauyos; 27. Hainan Island; 30. Guam; 32. Bushmen; 35. Buriats; 37. Shang Dynasty)

## British and Howells Male Samples

The sample analysed for the pooled data consists in 1036 male individuals. Just like for the non-pooled sample, the same selection of the main human groups from the Howells data set was included in the analysis. The classification accuracy amounts at 58.7% of the cases assigned correctly. The Eigenvalues (see Appendix 12) instead indicate that the first two functions account for 59.3% of the total variance (Function 1 = 39.2% and Function 2 = 20.1%).

Table 4.8 shows the classification results for the male samples analysed. Overall the percentage for correct classification of the individuals is higher than the non-pooled samples. Once again, the British and the European samples tend to locate the misclassified individuals into the British and European groups. The highest percentages of correctly classified cases are again showed by Guisborough (81.3%) and Linenhall (80%). St Leonard follows with 65.2% of correctly classified individuals, but five of its cases are misclassified in Yauyos and Far Eastern samples, while the majority are assigned to the other British groups. The results for the other British samples are quite similar, where Castle Hill sees just two misclassified cases, as well as Gloucester. Poulton shows the poorest classification value (32.6%), but the majority of its individuals are still misclassified in the British and European samples, apart from six cases. The same can be said for Ballumbie (40%), which sees just one individual assigned to the Buriats group. St Gregory also has a very poor classification percentage (33.3%), with six cases assigned to the extra-European sample. The 49.3% of London individuals are correctly assigned to their group, but 14.1% (ten individuals) are assigned to the Yauyos group, which is quite a consistent amount of cases.

For the non-European sample, the correct classification rises. The best results are shown by the Buriats (90.9%), Easter Island (89.8%), Australians (88.5%) and Bushmen (82.5%). The Guam sample also reports good classification results (73.3%), with six individuals assigned to the other two Far-Eastern groups. The Yauyos sample follows with a 69.1% of correctly classified cases, even though five individuals are assigned to the London sample, three to St Gregory and one to Ballumbie. The Shang Dynasty instead (61.9%) saw two cases assigned to the London group and one to Castle Hill. Finally, the Zulu and Hainan Island samples report the same percentage (60%), but both do not show any significant affinity with the European groups, while they are more similar to other geographically close groups.

In Fig. 4.21 can be easily analysed the groups' distribution. As can be observed, the European groups in blue tend to cluster together in the left side of the scatterplot. Poulton and Castle Hill seem very close, while Linenhall, Ballumbie, St Leonard and London form a looser association. St Leonard is forming another cluster with St Owen and the Berg group. Guisborough is the only sample that remains isolated as in the previous analyses, while the

Norse and Zalavar are fairly close. On the other side of the scatterplot, the Far-Eastern samples form a cluster reflecting their geographical proximity. The Zulu and the Bushmen maintain their isolated position in comparison to the European cluster, and in between the two samples is located the Australian group. The Easter Island sample as well occupies an isolated position, reiterating the results given for the non-pooled sample. Finally, the Buriats result as very dissimilar from the British sample, but very close to Guisborough. However, observing the results listed in Table 4.8, there are no evident similarities between the two groups, as just one individual from the British sample is misclassified in the second and none vice versa.

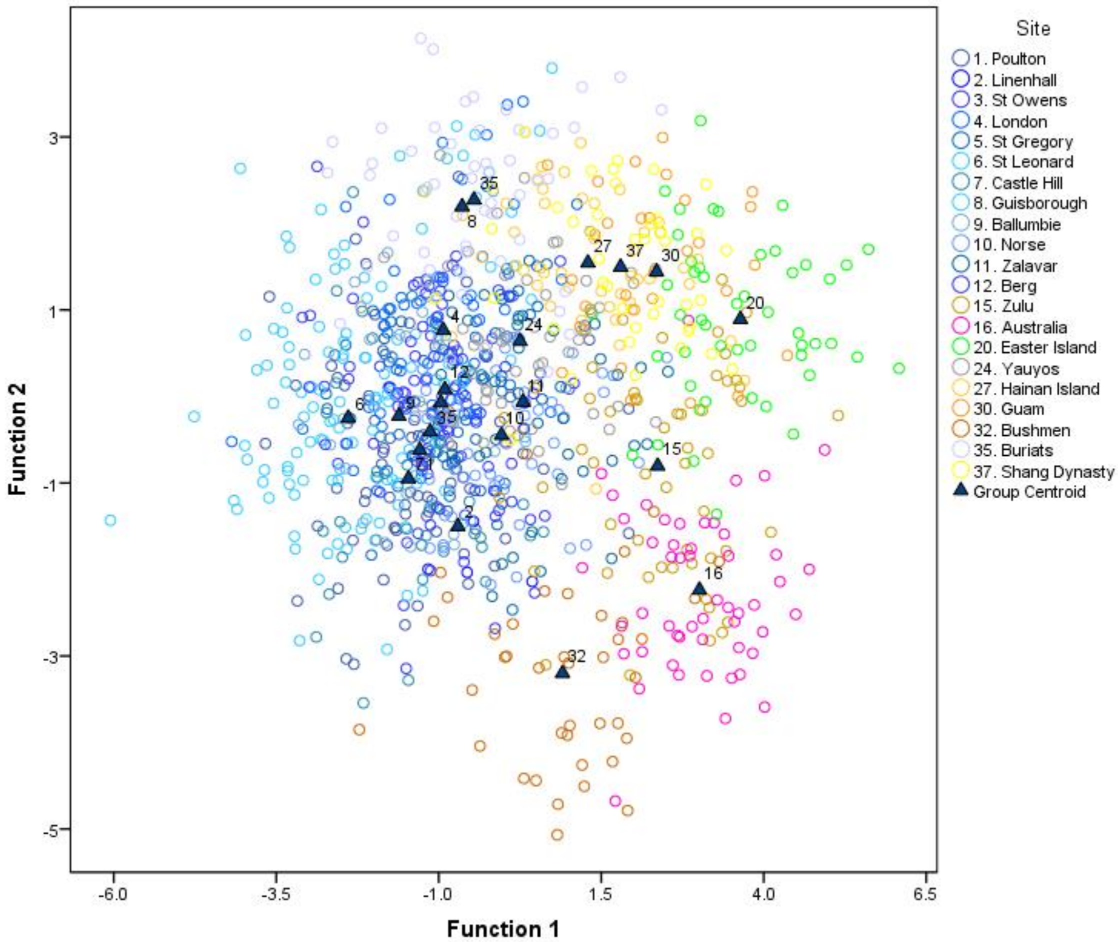


Figure 4.21: Scatterplot for the comparison between British and Howells' male samples

## Classification Results

| | Sample | Predicted Group Membership | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 15 | 16 | 20 | 24 | 27 | 30 | 32 | 35 | 37 | |
| % | 1 | 32.6 | 5.4 | 9.8 | 1.1 | 1.1 | 2.2 | 14.1 | 1.1 | 8.7 | 5.4 | 5.4 | 6.5 | 1.1 | .0 | .0 | 1.1 | .0 | 1.1 | 1.1 | 2.2 | .0 | 100.0 |
| | 2 | .0 | 80.0 | .0 | .0 | .0 | 20.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 15.4 | 5.1 | 43.6 | 7.7 | 7.7 | 2.6 | .0 | .0 | 7.7 | 5.1 | .0 | .0 | .0 | .0 | .0 | 5.1 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 4 | 1.4 | .0 | 2.8 | 49.3 | 1.4 | 2.8 | 1.4 | 9.9 | 8.5 | .0 | 2.8 | 1.4 | .0 | .0 | .0 | 14.1 | 2.8 | .0 | .0 | 1.4 | .0 | 100.0 |
| | 5 | 4.2 | 2.1 | 12.5 | 12.5 | 33.3 | .0 | 6.3 | .0 | 8.3 | 4.2 | .0 | 4.2 | .0 | .0 | .0 | 4.2 | 2.1 | .0 | 2.1 | 4.2 | .0 | 100.0 |
| | 6 | .0 | 2.7 | .9 | .0 | 10.7 | 65.2 | 7.1 | .0 | 5.4 | .9 | .0 | 2.7 | .0 | .0 | .0 | 1.8 | .9 | .9 | .0 | .9 | .0 | 100.0 |
| | 7 | 12.2 | 7.3 | 2.4 | .0 | 4.9 | 2.4 | 43.9 | 4.9 | 4.9 | 2.4 | .0 | 9.8 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | 2.4 | .0 | 100.0 |
| | 8 | .0 | .0 | .0 | 6.3 | .0 | .0 | .0 | 81.3 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.3 | .0 | 100.0 |
| | 9 | 4.0 | .0 | 12.0 | 12.0 | 8.0 | 4.0 | 8.0 | .0 | 40.0 | 4.0 | .0 | 4.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.0 | .0 | 100.0 |
| | 10 | 5.5 | .0 | 10.9 | 5.5 | 5.5 | .0 | 9.1 | .0 | 1.8 | 34.5 | 16.4 | 3.6 | .0 | 3.6 | 1.8 | 1.8 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 11 | .0 | 3.8 | .0 | 1.9 | 11.3 | .0 | 1.9 | 5.7 | .0 | 11.3 | 37.7 | 9.4 | .0 | .0 | 3.8 | 3.8 | 1.9 | 1.9 | 1.9 | .0 | 3.8 | 100.0 |
| | 12 | 5.4 | 1.8 | .0 | 3.6 | 5.4 | .0 | 1.8 | 1.8 | 1.8 | 5.4 | 3.6 | 60.7 | .0 | .0 | .0 | .0 | 1.8 | .0 | 1.8 | 5.4 | .0 | 100.0 |
| | 15 | .0 | 1.8 | .0 | 1.8 | .0 | .0 | 1.8 | .0 | .0 | 1.8 | .0 | .0 | 60.0 | 10.9 | 3.6 | 3.6 | 5.5 | 1.8 | 1.8 | .0 | 5.5 | 100.0 |
| | 16 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | 5.8 | 88.5 | .0 | .0 | .0 | 1.9 | 1.9 | .0 | .0 | 100.0 |
| | 20 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 89.8 | .0 | .0 | 6.1 | .0 | .0 | 4.1 | 100.0 |
| | 24 | .0 | .0 | .0 | 9.1 | 5.5 | .0 | .0 | .0 | 1.8 | .0 | .0 | 1.8 | 1.8 | .0 | .0 | 69.1 | 7.3 | 1.8 | .0 | .0 | 1.8 | 100.0 |
| | 27 | .0 | .0 | .0 | .0 | 4.4 | .0 | .0 | .0 | .0 | .0 | 4.4 | .0 | 2.2 | .0 | .0 | 6.7 | 60.0 | 2.2 | .0 | .0 | 20.0 | 100.0 |
| | 30 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.3 | .0 | 3.3 | .0 | 10.0 | .0 | .0 | 73.3 | .0 | .0 | 10.0 | 100.0 |
| | 32 | .0 | 2.5 | .0 | .0 | .0 | .0 | 2.5 | .0 | 2.5 | .0 | .0 | .0 | 5.0 | 5.0 | .0 | .0 | .0 | .0 | 82.5 | .0 | .0 | 100.0 |
| | 35 | 1.8 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | 90.9 | 1.8 | 100.0 |
| | 37 | .0 | .0 | .0 | 4.8 | .0 | .0 | 2.4 | .0 | .0 | .0 | 7.1 | .0 | 4.8 | .0 | .0 | 4.8 | 11.9 | 2.4 | .0 | .0 | 61.9 | 100.0 |

58.7% of original grouped cases correctly classified

Table 4.8: British and Howells' male samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie; 10. Norse; 11. Zalavar; 12. Berg; 15. Zulu; 16. Australia; 20. Easter Island; 24. Yauyos; 27. Hainan Island; 30. Guam; 32. Bushmen; 35. Buriats; 37. Shang Dynasty)

## British and Howells Female Samples

The samples analysed in the comparison between the females are considerably small. The Shang Dynasty group is excluded, as in Howells' dataset just the males were available. In this part of the study, the individuals used for the comparison are 728. The classification accuracy results now as 63.6%, and the Eigenvalues (see Appendix 12) indicate that the first two Functions account for 58.1% of the total variance (Function 1 = 37.4% and Function 2 = 20.7%).

The correctly classified cases into the original groups are shown in Table 4.9. Similar to the male sample, the British and Europeans tend to stay separated from the non-European groups. The best results for the classification are shown by Guisborough (100%) due to the very small sample included in the analysis. A reasonably good classification percentage is given by St Leonard (71.3%) that tends to be more similar to the British groups and the Berg sample, than the other groups. Another good result is shown by Castle Hill (69.2%), which shows no affinities with the non-European groups. Ballumbie reports 60% of its cases correctly classified, but two of its individuals are assigned to the Yauyos and one to the Buriats group. Even though Linenhall had a 50% classification accuracy, the sample size is very small, and it cannot be considered of vital importance for the analysis. St Owen saw the misclassified percentage assigned mostly to the British groups, while just one individual was assigned to the Easter Island sample. London (44% accuracy) reports most of the similarities with the Berg group and just two cases are assigned to the non-Europeans (Yauyos and Hainan). St Gregory as well has no significant association with the extra-European groups and the same can be said for Poulton, which showed the poorest classification rate (32.5%).

The non-European groups, on the other hand, seem to report better values. The highest percentages are shown by Easter Island (94.6%), Buriats (92.6%) and Guam (85.2%) samples. The Australian group has also an excellent classification rate (79.6%) and one of its individuals is classified in the St Owen group. The Bushmen as well show a reasonably good percentage (77.6%), with most of the affinities encountered with the Zulu. The Yauyos seem to be the group with most of the similarities with the British samples. In fact, eight of its cases are classified into London (four), St Gregory (two), Guisborough (one) and Ballumbie (one). Finally the Zulu and Hainan which do not show any significant similarity to any other group analysed.

In the scatterplot in Fig. 4.22 can be seen the differentiation between the female samples analysed. The British groups seem to form a looser cluster, compared to the previous analyses. Two main clusters are formed by Ballumbie, St Gregory, Poulton and the Berg samples, and another one with poorer connections between Linenhall, Castle Hill and St Leonard. Even though the British samples are more scattered, they are still concentrated on one side of the plot. St Owen tends more towards the Norse and Zalavar samples, while Guisborough maintains its isolated location. The groups from the Far East both cluster on the top of the main cluster, while the African ones tend to be isolated far away from the others in the lower left side. The Australians are plotted in between the Zulu and the Bushmen samples. It can be seen that in this analysis the Buriat females are more isolated than in the non-pooled and male samples. Finally, the Easter Island sample keeps its distance from all the other groups with no association confirmed also by the classification table.

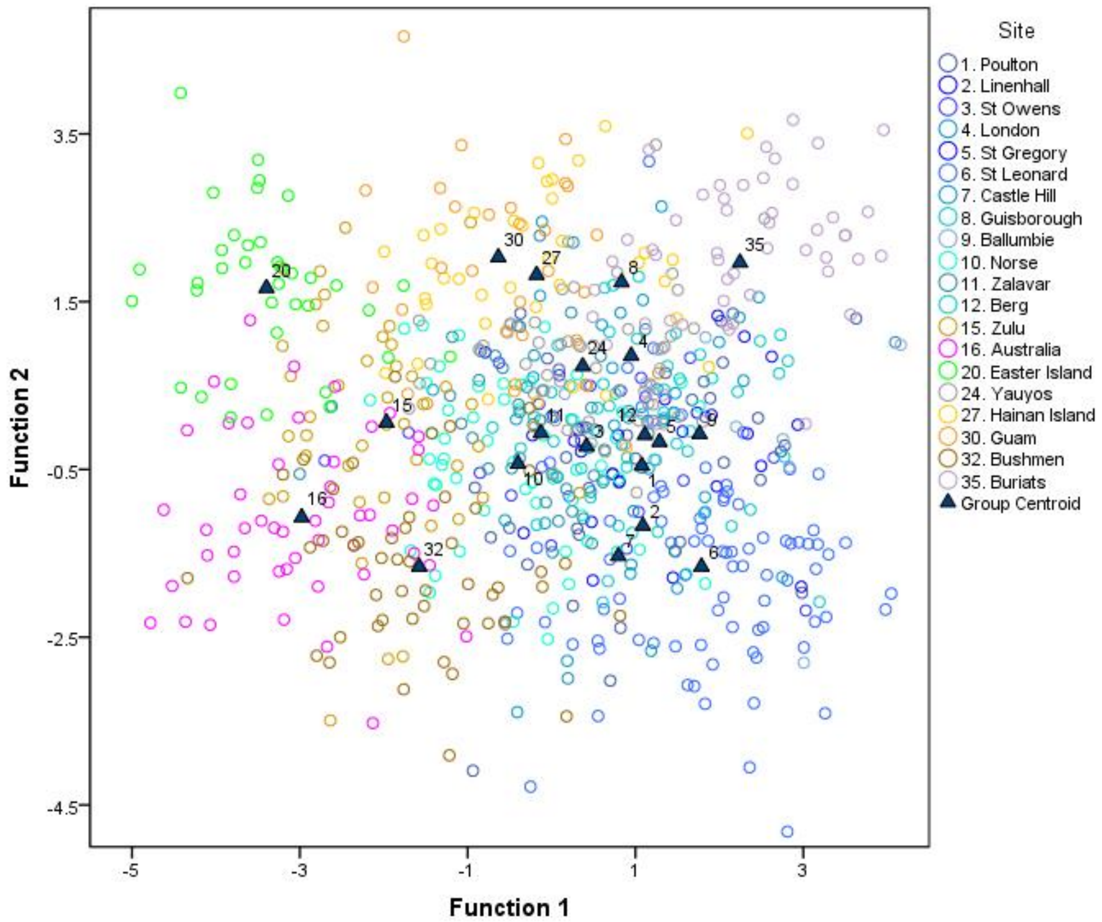


Figure 4.22: Scatterplot for the comparison between British and Howells' female samples

## Classification Results

| | Sample | Predicted Group Membership | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 15 | 16 | 20 | 24 | 27 | 30 | 32 | 35 | |
| % | 1 | 32.5 | 7.5 | 7.5 | 12.5 | 7.5 | .0 | 7.5 | .0 | 5.0 | .0 | 7.5 | 2.5 | 2.5 | .0 | .0 | .0 | .0 | 2.5 | .0 | 5.0 | 100.0 |
| | 2 | .0 | 50.0 | 50.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 3 | 15.8 | 10.5 | 47.4 | .0 | 5.3 | .0 | 5.3 | .0 | .0 | 5.3 | 5.3 | .0 | .0 | .0 | 5.3 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 4 | .0 | .0 | 8.0 | 44.0 | 4.0 | 4.0 | 8.0 | .0 | .0 | 4.0 | 4.0 | 16.0 | .0 | .0 | .0 | 4.0 | 4.0 | .0 | .0 | .0 | 100.0 |
| | 5 | 13.6 | 4.5 | 13.6 | .0 | 31.8 | 9.1 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | .0 | .0 | .0 | .0 | 4.5 | .0 | .0 | .0 | .0 | 100.0 |
| | 6 | 2.3 | 4.6 | 3.4 | 2.3 | 3.4 | 71.3 | 1.1 | .0 | 2.3 | 1.1 | 1.1 | 4.6 | .0 | .0 | .0 | .0 | 1.1 | 1.1 | .0 | .0 | 100.0 |
| | 7 | 7.7 | 15.4 | .0 | .0 | .0 | .0 | 69.2 | .0 | .0 | 7.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | 9 | .0 | .0 | .0 | .0 | 10.0 | .0 | .0 | .0 | 60.0 | .0 | .0 | .0 | .0 | .0 | .0 | 20.0 | .0 | .0 | .0 | 10.0 | 100.0 |
| | 10 | 5.5 | 3.6 | 9.1 | 3.6 | 1.8 | 1.8 | 1.8 | .0 | 1.8 | 40.0 | 16.4 | .0 | 5.5 | 1.8 | .0 | 3.6 | 1.8 | 1.8 | .0 | .0 | 100.0 |
| | 11 | 8.9 | .0 | 8.9 | 8.9 | 2.2 | 4.4 | .0 | .0 | .0 | 8.9 | 37.8 | 13.3 | 4.4 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | 100.0 |
| | 12 | 3.8 | .0 | .0 | 3.8 | 1.9 | 1.9 | .0 | .0 | 9.4 | 5.7 | 9.4 | 45.3 | .0 | .0 | .0 | 7.5 | 5.7 | .0 | .0 | 5.7 | 100.0 |
| | 15 | 4.3 | .0 | .0 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | 4.3 | .0 | 67.4 | 6.5 | 6.5 | .0 | .0 | .0 | 8.7 | .0 | 100.0 |
| | 16 | .0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | 8.2 | .0 | .0 | 6.1 | 79.6 | 2.0 | .0 | .0 | .0 | 2.0 | .0 | 100.0 |
| | 20 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 94.6 | 2.7 | .0 | 2.7 | .0 | .0 | 100.0 |
| | 24 | .0 | .0 | .0 | 5.5 | 3.6 | .0 | .0 | 1.8 | 1.8 | .0 | 1.8 | 3.6 | .0 | .0 | .0 | 74.5 | 5.5 | .0 | 1.8 | .0 | 100.0 |
| | 27 | .0 | .0 | .0 | 5.3 | .0 | .0 | .0 | .0 | .0 | .0 | 5.3 | 2.6 | 2.6 | .0 | .0 | 5.3 | 60.5 | 13.2 | .0 | 5.3 | 100.0 |
| | 30 | .0 | .0 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | 7.4 | 85.2 | .0 | .0 | 100.0 |
| | 32 | .0 | .0 | 2.0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | 2.0 | .0 | 10.2 | 4.1 | .0 | 2.0 | .0 | .0 | 77.6 | .0 | 100.0 |
| | 35 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | 1.9 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 92.6 | 100.0 |

63.6% of original grouped cases correctly classified.

Table 4.9: British and Howells' female samples classification results (1. Poulton; 2. Linenhall; 3. St Owen; 4. London; 5. St Gregory; 6. St Leonard; 7. Castle Hill; 8. Guisborough; 9.Ballumbie; 10. Norse; 11. Zalavar; 12. Berg; 15. Zulu; 16. Australia; 20. Easter Island; 24. Yauyos; 27. Hainan Island; 30. Guam; 32. Bushmen; 35. Buriats)

## 4.4 Principal Component Analysis

Differently from the previous discriminant function analysis, the means resulting from each variable in the different samples were employed for the data analysis. This procedure allowed to determine which variables had the most significance in discriminating between groups. After carrying out the PCA, the highest factor scores were retained to produce the three-dimensional scatterplots. The factor scores that showed Eigenvalues loadings of 10% or more were chosen to produce the graphs.

As for the DFA, the analysis was initially carried out only on the British samples. First, the non-pooled samples were examined, and secondly, the pooled samples were compared. The following step was to compare the British against Howells' European samples (Norse, Zalavar and Berg). First, the non-pooled samples were compared, and then males and the females were analysed. Finally, a selection of 21 Howells' main groups and the British sample were analysed. Just like for the previous analysis, the non-pooled samples were first compared and then the pooled samples were analysed.

### 4.4.1 Inter-population Analysis: Non-pooled British Samples

The first stage of the principal component analysis was to compare the British non-pooled samples. Four principal components were extracted from the analysis, and the Eigenvalues show that these account for 91% of the total variance (see Appendix 13). For the production of the scatterplot (Fig. 4.23), only the first three components were used, which accounted for 81.7% of the total variance (PC 1 = 48.561%, PC 2 = 22.509% and PC 3 = 10.646%)

The component matrix in Table 4.10 explains the loadings that the different variables show for each principal component. The variables that drive most of the variation on the first principal component are 1.4.2 (nasal height) with a value of .962, 1.2.8 (height of the upper face) showing a value of .923, and 1.1.20 (nasion-bregma chord) with a value of .916. Fairly high loading values are also shown by 1.1.17 (nasion-bregma arch), 1.1.4 (cranial base length), 1.4.1 (nasal breadth) and 1.3.5 (orbital height). On the second principal component, most of the variation is driven by 1.1.21 (bregma-lambda chord) with a value of .922 and 1.1.18 (parietal longitudinal arch) showing a value of .871. The following, but slightly less significant loadings, were 1.1.19 (occipital arch) and 1.1.1 (maximum length of the neural skull). Finally, the third principal component saw the major discrimination driven by 1.1.23 (foramen magnum length) with a loading value of .637 and 1.1.5 (maximum neurocranial breadth) with a value of .604.

The first principal component seems to discriminate between the samples mainly on the facial measurements. The samples that most seem to differ on the first principal component are

Linenhall and Guisborough, while St Leonard seems to be fairly close to Linenhall. In fact, if considering the nasal height, the means for Linenhall and St Leonard are equivalent (47.8 mm) and report the minimum value for this measurement, while Guisborough records the highest mean measurement (53.8 mm). The same can be stated for the nasion-bregma chord, as Linenhall and St Leonard are reasonably close in the measurements (108.9 mm and 109.2 mm), while Guisborough has the highest value (114.6 mm). Differences are shown by the height of the upper face, as Linenhall reports the lowest value (63.3 mm) and Guisborough the highest (76.2 mm), while St Leonard stands somewhere in the middle of the two groups (67.7 mm). The other groups appear to be located in between these samples, with St Gregory, London, Ballumbie and St Owen forming the bigger cluster and Castle Hill forming another cluster.

When analysing the second principal component, St Leonard and Linenhall occupy the two opposite positions of the scatterplot. The loadings for the variable in this axis seem to involve the neurocranial length. Linenhall appears to share similarities with Poulton, while Castle Hill and St Owen seem to be fairly close on the axis. In fact, the measurements of the bregma-lambda chord for these samples is relatively high, with the highest mean value shown by Castle Hill (113.7 mm). The main cluster can be seen connecting London, St Gregory, Ballumbie and Guisborough. St Leonard keeps its isolated location, fairly separated by the other groups, reporting the lowest mean value for this measurement (107.2 mm). The same can be said in regard to the parietal longitudinal arch. St Leonard has the smallest mean value (120.3 mm), while Poulton reports the highest (126.7 mm).

The third principal component axis instead shows the discrimination based on the foramen magnum length and the maximum breadth of the neurocranium. The scatterplot displays the main cluster formed by Linenhall, St Leonard and Guisborough, occupying an average location. The extremes of the plot are represented by St Owen and Ballumbie. St Owen forms a loose cluster with London, while Poulton and Castle Hill occupy slightly isolated points.

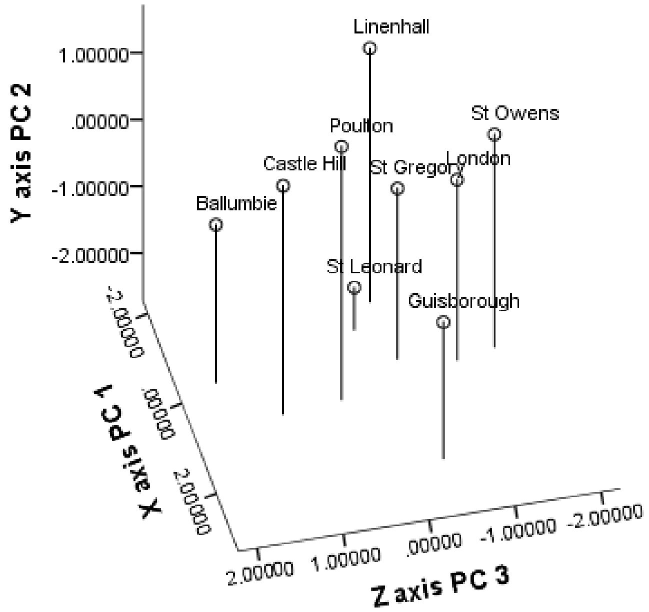


Figure 4.23: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the non-pooled British samples

**Component Matrix**

| | Component 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| B1.1.1 | .615 | .746 | -.035 | .128 |
| B1.1.4 | .886 | -.261 | -.218 | .287 |
| B1.1.5 | .644 | -.247 | .604 | .121 |
| B1.1.9 | .552 | -.204 | -.392 | .445 |
| B1.1.17 | .889 | .311 | .029 | .079 |
| B1.1.18 | .404 | .871 | -.055 | -.126 |
| B1.1.19 | .122 | .792 | -.312 | .269 |
| B1.1.20 | .916 | .203 | .125 | .269 |
| B1.1.21 | .209 | .922 | .105 | .273 |
| B1.1.22 | -.468 | -.540 | -.307 | .608 |
| B1.1.23 | .514 | -.345 | .637 | .369 |
| B1.2.1 | .716 | -.217 | -.577 | .059 |
| B1.2.6 | .787 | -.502 | -.284 | .011 |
| B1.2.8 | .923 | -.336 | -.084 | -.109 |
| B1.3.4 | -.407 | .107 | .396 | .660 |
| B1.3.5 | .831 | .030 | .263 | -.319 |
| B1.4.1 | .871 | -.338 | .255 | -.150 |
| B1.4.2 | .962 | .040 | -.100 | -.211 |

Extraction Method: Principal Component Analysis.

Table 4.10: Component matrix showing the loadings assigned to each variable for the non-pooled British samples (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.17 Nasion-bregma arch; 1.1.18 Parietal longitudinal arch; 1.1.19 Occipital arch; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

## 4.4.2 Pooled Samples Analysis

**British Males**

In the analysis of the British male sample, four principal components were extracted, and the Eigenvalues show that these account for the 88.1% of the total variance (see Appendix 13). For the production of the three-dimensional scatterplot in Fig. 4.24, only the first three components were used, which explain 79.2% of the total variation (PC 1 = 44.242%, PC 2 = 22.566% and PC 3 = 12.408%).

The component matrix in Table 4.11 shows the loadings that the variables have for the different principal components. The variables that drive most of the variation in the first component are 1.2.8 (height of the upper face) that shows a value of .973 and 1.1.4 (cranial base length) with a value of .944. Fairly significant are also the variables 1.4.2 (nasal height), 1.4.1 (nasal breadth) and 1.1.20 (nasion-bregma chord), with loadings not much dissimilar from the first two. On the second principal component, the majority of the difference between samples is determined by the measurements 1.1.18 (parietal longitudinal arch) with a loading value of .928 and 1.1.21 (bregma-lambda chord) showing loading of .873. The following measurements with fairly high influence on the variability between samples are 1.1.1 (maximum length of the neural skull) and 1.1.22 (lambda-opisthion chord). On the third principal component, only two measurements seem to have a significant impact on the variability between groups, that is 1.3.4 (orbital breadth) with a loading value of .824 and 1.2.1 (length of the face) with a value of -.742.

In Fig. 4.24 the spatial distribution of these samples can be observed. On the first principal component axis X, the samples seem to cluster mainly based on their affinities on the facial and frontal skeleton. The only two samples that result as outliers are Linenhall and Guisborough. In fact, regarding the facial height, Linenhall seems to have the lowest measurement (63 mm), while Guisborough shows the highest value (76.2 mm). The same can be said for the cranial base length, where again Linenhall reports the lowest value (95.3 mm) and Guisborough the highest (102.7 mm). The same can be stated regarding the dimensions of the nose and the nasion-bregma chord.

When analysing the second principal component, the samples appear more scattered, and their differences are mainly located on the neural skull. The samples that show most of the similarities are St Owen, Ballumbie, Linenhall and Castle Hill with a second cluster formed by London, Guisborough and Linenhall. St Gregory is slightly separated from this cluster, while the two extremities are occupied by St Leonard and Poulton. In fact, regarding both the measurements of the parietal longitudinal arch and the bregma-lambda chord, St Leonard reports the smallest values (122 mm and 108.9 mm) and Poulton the highest (127.7 mm and 114.3 mm).

Finally, the third principal component distinguishes between the samples based on the orbital breadth and the length of the face. For this comparison, the samples form two different clusters. One is formed by St Leonard, Poulton and Ballumbie, while the second one sees St Owen and St Gregory sharing similarities. London and Linenhall are somewhat detached from these clusters, while the samples that differ the most for these traits are Guisborough and Castle Hill. In fact, for the orbital breadth Guisborough reports the greatest measurement (42.5 mm) and Castle Hill the smallest (38 mm).

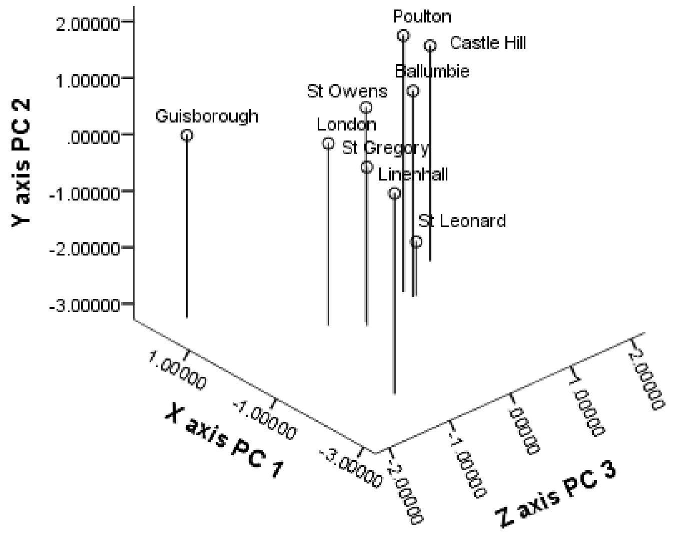


Figure 4.24: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the male British samples

**Component Matrix**

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| B1.1.1 | .351 | .860 | .107 | .179 |
| B1.1.4 | .944 | -.154 | .052 | .204 |
| B1.1.5 | .786 | -.163 | .499 | .012 |
| B1.1.9 | .348 | -.583 | -.268 | -.073 |
| B1.1.17 | .912 | .267 | -.044 | .046 |
| B1.1.18 | -.242 | .928 | -.071 | -.070 |
| B1.1.19 | .062 | .497 | .270 | .760 |
| B1.1.20 | .941 | .225 | .003 | -.073 |
| B1.1.21 | -.193 | .873 | .289 | -.136 |
| B1.1.22 | -.163 | -.839 | .300 | .282 |
| B1.1.23 | .399 | -.072 | .460 | -.742 |
| B1.2.1 | -.219 | -.073 | -.742 | .129 |
| B1.2.6 | .843 | -.261 | .187 | .392 |
| B1.2.8 | .973 | -.129 | -.181 | .053 |
| B1.3.4 | -.269 | -.100 | .824 | .001 |
| B1.3.5 | .808 | .299 | -.311 | -.280 |
| B1.4.1 | .942 | -.123 | .053 | -.167 |
| B1.4.2 | .943 | .159 | -.192 | .073 |

Extraction Method: Principal Component Analysis.

Table 4.11: Component matrix showing the loadings assigned to each variable for the male British samples (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.17 Nasion-bregma arch; 1.1.18 Parietal longitudinal arch; 1.1.19 Occipital arch; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

### British Females

For the analysis of the British female groups, five principal components were extracted and these account for 91% of the total variance (see Appendix 13). To generate the scatterplot in Fig. 4.25, the first three principal components were used, which account for 73.1% of the overall variation between groups (PC 1 = 37.835%, PC 2 = 20.164% and PC 3 = 15.184%).

In Table 4.12 can be seen the component matrix, with the loadings assigned to each variable used for this analysis. The variables that show the most significant loadings for the first principal component are 1.1.21 (bregma-lambda chord) with a value of .973 and 1.1.1 (maximum length of the neural skull) showing a value of .964. Significant impact is given by other variables, that is 1.1.18 (parietal longitudinal arch), 1.1.22 (lambda-opisthion chord) and 1.1.19 (occipital arch). The differences that are determined by the second principal component are determined by the measurement 1.3.5 (orbital height) with a loading value of .881. Relatively high values, but less significant than the last one, are shown by the measurements 1.1.5 (maximum neurocranial breadth), 1.4.1 (nasal breadth) and 1.1.4 (cranial base length). Finally, the third principal component shows that the main differences are determined by the measurements 1.2.8 (height of the upper face), reporting a loading value of .752, and measurement 1.2.1 (length of the face), with a value of .745.

Fig. 4.25 shows how the samples are spatially related in the three-dimensional scatterplot. As it can be seen from the graph, it was not possible to include Guisborough in the analysis, as the female sample did not have a complete set of measurements and therefore it was not possible to carry out the comparison. The differences on the first principal component seem to distinguish the most by neurocranial measurements. A cluster is formed by Poulton, Linenhall, St Owen and St Gregory. London is located slightly on the side of this group, while St Leonard is plotted in a more isolated location of the graph. The two most differing samples are Ballumbie and Castle Hill. The first sample shows for both the bregma-lambda chord and the maximum length of the neural skull the lowest measurements (104 mm and 170.8 mm). On the other hand, Castle Hill showed the greatest measurements (113.4 mm and 180.7 mm).

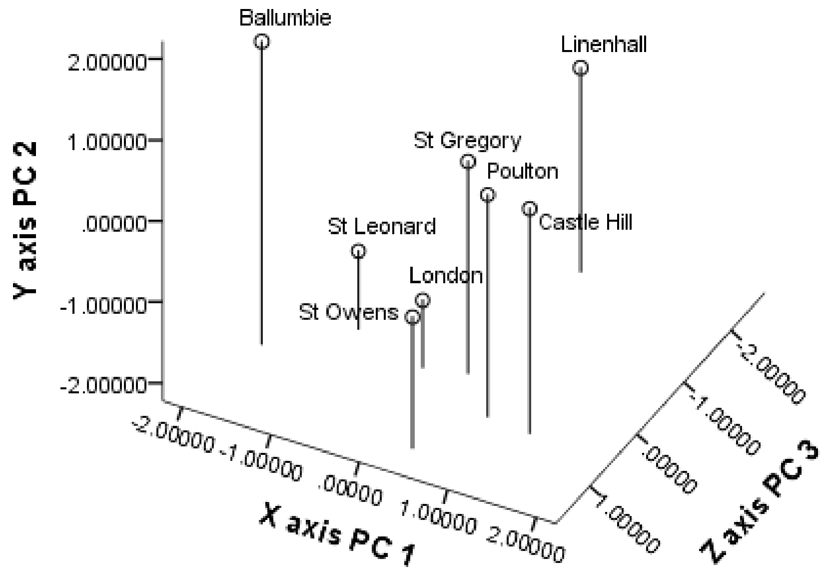


Figure 4.25: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the female British samples

**Component Matrix**

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| B1.1.1 | .964 | .181 | .088 | .122 | -.011 |
| B1.1.4 | .599 | -.658 | .372 | -.072 | .246 |
| B1.1.5 | -.183 | .694 | -.353 | .058 | .568 |
| B1.1.9 | .671 | -.510 | .033 | -.106 | .471 |
| B1.1.17 | .810 | .296 | -.305 | .070 | .311 |
| B1.1.18 | .957 | .037 | .108 | .188 | .163 |
| B1.1.19 | .850 | .281 | -.232 | .080 | -.307 |
| B1.1.20 | .789 | .290 | .217 | -.356 | .143 |
| B1.1.21 | .973 | .073 | -.084 | -.007 | .003 |
| B1.1.22 | .875 | -.098 | -.115 | -.017 | -.133 |
| B1.1.23 | -.217 | .057 | .652 | -.643 | .245 |
| B1.2.1 | .123 | -.572 | .745 | .217 | .001 |
| B1.2.6 | -.196 | -.413 | -.633 | .310 | .391 |
| B1.2.8 | -.112 | .378 | .752 | .241 | .157 |
| B1.3.4 | .254 | .266 | -.226 | -.530 | -.196 |
| B1.3.5 | .185 | .881 | .204 | -.153 | -.255 |
| B1.4.1 | -.426 | .671 | .154 | .018 | .549 |
| B1.4.2 | .128 | .462 | .417 | .756 | -.129 |

Extraction Method: Principal Component Analysis.

Table 4.12: Component matrix showing the loadings assigned to each variable for the female British samples (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.17 Nasion-bregma arch; 1.1.18 Parietal longitudinal arch; 1.1.19 Occipital arch; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

The second principal component discriminates between the British female samples mainly by the orbital height. The scatterplot shows the main cluster formed by Linenhall, St Gregory, Poulton and Castle Hill. On the side of this cluster is located St Owen, with slightly lower values, while the samples that are located at the greatest distance are St Leonard and London on one side and Ballumbie on the opposite. Regarding the orbital height, Ballumbie does not have the greatest measurement (35.5 mm) that is shown by Castle Hill instead (35.8 mm). On the opposite side, London has the smallest mean (32.2 mm), which is very close to the one given by St Leonard (32.6 mm). Analysing the maximum neurocranial breadth instead, Ballumbie does not report the highest mean value (142.9 mm), but this is shown by Poulton (143.2 mm). In this case, London and St Leonard are equivalent, as they report an equivalent mean value (139.9 mm), but it is not the smallest, which is found in Poulton (138.2 mm). On the other hand, Ballumbie and London represent the opposites on the basis of the nasal breadth, where the first sample reports the highest value (24.4 mm), while the second reports the lowest (23.4 mm).

The differences between the groups displayed on the third principal component are mainly driven by the height of the upper face. Two clusters can be distinguished on the scatterplot. The first is formed by Castle Hill, Poulton and Ballumbie, while the second is formed by a looser association between London, St Gregory and St Leonard. The most differing samples, in this case, are Linenhall and St Owen. Linenhall reported the lowest measurement in the height of the upper face (63.5 mm), while St Owen the greatest (67.6 mm). In the case of the length of the face, the same can be said for Linenhall (86.5 mm), and the greatest measurement is reported by St Owen (94 mm).

## 4.4.3 Comparison with W.W. Howells data set

### British and Howells European Non-pooled Samples

The first analysis carried out with the Howells' dataset aimed to compare the British and the European non-pooled samples. Five principal components were extracted, and the Eigenvalues show that these accounted for 92.5% of the total variation (see Appendix 14). To generate the three-dimensional scatterplot, the first three principal components were used, which account for 73.9% of the total variance (PC 1 = 43.087%, PC 2 = 18.138% and PC 3 = 12.724%). For a better understanding of the analysis, a further graph was produced with the first, second and fourth principal components, as the fourth principal component accounted for more than 10% of the variance (PC 4 = 11.398%) and it can be observed in Appendix 16.

The component matrix in Table 4.13 shows the loadings assigned to the variables for each component. The differences between the samples on the first principal component are mainly determined by the measurements 1.4.2 (nasal height) with a loading of .939, 1.2.8 (height of the upper face) reporting a value of .920, and 1.1.4 (cranial base length) showing loading of .905. Significant impact is shown by further measurements, such as 1.2.6 (maximum bimaxillary breadth of the midface) and 1.1.20 (nasion-bregma chord). The primary measurement driving the discrimination on the second principal component is 1.1.21 (bregma-lambda chord) with the loading of .733. Further measurements seem to have reasonably high loadings, such as 1.1.23 (foramen magnum length) and 1.1.1 (maximum length of the neural skull). On the third principal component, only one measurement seems to drive the differences between samples that is 1.1.22 (lambda-opisthion chord) with the loading of .751. Finally, the fourth principal component is mainly influenced by the measurement 1.1.5 (maximum neurocranial breadth), showing a slightly lower loading value of .569.

In Figure 4.26 is shown how the samples are distributed in a three-dimensional scatterplot based on the first three principal components. On the first principal component, the samples seem to be discriminated mainly on the measurements located on the frontal part of the cranium. The main cluster can be observed, formed by St Owen, Poulton, Castle Hill, London, the Norse and Zalavar samples. Another cluster is formed by St Leonard, Ballumbie and the Berg samples. The two groups that differ the most from each other and the other samples are Linenhall and Guisborough. In fact, in all the measurements that drive the difference on the first principal components, Linenhall shows the lowest measurements, while Guisborough stands out for much greater measurement values.

The second principal component differentiates between groups based on the length of the skull and the foramen magnum. In this case, the samples appear more scattered than on the first principal component. In fact, different clusters can be seen. The main group is formed by

London, St Gregory, Norse and Zalavar. Another cluster, which is also plotted at one of the extremities of the graph, is formed by Poulton, Castle Hill, St Owen and Linenhall. St Leonard is located not far from the first cluster, but with a slightly looser connection. Somewhat isolated is Guisborough, while Ballumbie is plotted on a separate location of the graph. Berg is placed far away from the clusters, and it is located in the opposite position to the first group. In fact, Berg displays the smallest mean measurements concerning the maximum length of the neural skull (175.6 mm) and the largest foramen magnum length (37.6 mm), while the smallest mean value for the bregma-lambda length is showed by St Leonard (107.2 mm). On the other hand, Castle Hill seems to have the lowest mean value for 1.1.21 (113.7 mm), while Linenhall shows the minimum length of the foramen (33.2 mm). Finally, the largest mean value for 1.1.1 is reported by the Norse (184.2 mm).

The differences between samples on the third principal component are driven by the chord of the occipital. The scatterplot shows the main cluster created by St Gregory, London, Guisborough, Castle Hill, St Owen, Ballumbie and Poulton, showing that nearly all the British sample report a similar measurement for this variable. Linenhall is similar to these groups, but it is linked to them by a looser connection. The European samples seem to be separated by the British on the plot, regarding this measurement. The Berg sample is slightly more similar to the British group but still separated. Another cluster, which also represents one of the extremities of the cluster, is defined by the Norse and Zalavar samples. On the opposite side of the graph is located St Leonard, which also results significantly different from the other British samples. In fact, St Leonard reports the greatest measurement (102.2 mm), while the European groups result with the shortest occipital cords.

Finally, as can be seen in the graph in Appendix 10, it was also essential to take into account the fourth principal component. This component is mainly influenced by the cranial breadth. On this axis, the samples are more spatially spread than in the third, and they tend to form smaller clusters. In fact, one can be seen formed by Ballumbie and Poulton, while the second one comprises St Gregory and Guisborough, and a third one connects the Norse sample with London. Somewhat isolated positions are occupied by Linenhall, the Berg sample, which is remarkably close to the second cluster, and St Owen, which is in between the first and the third cluster. Finally, the opposites are represented by Castle Hill and Zalavar, which is very similar to St Leonard.

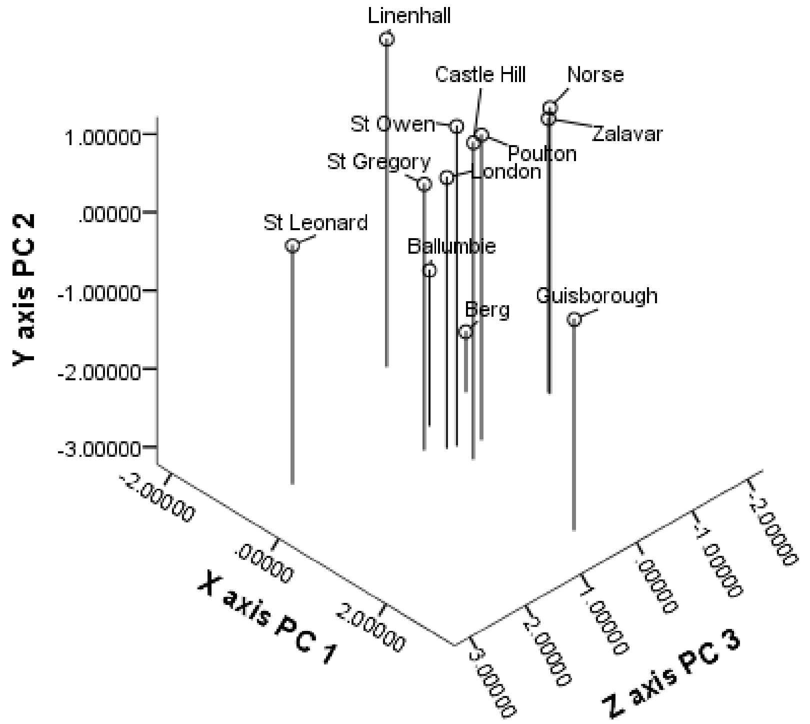


Figure 4.26: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the non-pooled British and Howells' European samples

**Component Matrix**

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| B1.1.1 | .523 | .645 | -.428 | .290 | -.042 |
| B1.1.4 | .905 | .234 | .062 | -.230 | .219 |
| B1.1.5 | .292 | -.400 | .572 | .569 | -.001 |
| B1.1.9 | .541 | .460 | .277 | -.263 | .174 |
| B1.1.20 | .829 | .300 | .094 | .394 | .091 |
| B1.1.21 | .161 | .733 | -.521 | .319 | .136 |
| B1.1.22 | -.157 | .546 | .751 | -.255 | .122 |
| B1.1.23 | .230 | -.647 | -.215 | .076 | .666 |
| B1.2.1 | .745 | .181 | -.159 | -.526 | .012 |
| B1.2.6 | .870 | -.132 | .239 | -.367 | .023 |
| B1.2.8 | .920 | -.094 | .331 | .052 | -.154 |
| B1.3.4 | -.386 | .374 | .302 | .394 | .552 |
| B1.3.5 | .707 | -.100 | .188 | .526 | -.313 |
| B1.4.1 | .716 | -.552 | -.235 | -.035 | .255 |
| B1.4.2 | .939 | -.147 | -.233 | .069 | -.146 |

Extraction Method: Principal Component Analysis.

Table 4.13: Component matrix showing the loadings assigned to each variable for the non-pooled British and Howells European samples (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

## British and Howells European Male Samples

As for the discriminant function analysis, the male sample was examined in the principal component analysis to determine which measurements drive the differences between the British and the Howells' European male samples. Five principal components were extracted, and the Eigenvalues show that these account for 90.7% of the total variance (see Appendix 14). To produce the three-dimensional scatterplot in Fig. 4.27, the first three principal components were used, which account for 71.7% of the total variance (PC 1 = 39.451%, PC 2 = 18.360% and PC 3 = 13.985%). A further scatterplot was produced with the first, second and fourth principal components, as this accounts for more than 10% of the variance (PC 3 = 10.814%) (Appendix 17).

The component matrix in Table 4.14 shows the factor loadings for each variable in the five principal components. The first component shows the most significant factor loadings assigned to the measurements 1.4.2 (nasal height) with a value of .947, 1.2.8 (height of the upper face) with a significance of .915, and 1.1.20 (nasion-bregma chord) with a value of .902. Fairly significant factor loadings are assigned to further measurements, such as 1.1.4 (cranial base length), 1.4.1 (nasal breadth) and 1.2.6 (maximum bimaxillary breadth of the midface). On the second principal component, three measurements report significant loadings, such as 1.1.21 (bregma-lambda chord) with a value of .875, 1.1.1 (maximum length of the neural skull) with a .790 loading, and 1.1.5 (maximum neurocranial breadth) with a value of -.744. On the third principal component, just two variables seem to show a significant correlation, that is 1.1.9 (basion-bregma height) with a value of .764 and 1.1.22 (lambda-opisthion chord) with a .699 loading. Finally, the fourth principal component shows just one significant correlation, that is 1.3.4 (orbital breadth) with a loading value of .827.

Figure 4.27 shows the spatial distribution on the graph of the male samples. On the first principal component, the groups are mainly discriminated based on the morphology of the frontal part of the cranium. The main cluster is formed by Poulton, London, St Owen, Ballumbie, St Gregory, St Leonard and the Berg sample. Another cluster is formed by Castle Hill and the Zalavar and Norse groups. The samples that most differentiate from these two clusters are Linenhall and Guisborough. In fact, regarding the measurement of the nasal height, Linenhall reports the lowest mean value (47 mm), while Guisborough the highest (53.8 mm). The same can be said for the height of the upper face, where Linenhall's mean measurement is 63 mm, while Guisborough amounts at 76.2 mm. The nasion-bregma chord also displays the same results, with a measurement of 109.2 mm for Linenhall and 115.7 for Guisborough. Similar results are given for the other significantly correlated measurements.

On the second principal component, the samples seem to differentiate mainly on the measurements of the neural skull. The central cluster is formed by St Owen, Castle Hill, Guisborough, London and St Gregory. Ballumbie and the Berg samples seem to slightly differentiate from this central cluster, showing some similarities between them. Poulton is also slightly detached from this group, while Linenhall is plotted more on the side of this cluster. The extremities are occupied by St Leonard, the Zalavar and Norse group. In fact, St Leonard seems to have the shortest neurocranium, with values for the bregma-lambda length and the maximum length respectively of 108.9 mm and 177.8 mm. The Norse sample instead reports the highest value for the maximum neurocranial length of 188.5 mm, while the Zalavar sample shows the highest measurement of the bregma-lambda chord (115.3 mm). On the other hand, regarding the maximum neurocranial breadth, St Leonard reports a broader neurocranium than the two European samples.

The third principal component is mostly influenced by the cranial height. At first, two main clusters can be distinguished. The first group is formed by London, St Owen, Guisborough, St Gregory and the Zalavar sample. The second cluster is formed by Poulton, Castle Hill and the Norse sample. In between these two groups is located Linenhall. On a slightly isolated position is situated Ballumbie. The two collections that differ the most from the others are the Berg group and St Leonard. The Berg sample reports the lowest basion-bregma height, as well as the lambda-opisthion chord, with measurements of respectively 130.3 mm and 94 mm. On the other hand, St Leonard has the highest value for the lambda-opisthion chord (108.5 mm), while the highest mean for the skull height is shown by the Zalavar sample (134.8 mm), a value that is very close to the one reported by St Leonard (134 mm).

Finally, the fourth principal component is discriminating between the samples based on the orbital breadth. On this axis, the samples seem to cluster in three main groups. The first is represented by Ballumbie, St Gregory, St Owen and the Berg sample. The second sees Poulton and the Norse sample very close, and the last one, which is also occupying one of the extremes of the graph, is grouping St Leonard, Castle Hill and the Zalavar sample. London and Linenhall are relatively close to each other, but in a distinct position compared to the first cluster. Finally, in an isolated position, far from the other groups in the graph, is Guisborough. Castle Hill reports the widest orbits, with a mean measurement of 42.5 mm, immediately followed by St Leonard (41.9 mm). On the other hand, Guisborough shows the narrowest orbits, with a mean measurement of 38 mm. The graph that shows the differences in the fourth principal component can be seen in Appendix 11.

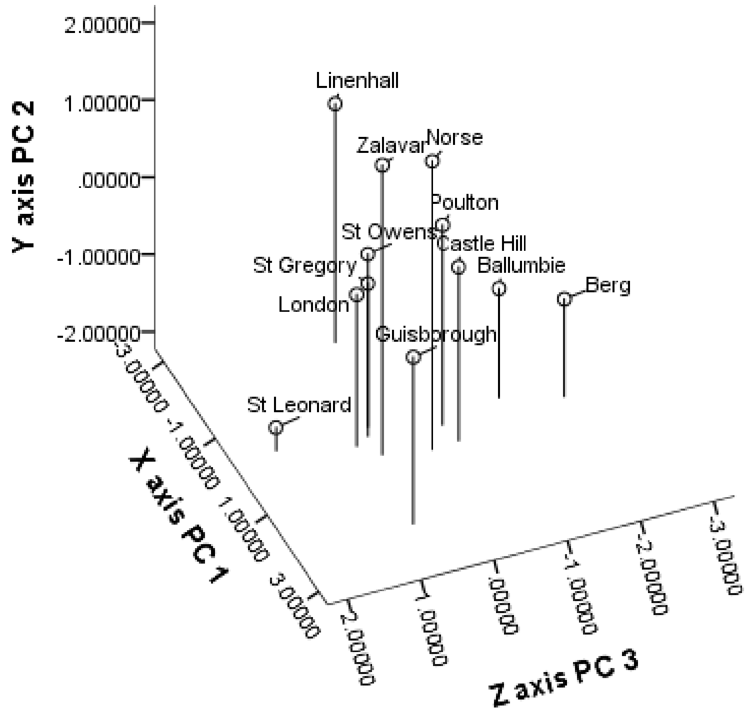


Figure 4.27: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the male British and Howells' European samples

**Component Matrix**

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| B1.1.1 | .397 | .790 | -.132 | .201 | .356 |
| B1.1.4 | .896 | .118 | .292 | .258 | .027 |
| B1.1.5 | .471 | -.744 | -.303 | .145 | .119 |
| B1.1.9 | .247 | .103 | .764 | .085 | -.319 |
| B1.1.20 | .902 | .153 | .108 | .012 | .268 |
| B1.1.21 | -.015 | .875 | -.158 | .329 | .178 |
| B1.1.22 | -.250 | -.483 | .699 | .375 | .094 |
| B1.1.23 | .284 | -.029 | -.600 | .331 | -.628 |
| B1.2.1 | -.059 | .612 | .480 | -.193 | -.332 |
| B1.2.6 | .823 | -.219 | .207 | .267 | -.035 |
| B1.2.8 | .915 | -.213 | .264 | -.172 | .106 |
| B1.3.4 | -.312 | -.141 | -.056 | .827 | .304 |
| B1.3.5 | .686 | -.147 | -.166 | -.511 | .356 |
| B1.4.1 | .855 | .002 | -.216 | .205 | -.345 |
| B1.4.2 | .947 | .142 | -.119 | -.049 | -.129 |

Extraction Method: Principal Component Analysis.

Table 4.14: Component matrix showing the loadings assigned to each variable for the male British and Howells European samples (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

## British and Howells European Female Samples

For the analysis of the British and Howells' European females, the number of the samples is smaller, as the females analysed for Guisborough did not report some of the measurements used in the comparison. Four principal components were extracted, which account for 80.5% of the total variance (see Appendix 14). For the production of the three-dimensional scatterplot in Fig. 4.28, only the first three principal components were used and they account for 70.4% of the variation between samples (PC 1 = 32.144%, PC 2 = 24.618% and PC 3 = 13.651%). A further graph comparing the first, second and fourth principal components was also produced, as the fourth principal component accounts for more than 10% of the variance (PC 4 = 10.110%) (Appendix 18).

Table 4.15 shows the component matrix with the loadings assigned for each variable based on the principal components extracted for the analysis. The first principal component shows significant correlation for the measurements 1.1.1 (maximum length of the neural skull) with a value of .939, 1.1.22 (lambda-opisthion chord) with .910 loading and 1.1.21 (lambda-bregma chord) with a value of .908. A further measurement reports a significant but slightly lower loading that is 1.1.20 (nasion-bregma arch). The discrimination on the second principal component is mainly determined by the measurement 1.3.5 (orbital height) with a loading value of .894 and 1.1.5 (maximum neurocranial breadth), with a .770 factor loading. A negative and slightly less significant correlation is shown by the measurements 1.1.4 (cranial base length) and 1.2.1 (length of the face). The factor loadings correlated with the third principal component show a lower significance if compared with the previous ones, showing a similar value in all the cases. The most correlated are 1.2.6 (maximum bimaxillary breadth of the midface) with the loading of -.595, and 1.4.2 (nasal height) reporting a value of .591. Slightly lower significant results for the measurements 1.2.1 (length of the face) and 1.1.23 (foramen magnum length). Finally, the fourth principal component reports a significant correlation with the variables 1.4.2 (nasal height) with the loading of .688, and 1.1.23 (foramen magnum length), but different from the previous component, the value is negative (-.665).

Figure 4.28 shows the distribution of the samples in the graph, based on the first three principal components. The first principal component divides the samples on the base of the neurocranial length, and it seems that there are some dissimilarities in this area of the skull between males and females. London and Zalavar appear very close in the plot. The same can be said about the cluster formed by Linenhall, St Gregory and the Norse sample. Another cluster is instead formed by St Owen and Poulton. St Leonard is plotted in an isolated position compared to the other groups, as well as Castle Hill that occupies one of the extremities of the graph. On the other side of the plot is the association between Ballumbie and the Berg sample. The females from Castle Hill have the highest value for all the three measurements (respectively 180.7 mm, 97.2 mm and 113.4 mm), while the Berg sample has the smaller mean values for 1.1.1 and 1.1.21 (170.5 mm and 105.2 mm). Ballumbie instead shows the smallest mean measurement for 1.1.22 (104 mm).

The differences on the second principal component are given by the orbital height and the breadth of the neurocranium. In this case, the samples are more scattered in the plot. St Gregory and Poulton appear to be very close, as well as Castle Hill and Linenhall. St Owen is located close to the first two samples, but with a looser connection. The Berg group and St Leonard appear to be reasonably similar, likewise London and the Norse sample. The two samples that seem to differ the most are Zalavar and Ballumbie. The two samples show very different mean values for the first two variables. In fact, Ballumbie shows high orbits (35.5 mm), while Zalavar relatively narrow (32.1 mm). The same can be said for the neurocranial breadth mean, for which Ballumbie records a broad head (142.9 mm), while Zalavar's mean is lower (136.9 mm).

The differences that separate the samples on the third principal component are mainly on the facial skull. Poulton, Castle Hill, Berg and Zalavar samples form a cluster, which is relatively similar to the Norse group. London instead is very close to St Gregory. On the other hand, St Leonard is located in an isolated position on the plot. The extremities are represented by Linenhall and on the other side Ballumbie, together with St Owen. Even if these samples appear to be the most different, as the loadings show similar values, their position in the graph seems to be a result of the combination of the effect of the four measurements.

Finally, the fourth principal component represents the significance of the correlation with the nasal height and the size of the foramen magnum. The samples appear to be located in broader spatial distribution. The Zalavar sample and Poulton seem to form a first cluster, while St Gregory, Ballumbie and the Norse sample form another group. Reasonably close to this group is located Linenhall, while St Leonard is more isolated on the other side of the graph. The two samples that differ the most are St Owen and Castle Hill. In fact, St Owen seems to have the highest nose (50.3 mm), but an average foramen magnum length (33 mm). The lowest value for the measurement 1.4.2 seems to be held by St Leonard (46.2 mm), while the lowest mean value for the foramen magnum can be seen in Linenhall (30.5 mm).

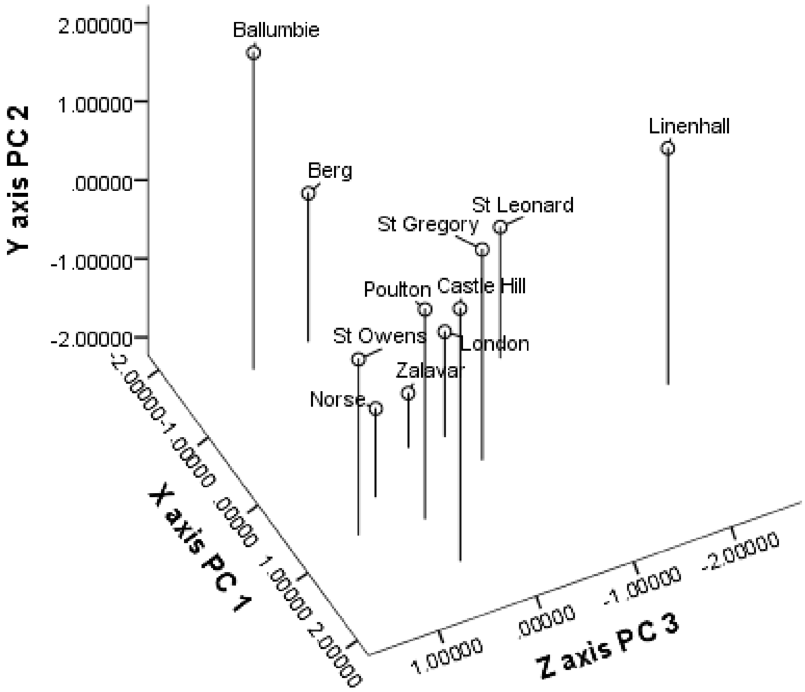


Figure 4.28: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the female British and Howells' European samples

**Component Matrix**

| | Component 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| B1.1.1 | .939 | .012 | .093 | -.109 |
| B1.1.4 | .663 | -.685 | .175 | .072 |
| B1.1.5 | -.185 | .770 | -.267 | .038 |
| B1.1.9 | .631 | -.563 | -.176 | .189 |
| B1.1.20 | .781 | .329 | .131 | .396 |
| B1.1.21 | .908 | -.053 | -.084 | .071 |
| B1.1.22 | .910 | .069 | -.212 | -.096 |
| B1.1.23 | -.320 | -.226 | .578 | .688 |
| B1.2.1 | .235 | -.682 | .584 | -.175 |
| B1.2.6 | -.196 | -.524 | -.595 | -.355 |
| B1.2.8 | .197 | .564 | .448 | -.229 |
| B1.3.4 | .350 | .426 | -.330 | .348 |
| B1.3.5 | .277 | .894 | .199 | .068 |
| B1.4.1 | -.575 | -.156 | .329 | .199 |
| B1.4.2 | .200 | .287 | .591 | -.665 |

Extraction Method: Principal Component Analysis.

Table 4.15: Component matrix showing the loadings assigned to each variable for the female British and Howells European samples (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

## British and Howells Non-pooled Samples

The principal component analysis for the British and the Howells' craniometric data was carried out, as for the discriminant function analysis, on a set of selected samples of the Howells' data set. The first analysis was carried out on the non-pooled sample. Four principal components were extracted, which account for 83.2% of the total variation. For the production of the three-dimensional scatterplot in Fig. 4.29, the first three principal components were used, as the fourth accounts for less than 10% of the total variation (see Appendix 15). The first three principal components account for 75.4% of the total variation (PC 1 = 39.751%, PC 2 = 21.255% and PC 3 = 14.434%).

The component matrix in Table 4.16 illustrates the factor loadings that the variables have for each principal component. The first principal component has a significant correlation with the measurements 1.1.4 (cranial base length) with loading of .899, 1.1.20 (nasion-bregma chord) with a value of .881, 1.4.2 (nasal height) with loading of .842, and 1.1.9 (basion-bregma height) with loading of .835. The second principal component shows a high correlation with measurement 1.1.5 (maximum neurocranial breadth) with loading of .891. The following loadings show relatively high correlation, but less significant than the previous one. Measurement 1.4.1 (nasal breadth) correlates with the second component with a value of -.669, 1.2.1 (length of the face) has a loading value of -.653, and 1.2.8 (height of the upper face) reports a value of .620. The third principal component finally shows a reasonably high correlation with the measurements 1.1.1 (maximum length of the neural skull) and 1.1.21 (bregma-lambda chord), with loading values respectively of .653 and .641.

The first principal component seems to be mainly influenced by the anterior part of the cranium and the height of the skull. Observing the scatterplot can be noticed that the British samples are spread on the X axis. St Leonard is close to Ballumbie, while a greater cluster is formed by St Gregory, London, St Owen, Norse, Zalavar, Hainan Island and Australian sample. A further cluster is made by Poulton and Zulu samples. Castle Hill seems to share similarities with the Buriats, but this cluster has looser connections compared to the previous ones. Linenhall is also very close to the Yauyos sample. The extremities of the axis are occupied by the Bushmen and the cluster formed by the Shang Dynasty, Guisborough, Guam and the Easter Island samples. In fact, for all the variables the Bushmen show the lowest recorded values. On the other side, the Eastern Island group has the longest cranial base (187.2 mm), with a mean value that highly differs from the other samples. The highest mean value for the nasion-bregma chord is recorded instead in Castle Hill and Guisborough (respectively 114.6 mm and 114.5 mm), which represent the highest values for the British samples, with only ~1mm difference with the Far Eastern groups. The highest mean value for the nose height is shown by the Buriats (55.1 mm), which is very close to the cluster. Finally, the highest skull is recorded for the Eastern Island sample (141.5 mm), which does not significantly differ from the Guam and Shang Dynasty groups (respectively 140.3 mm and 140.5 mm).

The second principal component is majorly influenced by the maximum breadth of the skull. On the Y axis, the British groups seem to be clustering together with some loose connections with the Norse, Berg and Guam samples. Similarities are shared between the Zalavar and Hainan Island samples. The Shang Dynasty sample is slightly detached from these groups, while the Zulu, Easter Island, Bushmen and Australian samples are entirely plotted on the opposite of the graph, showing great dissimilarities from the European and Far Eastern groups. The smallest mean measurement for the cranial breadth is reported by the Australian sample (129.8 mm), while the greatest value can be found in Guisborough (151.7 mm). Regarding the nasal breadth, the highest value is reported by the Zulu and the Shang Dynasty (28.3 mm), while the lowest is measured in Linenhall (23.5 mm). Finally, the length of the face is highest in the Easter Island group (104.2 mm), while the lowest value is again given by Linenhall and Ballumbie (90.3 mm).

The third principal component is correlated with the length of the skull. In this case, the samples are widely spread, and there does not seem to be any similarity on the basis of geographical proximity. Poulton, Castle Hill and St Owen are close on the graph, similarly to the Norse, Australian and Easter Island samples. Close to this cluster is located the group formed by St Gregory, Zalavar, St Leonard and London, which are relatively close to the Zulu sample. Similarities are also encountered between the Guam sample and Ballumbie. The cluster formed by Guisborough, Shang Dynasty and the Bushmen samples differentiates from the previous ones, which are plotted very close together on the graph. Fairly distant on the plot are located the Yauyos, Berg and Hainan Island groups. The two opposites in relation to the length of the head are represented by Linenhall and the Buriats. In fact, the Buriat sample reports the shortest mean value for the bregma-lambda chord (106.2 mm) and also falls into the group that has the lowest values for the maximum length, even if the Yauyos sample has the shortest head. On the other side, Linenhall is part of the samples that show the highest measurement of the bregma-lambda chord (112.3 mm), differing from the Shang Dynasty for only ~1 mm.

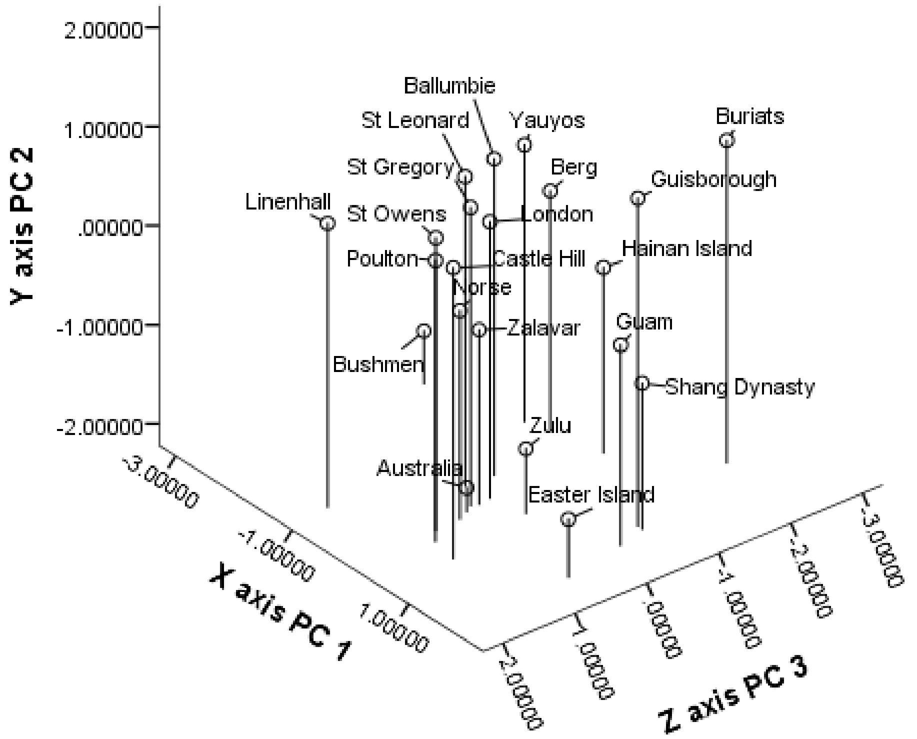


Figure 4.29: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the non-pooled British and Howells' samples

**Component Matrix**

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| B1.1.1 | .579 | -.266 | .653 | .241 |
| B1.1.4 | .899 | -.248 | .139 | -.034 |
| B1.1.5 | .181 | .891 | -.120 | .271 |
| B1.1.9 | .835 | -.090 | .025 | -.430 |
| B1.1.20 | .881 | .184 | .184 | .116 |
| B1.1.21 | .504 | -.401 | .641 | .003 |
| B1.1.22 | .500 | .411 | .325 | -.511 |
| B1.1.23 | .311 | -.403 | -.466 | .490 |
| B1.2.1 | .651 | -.653 | -.035 | .013 |
| B1.2.6 | .686 | -.129 | -.574 | -.148 |
| B1.2.8 | .702 | .620 | -.184 | .017 |
| B1.3.4 | .170 | .149 | .491 | .519 |
| B1.3.5 | .599 | .558 | -.100 | .198 |
| B1.4.1 | .481 | -.669 | -.482 | .090 |
| B1.4.2 | .842 | .348 | -.298 | .038 |

Extraction Method: Principal Component Analysis.

Table 4.16: Component matrix showing the loadings assigned to each variable for the non-pooled British and Howells sample (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

### British and Howells Male Samples

In the principal component analysis for the British and Howells' male samples, four components were extracted that account for 82.03% of the total variation. For the production of the three-dimensional scatterplot in Figure 4.30, only the first three components were used, as the fourth accounts for less than 10% of the total variation (see Appendix 15). The first three components account for 73.4% of the total variation (PC 1 = 39.197%, PC 2 = 22.052% and PC 3 = 12.173%).

The component matrix in Table 4.17 shows the loadings for each variable analysed. The first principal component shows a significant correlation with the measurements 1.1.4 (cranial base length), 1.1.20 (nasion-bregma chord) and 1.4.2 (nasal height), with loading values of respectively .931, .846 and .831. Two further measurements seem to influence the analysis, but with lower loadings (.789 and .722) and these are respectively 1.1.9 (basion-bregma height) and 1.2.6 (maximum bimaxillary breadth of the mid-face). The second principal component reports a significant correlation with two measurements: 1.1.5 (maximum neurocranial breadth) and 1.2.8 (height of the upper face). The loadings for these two measurements are respectively .867 and .737. Finally, the third component shows less strong correlations than the previous ones with four measurements. The highest correlation (-.556) is shown by 1.4.1 (nasal breadth), followed by 1.1.23 (foramen magnum length) with a loading value of -.537, 1.1.22 (lambda-opisthion chord) with a value of .512 and 1.2.6 (maximum bimaxillary breadth of the mid-face) with a loading value of -.502.

The measurements that are correlated to the first principal component are mainly located on the face. On the X axis, the majority of the British samples are plotted close to each other, creating two main clusters formed by Ballumbie, St Gregory and St Leonard on one side and London, St Owen and Poulton on the other. The samples that seem to differ slightly from these clusters are Linenhall, Castle Hill and Guisborough, but still located not at a far distance in the graph. Castle Hill seems to share some similarities with the Norse and Zalavar sample, while the Yauyos group is plotted in between the British cluster and Linenhall. In between the second British cluster and Guisborough, are located the Zulu, Australian and Shang Dynasty samples. A difference is marked by the distance between the main clusters and the Buriats and the Guam groups. Finally, the samples that most differ from the others are on one side the Bushmen and on the other side the Easter Island group. In fact, the Easter Island reports the longest face with a value of 111 mm for the measurement 1.1.4, against the shortest shown by the Bushmen (94.8 mm). The same can be said for the nasion-bregma chord, as the Easter Island falls in the highest range for this measurement, with the Guam sample (respectively 116.1 mm and 116.4 mm), while the Bushmen seem to be very similar to Linenhall (both 109.2 mm). Finally, even if the

Buriats sample is closer to the central clusters, the value for the nasal height is the highest (56.9 mm), ~3 mm more than the Easter Island sample. On the other hand, the Bushmen show the lowest nose measurement (43.8 mm).

On the second principal component, different clusters between the British samples are created. In fact, the samples seem to be divided into two main groups: one is formed by Guisborough and St Leonard and the second is formed by London, St Owen, Ballumbie, St Gregory, Castle Hill and Poulton. Few of the Howells' samples seem to share some similarities with the British clusters, which are the Buriats, Berg and the Yauyos group. Slightly separated from this cluster are plotted the Guam and the Hainan Island samples, which are also close to the Norse and Linenhall and Zalavar groups. On the opposite side of the graph in respect to the British cluster, are plotted the Zulu and Easter Island, and slightly farther the Bushmen and Australia samples. The groups that are plotted on the extremes of the graph are Guisborough and the Australian group. In fact, according to the maximum breadth of the neurocranium, the British sample falls in the group with the highest measurements (145.9 mm) followed by St Leonard with just ~0.7 mm difference and the Berg sample, that reports the largest neurocranium. On the other side, the Australian sample shows the narrowest head, with a measurement of 131.9 mm. Regarding the height of the upper face, Guisborough shows the highest face (76.2 mm), but in the case of the lowest measurement, this is reported by Linenhall (63 mm), with a difference of ~1.8 mm from the Australian group.

The third principal component is influenced by a higher number of measurements compared to the previous two, but with lower loading values. In this case, the British samples are split into two main clusters formed by Linenhall, St Owen, Poulton, St Leonard and Castle Hill and St Gregory, London and Ballumbie. Between the two groups are located the Norse and the Easter Island samples, while the Zalavar, Australian and Guam samples share similarities with the second cluster. On the other half of the graph, the remaining samples seem fairly scattered, without any significant link between each other. The closest groups to the second cluster are the Zulu sample and Guisborough, followed by the Shang Dynasty and the Yauyos groups. Lastly, there can be seen the Berg, Bushmen, Hainan Island and Buriats. Regarding the nasal breadth, Linenhall seems to have the narrowest nose (23.5 mm), while the largest is represented by the Zulu (28.7 mm) and the Buriats (28.4 mm). Comparing the length of the foramen magnum instead, St Owen has the shortest (34 mm), while the Berg group shows the highest measure, exceeding ~5 mm compared to the previous sample. In the case of the lambda-opisthion chord, St Leonard reports the highest value (108.5 mm), which is much higher than the mean measurement for the Australians, which is 92.1 mm. Finally, the measurement 1.2.6 sees Linenhall with the lowest value (87 mm), while the Buriats seem to have the largest mid-face (104.3 mm).

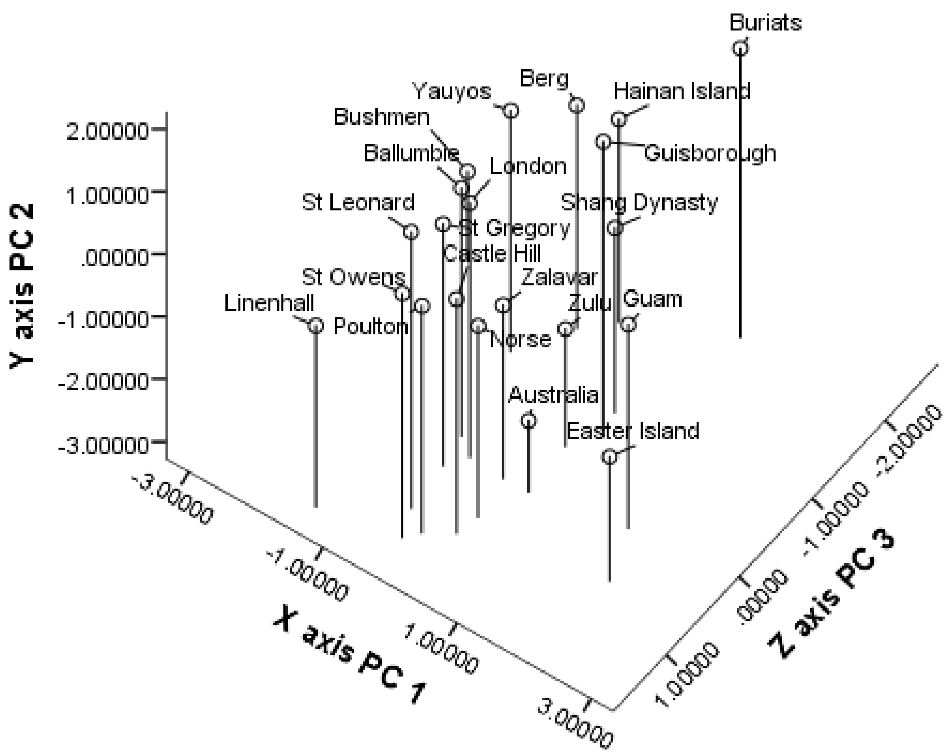


Figure 4.30: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the male British and Howells' samples

**Component Matrix**

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| B1.1.1 | .635 | -.402 | .470 | .314 |
| B1.1.4 | .931 | -.125 | .143 | -.068 |
| B1.1.5 | .059 | .867 | -.041 | .404 |
| B1.1.9 | .789 | .050 | .123 | -.474 |
| B1.1.20 | .846 | .173 | .199 | .119 |
| B1.1.21 | .548 | -.601 | .406 | .093 |
| B1.1.22 | .245 | .443 | .512 | -.485 |
| B1.1.23 | .310 | -.390 | -.537 | .347 |
| B1.2.1 | .685 | -.574 | .037 | -.121 |
| B1.2.6 | .722 | .035 | -.502 | -.108 |
| B1.2.8 | .605 | .737 | -.078 | -.008 |
| B1.3.4 | .213 | -.058 | .418 | .600 |
| B1.3.5 | .616 | .575 | -.077 | .172 |
| B1.4.1 | .584 | -.502 | -.556 | -.063 |
| B1.4.2 | .831 | .422 | -.250 | .050 |

Extraction Method: Principal Component Analysis.

Table 4.17: Component matrix showing the loadings assigned to each variable for the male British and Howells sample (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

### British and Howells Female Samples

The principal component analysis was carried out on the British and Howells' samples. Similarly to the previous analyses, the number of groups for the female sample is lower, as Guisborough did not have a complete set of measurements, while the Shang Dynasty sample only included male individuals.

Four principal components were extracted, which account for 82.6% of the total variation. For the production of the three-dimensional scatterplot in Fig. 4.31, only the first three principal components were used, as the fourth accounted for less than 10% of the total variation (see Appendix 15). The three components account for 74.5% of the total variation between the samples (PC 1 = 32.475%, PC 2 = 24.849% and PC 3 = 17.239%).

The component matrix in Table 4.18 shows the loading values for the measurements in each principal component. The first principal component shows a significant correlation with the measurements 1.1.22 (lambda-opisthion chord) and 1.1.20 (nasion-bregma chord), with values of respectively .837 and .832. Lower loading values (.752 and .742) are reported by the measurements 1.4.2 (nasal height) and 1.1.9 (basion-bregma height). The second principal component shows high correlation with the measurements 1.2.1 (length of the face), which reports a loading of .854, while 1.1.5 (maximum neurocranial breadth) shows a negative loading of -.843. Measurement 1.4.1 (nasal breadth) shows a less significant association (.729) if compared to the previously mentioned. Finally, the third principal component results as significantly correlated with the measurements 1.2.6 (maximum bimaxillary breadth of the mid-face), 1.1.21 (bregma-lambda chord) and 1.1.1 (maximum length of the neural skull) (respectively .729, -.725 and -.706).

The differences on the first principal component are mainly affected by the measurements on the neurocranium. The British samples seem to split in different groupings, where the first one is formed by Castle Hill, the Buriats and the Easter Island samples. Close to this cluster, Poulton, St Gregory and St Owen are plotted. Not far, Linenhall clusters with the Norse, Zulu and Hainan Island. Slightly detached from this last group, there are London and the Zalavar groups, followed by another cluster formed by St Leonard, Ballumbie and the Australian sample. Finally, the Berg and Yauyos seem to share some similarities, while the Bushmen are located in an isolated position in the graph, similarly to the Guam sample, on the opposite side of the scatterplot. If comparing the distribution of the samples on the first principal component with the measurements, it can be seen that for the lambda-opisthion chord the Bushmen show the lowest value (88.5 mm), while the Guam sample falls into the highest range (96.2 mm). The same can be said for measurement 1.1.20, where the Bushmen record the shortest chord (105.1

mm) similarly to the Yauyos group,  while in this case the highest value is shown by Castle Hill and Poulton (113.9 mm and 111.7 mm).

The second principal component seems to associate the British samples in a loose cluster on one half of the graph together with the Buriats, Berg and Yauyos, while the other groups are plotted on the other half of the graph. The Norse and the Zalavar samples are located close to the British group, while the other non-European samples are more scattered on the scatterplot. The Hainan Island group seems to have some similarities with the Guam sample, while the Australian and the Zulu groups are grouped with a distance from the previous cluster. Between these two groupings is plotted the Bushmen group, which results as reasonably isolated. On the other extreme of the plot, in comparison with the British groups, is the Easter Island sample. In fact, the Easter Island group seem to have the longest face between the groups (101.2 mm), while the shortest is recorded on Linenhall (86.5 mm). On the other hand, as the loading resulted as negative, the Easter Island shows the narrowest head (128.5 mm), while Poulton reports the largest neurocranial breadth (143.2 mm).

The third principal component does not group the British samples, and these can be seen spread along the Z axis. In one of the extremes of the graph is located Castle Hill, which is close to Linenhall. Poulton, St Owen, the Australian and the Norse sample form a cluster, while another one is formed by London, St Gregory and the Zalavar, Zulu, Bushmen and Easter Island groups. Close to this cluster is located St Leonard. Distant from this group can be seen another cluster formed by Ballumbie, Berg, Yauyos, Hainan Island and the Guam samples. Finally, on the other extreme of the graph are located the Buriats. In fact, the Buriats report the largest bimaxillary breadth of the mid-face (96.5 mm) together with the Guam sample (96.7 mm), while on the other side the sample from Castle Hill seems to have the narrowest face (87.5 mm). The same can be said for the bregma-lambda chord, where the Buriats group records a mean measurement for the females of 102.7 mm, while Castle Hill exceeds this one of ~11 mm. The same result is reflected in the maximum length of the neural skull, as the mean calculated for Castle Hill is above the highest ones (180.7 mm), together with the Easter Island sample, while the one calculated for the Buriats is one of the lowest (171.8 mm), following the Berg sample (170.5 mm).

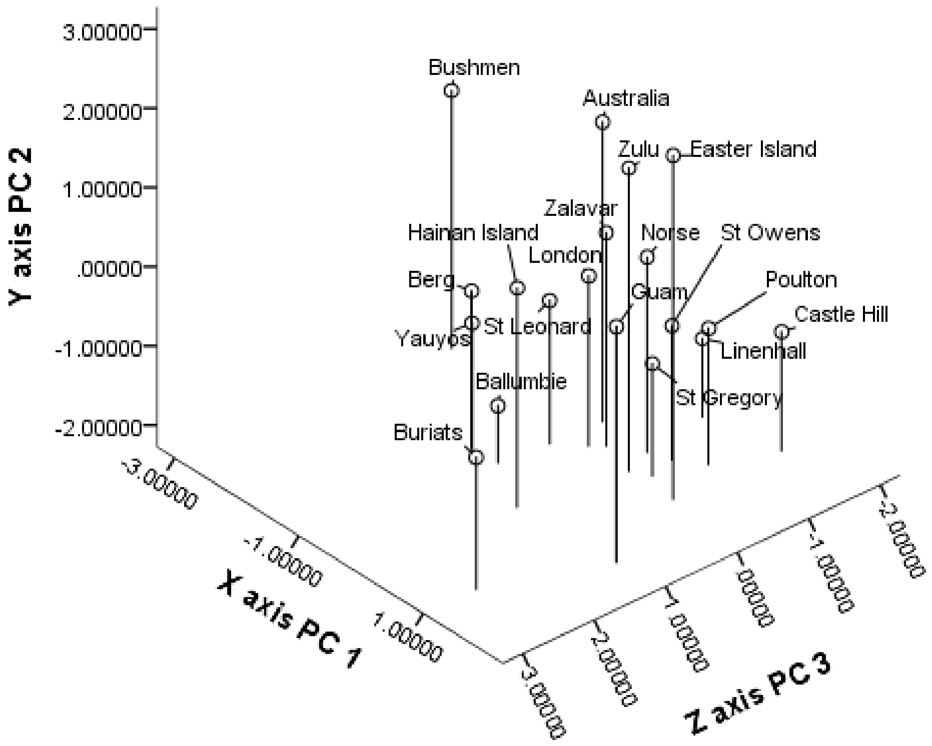


Figure 4.31: Three-dimensional scatterplot showing PC1, PC2 and PC3 for the female British and Howells' samples

**Component Matrix**

| | Component 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| B1.1.1 | .533 | .312 | -.706 | .157 |
| B1.1.4 | .683 | .619 | -.048 | -.061 |
| B1.1.5 | .307 | -.843 | .227 | .120 |
| B1.1.9 | .742 | .418 | .170 | -.342 |
| B1.1.20 | .832 | -.070 | -.196 | .200 |
| B1.1.21 | .492 | .283 | -.725 | -.054 |
| B1.1.22 | .837 | -.161 | -.144 | -.373 |
| B1.1.23 | .011 | .388 | .444 | .637 |
| B1.2.1 | .336 | .854 | .139 | .123 |
| B1.2.6 | .372 | .240 | .729 | -.205 |
| B1.2.8 | .679 | -.566 | .344 | .064 |
| B1.3.4 | .404 | -.290 | -.357 | .533 |
| B1.3.5 | .619 | -.532 | .075 | .225 |
| B1.4.1 | .129 | .729 | .469 | .256 |
| B1.4.2 | .752 | -.308 | .447 | -.075 |

Extraction Method: Principal Component Analysis.

Table 4.18: Component matrix showing the loadings assigned to each variable for the female British and Howells sample (1.1.1 Max length of the neural skull; 1.1.4 Cranial base length; 1.1.5 Max neurocranial breadth; 1.1.9 Basion-bregma height; 1.1.20 Nasion-bregma chord; 1.1.21 Bregma-lambda chord; 1.1.22 Lambda-opisthion chord; 1.1.23 Foramen magnum length; 1.2.1 Length of the face; 1.2.6 Max bimaxillary breadth of the midface; 1.2.8 Height of the upper face; 1.3.4 Orbital breadth; 1.3.5 Orbital height; 1.4.1 Nasal breadth; 1.4.2 Nasal height)

## 4.5 Hierarchical Cluster Analysis

The Hierarchical Cluster Analysis was used to show better the similarities between the samples analysed and to create dendrograms to illustrate the clustering of the groups. After carrying out the PCA, the most significant factor scores were retained, and these were used to produce the dendrograms. Only two methods were included in this thesis, the between-groups linkage and Ward's method, to show that both the approaches give equal results and to confirm the validity of the analysis.

As for the DFA and the PCA, the analysis was initially carried out only on the British samples. First, the non-pooled samples were examined, and secondly, the pooled samples were compared. The following step was to compare the British against Howells' European samples (Norse, Zalavar and Berg). The same procedure was applied: first, the non-pooled samples were compared, and then males and the females were analysed. Finally, a selection of 21 main Howells' groups and the British sample were analysed. Similarly to the previous analysis, the non-pooled samples were first compared and then the pooled samples were analysed.

### 4.5.1 Inter-population Analysis: Non-pooled British Samples

For the production of the two dendrograms shown in Figures 4.32 and 4.33, the factors extracted by the principal component analysis of the non-pooled British samples were used. Four principal components were extracted, and the Eigenvalues show that these account for 91% of the total variance.

Comparing the two dendrograms, it is visible that the two most similar samples to be clustered are St Owen and London. St Owen seems to be also similar to St Gregory, which is the second pair of groups to be clustered. The third pair to be similar is formed by Poulton and Castle Hill, which are not closely linked to the first group. In fact, it seems that Linenhall has closer linkages to St Owen, compared to the previous cluster. Another pair is formed by Guisborough and Ballumbie, but their similarities appear less significant than the previous ones. In both the dendrograms, it is visible that St Leonard does not tend to cluster with any of the other samples. This confirms the results also given by the previous statistical analyses, where the sample from Kent tended to be isolated from the others.

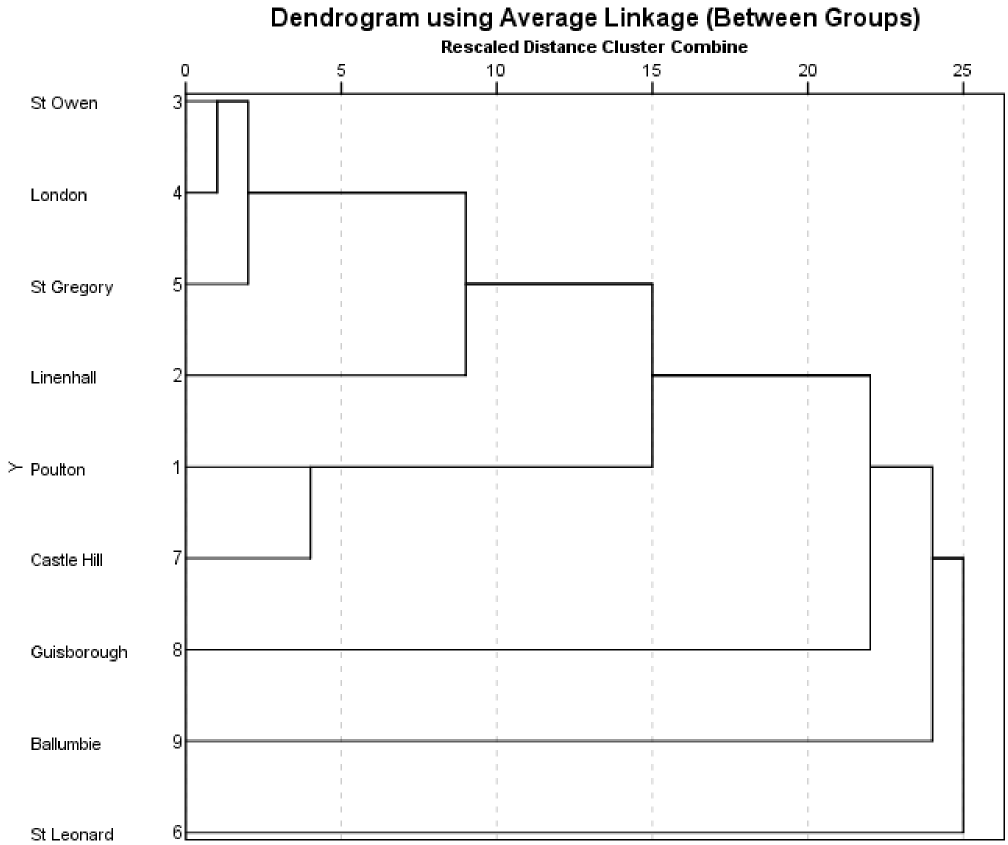


Figure 4.32: Between-groups linkage dendrogram for the non-pooled British samples

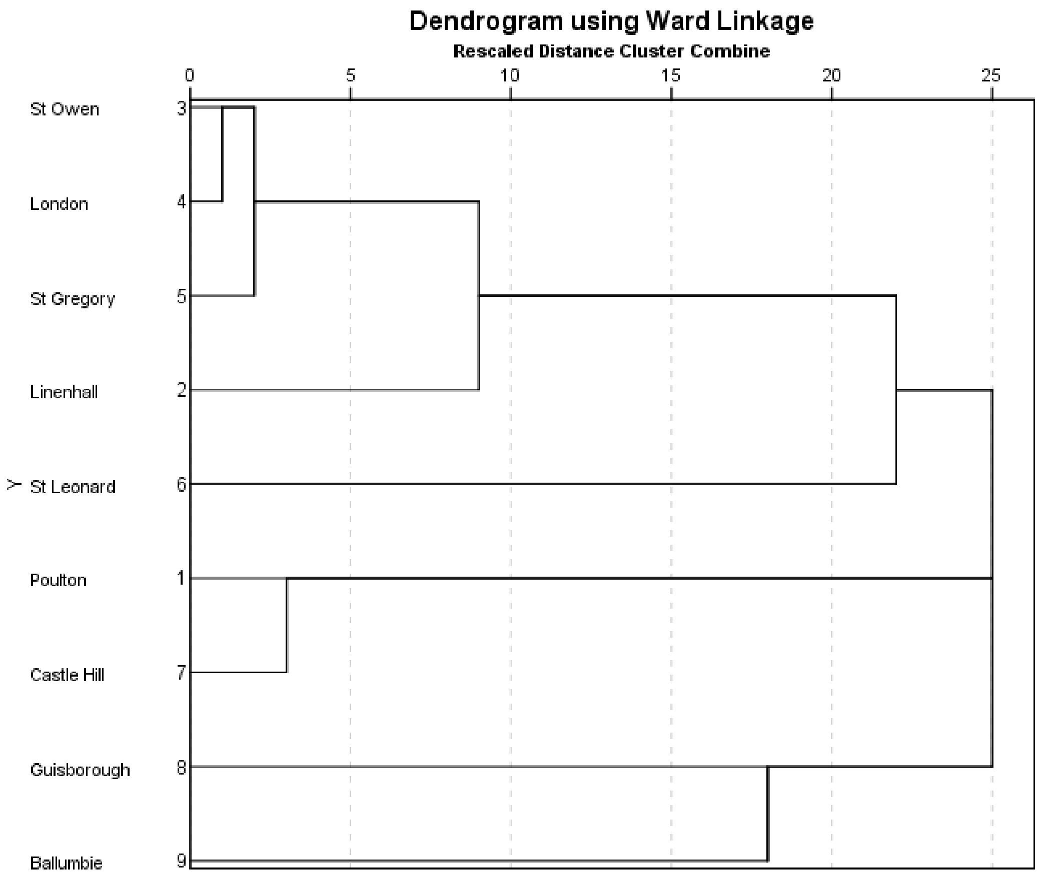


Figure 4.33: Ward's linkage dendrogram for the non-pooled British samples

## 4.5.2 Pooled Samples Analysis

### British Males

The dendrograms for the comparison between the British male samples are shown in Figures 4.34 and 4.35. To produce these graphs, the four principal components that were extracted by the principal component analysis were used. The Eigenvalues show that these account for the 88.1% of the total variance.

It is clear that the first four steps of the analysis agree in their results. The first cluster that is formed is the one between London and St Gregory. The second pair is then formed between Castle Hill and Ballumbie. Secondly, another cluster is formed by Castle Hill and Poulton, while another one is later formed by London and St Owen. The two methods then assign the similarities in different ways. The between groups linkage tend to locate all the connections between the remaining samples and Poulton, while Ward's method sorts out the correspondences more homogeneously. However, the difference is limited, as the samples that tend not to be tightly clustered are St Leonard, Linenhall and Guisborough in both the hierarchical clusters. This means that there is a certain degree of differentiation that remains constant in both the classification procedures.

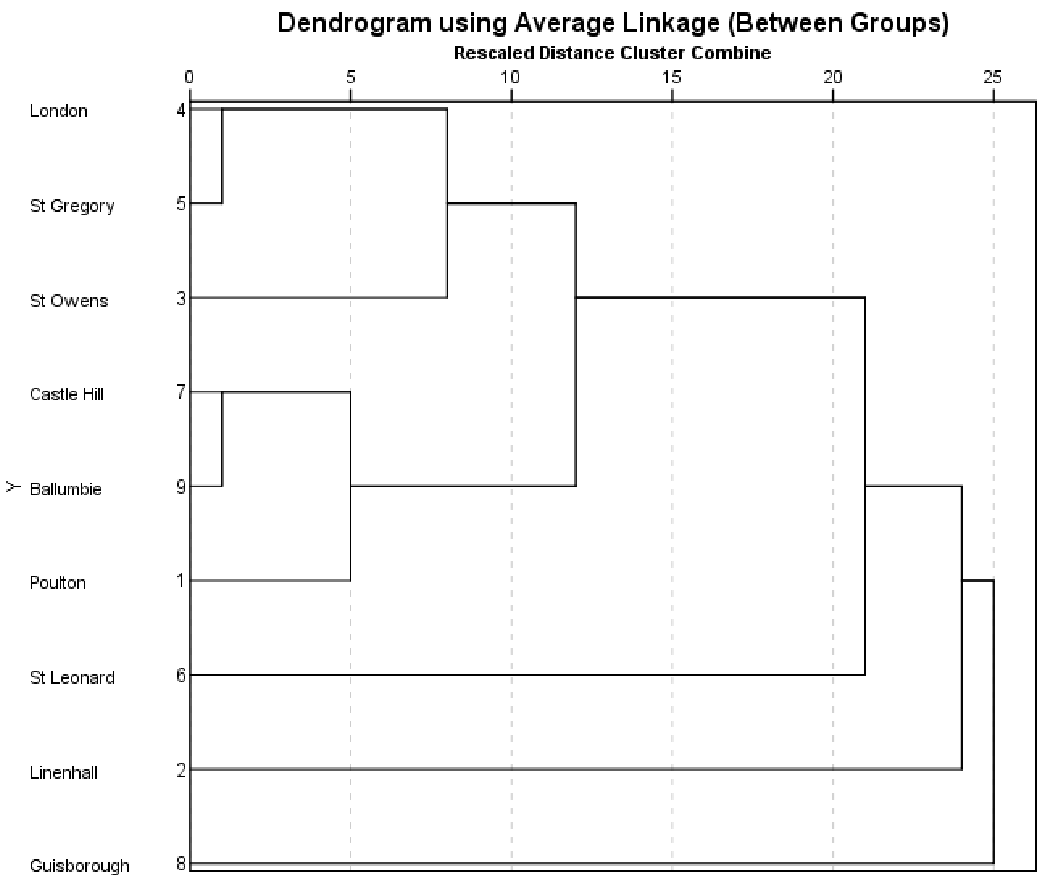


Figure 4.34: Between-groups linkage dendrogram for the male British samples

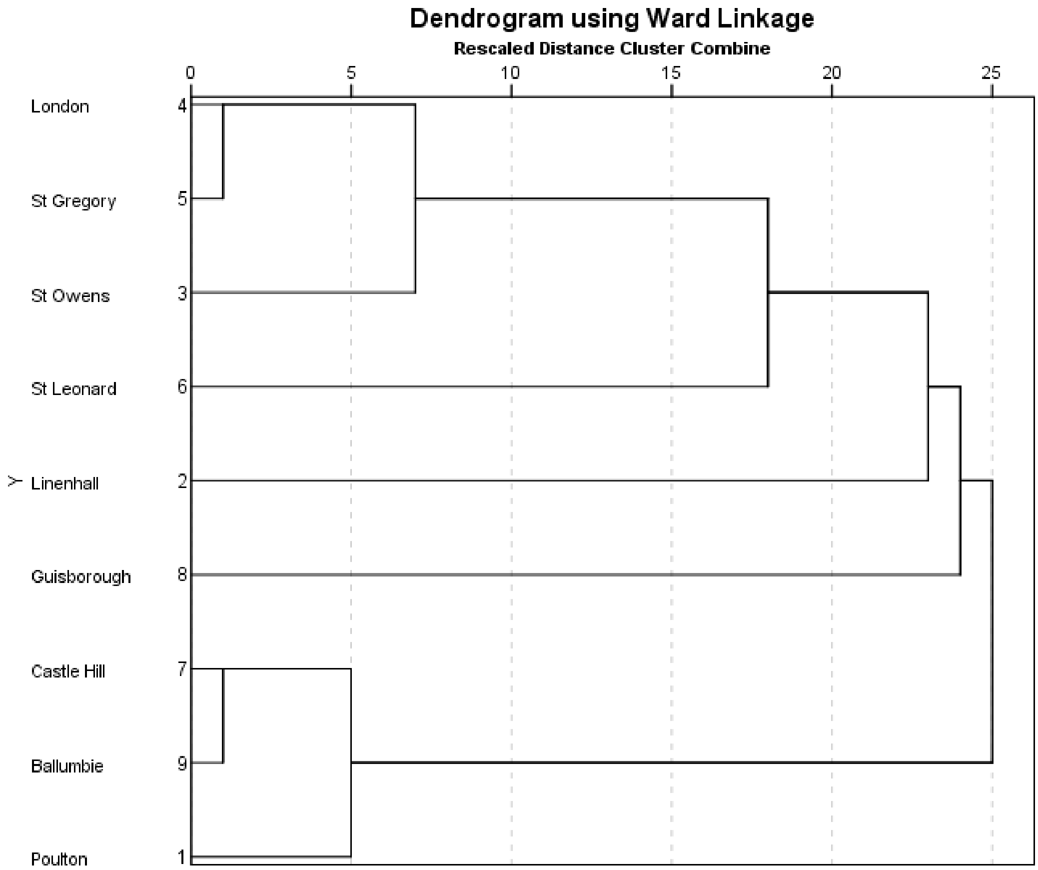


Figure 4.35: Ward's linkage dendrogram for the male British samples

## British Females

In the comparison between the British female samples, for the production of the dendrograms in Figures 4.36 and 4.37, the five principal components extracted for the principal component analysis were used. These account for 91% of the total variance.

It also seems to be the case for the analysis of female samples, where a similar consistency in results can be observed. In fact, the first cluster is formed by Poulton and St Gregory in both graphs. The second most similar samples are St Owen and London. Then, the grouping of the samples seems to differ in the clustering graphs slightly. While the between groups linkage tends to connect all the remaining groups to Poulton, Ward's method results form further clusters between St Leonard and Castle Hill and St Leonard and Ballumbie. However, the fusion of these clusters seems to be somewhat distant, which means that the similarities are not particularly significant between these last groups.

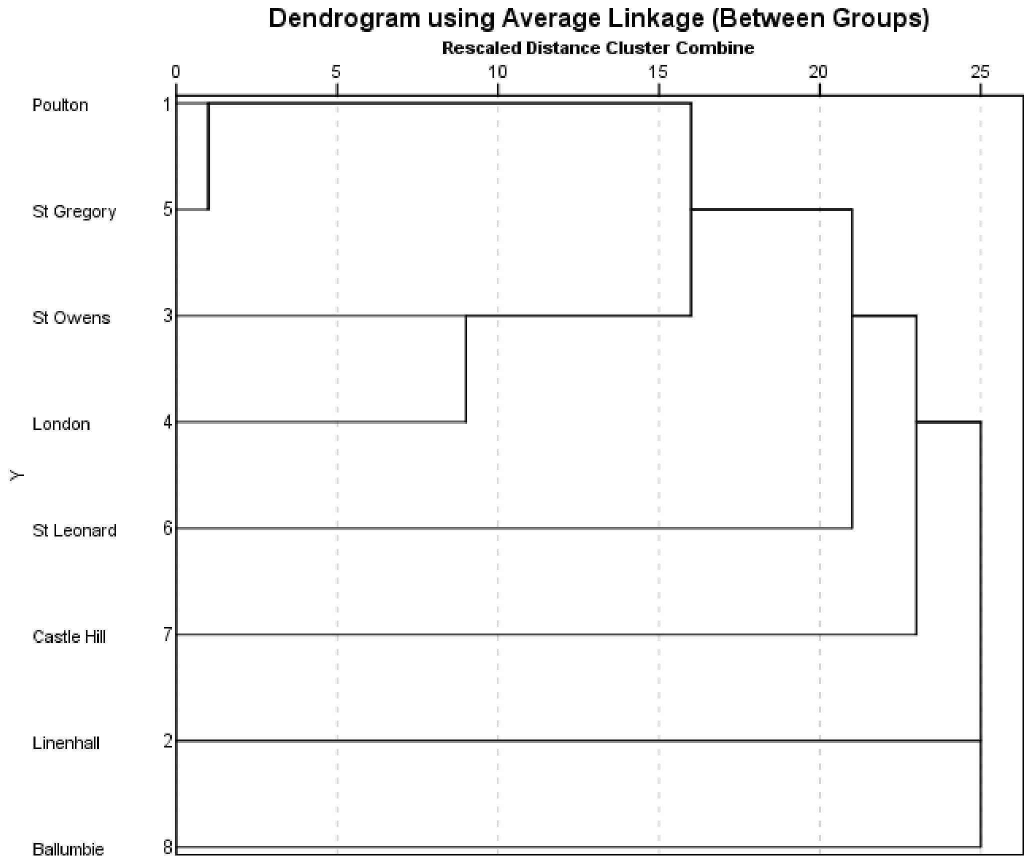


Figure 4.36: Between-groups linkage dendrogram for the female British samples

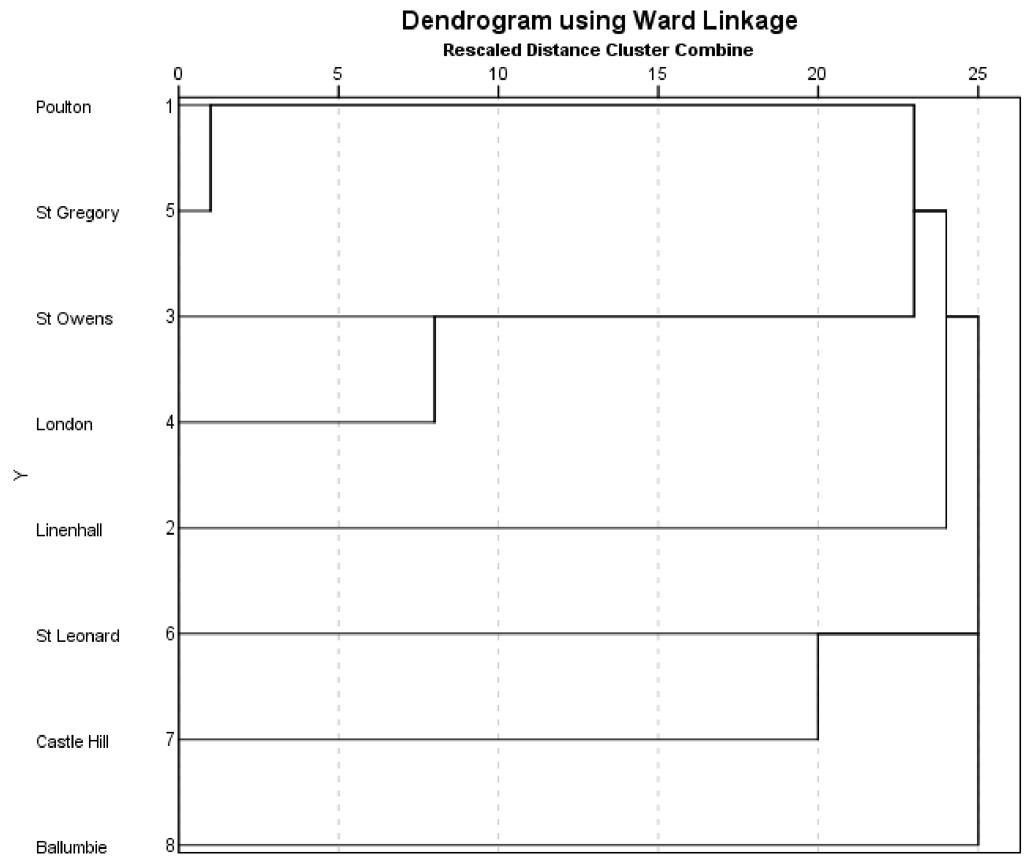


Figure 4.37: Ward's linkage dendrogram for the female British samples

## 4.5.3 Comparison with W.W. Howells data set

### British and Howells European Non-pooled Samples

The first comparison carried out with the Howells' data set is the one between British and European non-pooled samples. The five principal components extracted for the previous analysis were used for the production of the dendrograms in Figures 4.38 and 4.39, and the Eigenvalues show that these accounted for 92.5% of the total variation.

Once again, the results for the two different methods used show use accordant outcomes. The first samples that cluster together are St Owen and London, followed by the Norse and Zalavar that form a completely different pair. St Owen then is also connected to St Gregory, while Poulton and Castle Hill form a separate cluster. The only cluster formed by a British and one of the Howells' samples is the group formed by Ballumbie and Berg. Another linkage can be seen between Linenhall and the Norse sample, even though the fusion between the two clusters is fairly distant, which indicates a minimal similarity between the two groups. Furthermore, both the methods locate St Leonard and Guisborough in an outlier position compared to the other samples.

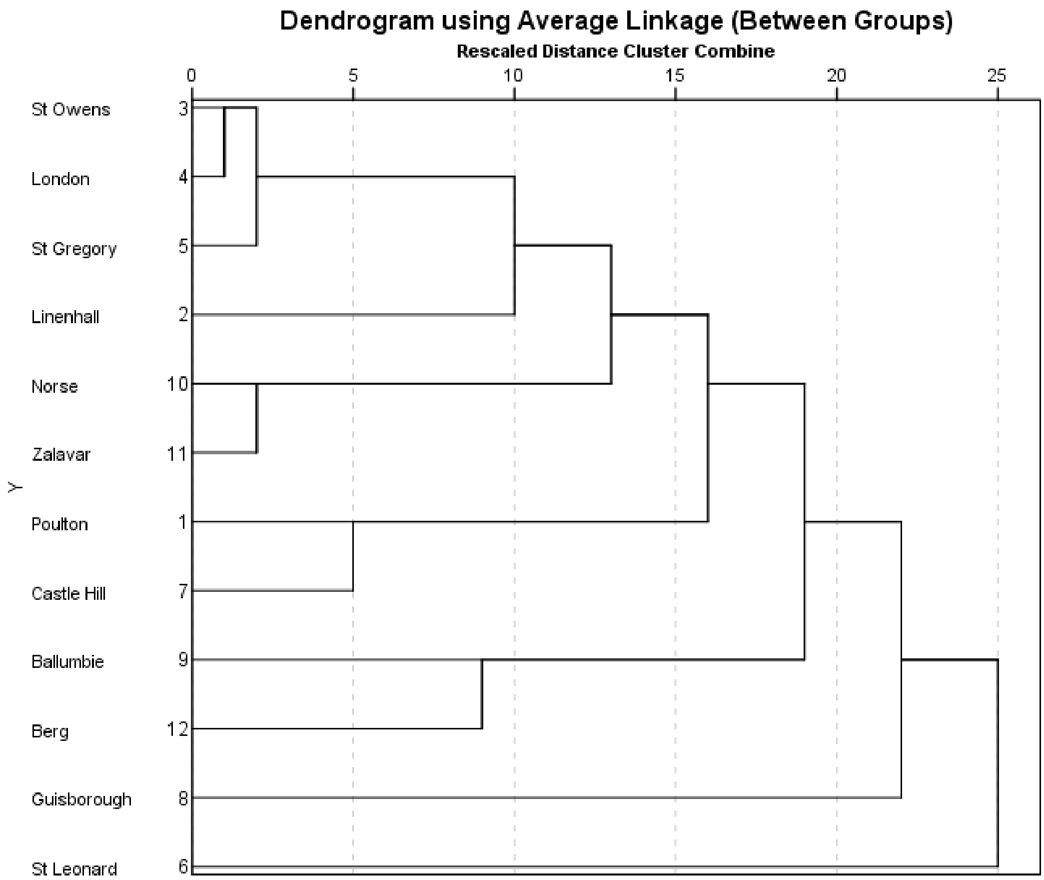


Figure 4.38: Between-groups linkage dendrogram for the non-pooled British and Howells' European samples

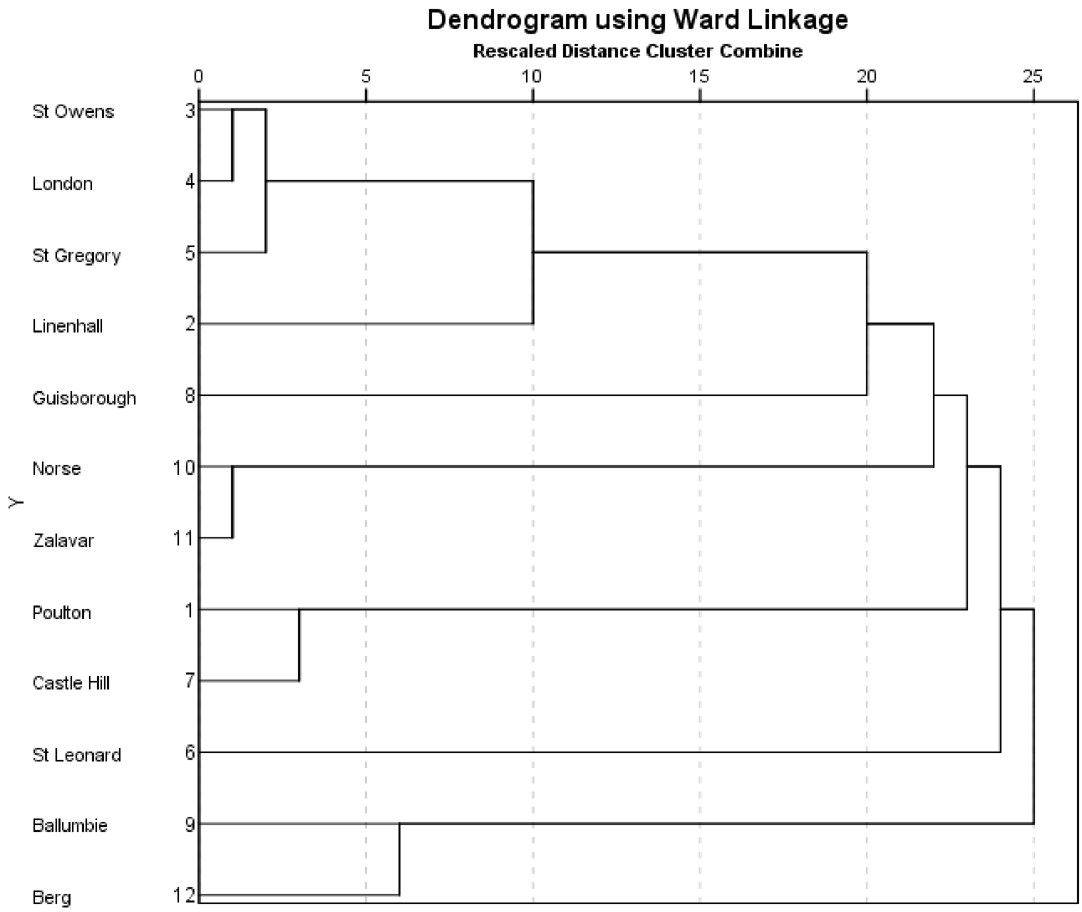


Figure 4.39: Ward's linkage dendrogram for the non-pooled British and Howells' European samples

## British and Howells European Male Samples

The analysis between pooled samples was carried out and, similarly to the previous analyses, the British and Howells' European samples were first compared. For the creation of the graphs in Figures 4.40 and 4.41, the five principal components previously extracted were used and the Eigenvalues show that these account for 90.7% of the total variance.

In both the dendrograms, the most similar samples that form the first cluster are London and St Gregory. The second samples that cluster are Poulton and Castle Hill, followed by the Norse and Zalavar groups, but connected in a different grouping. St Owen is also clustered with Poulton, forming a branch together with the aforementioned Castle Hill and a further more distant fusion with Ballumbie. Guisborough connects with the first cluster, followed by Linenhall, which shows less strong similarities with this group. Finally, the Berg and St Leonard samples occupy an isolated position as they represent two outliers, even though they have a very loose connection with respectively Norse and Poulton.

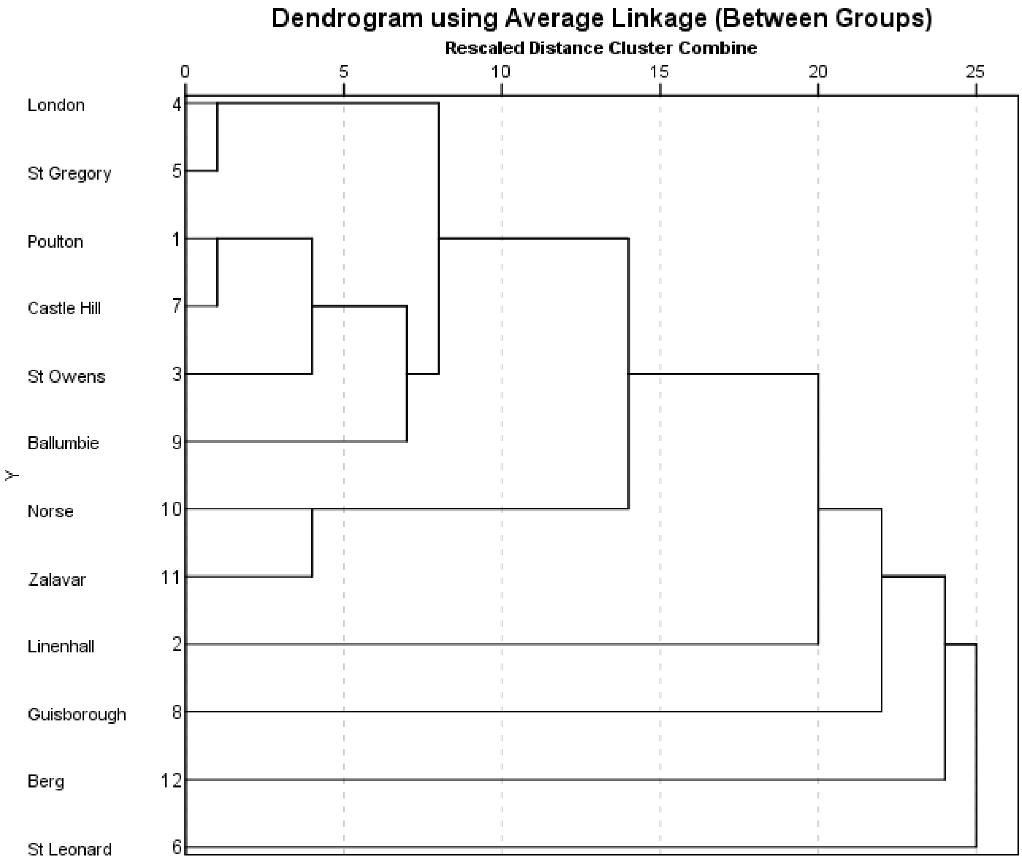


Figure 4.40: Between-groups linkage dendrogram for the male British and Howells' European samples

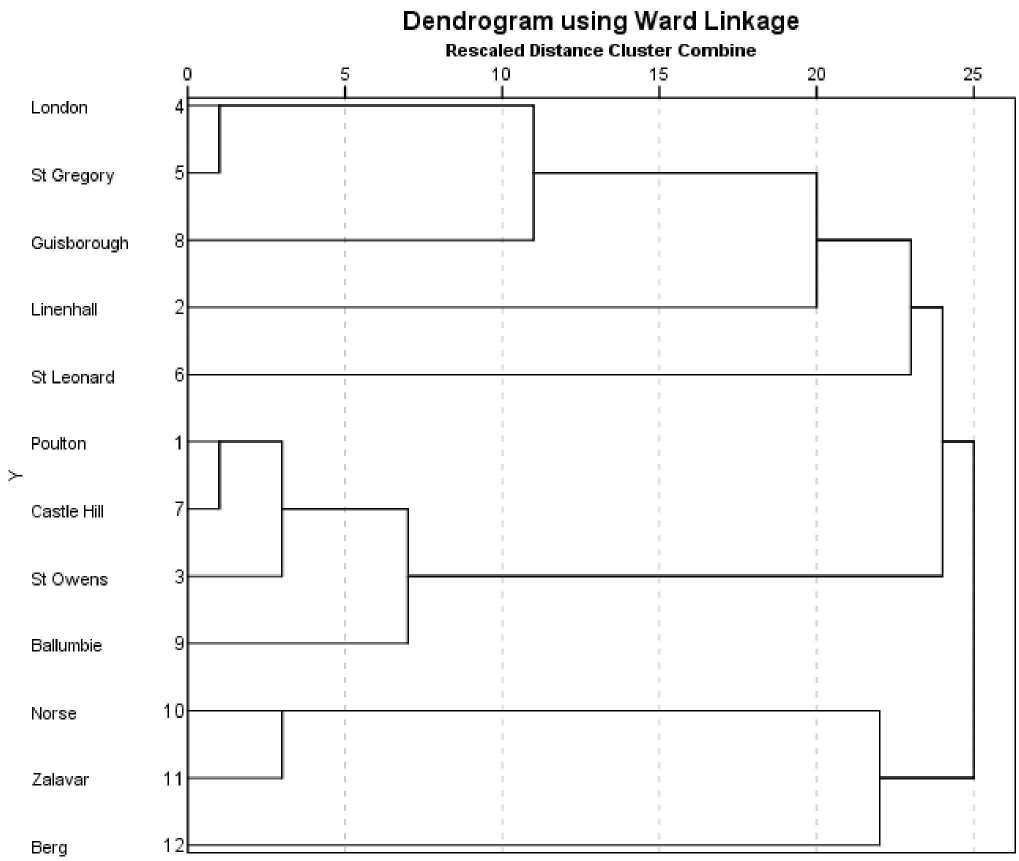


Figure 4.41: Ward's linkage dendrogram for the male British and Howells' European samples

## British and Howells European Female Samples

The last analysis of the British and Howells' European groups involved the female samples. The two dendrograms that can be seen in Figures 4.42 and 4.43 were made using the four principal components extracted from the principal component analysis, which account for 80.5% of the total variance.

The sample form Guisborough, just like for the principal component analysis, was not analysed in this case, as the measurements were incomplete and therefore it was not possible to include it in this dendrogram. The two graphs show that the first two most similar samples are London and the Norse group, which are also linked to the Zalavar sample, with a slightly less similarity. Another cluster is formed by Poulton and St Gregory. St Leonard, in this case, is not isolated but shows some similarities with the Berg sample. While in the dendrograms resulting from the application of Ward's method Ballumbie is forming a branch with the last cluster mentioned, in the between groups linkage this is connected very loosely with Poulton. The two samples that in this case seem to constitute two outliers are Castle Hill and Linenhall, which differ the most from the other groups.

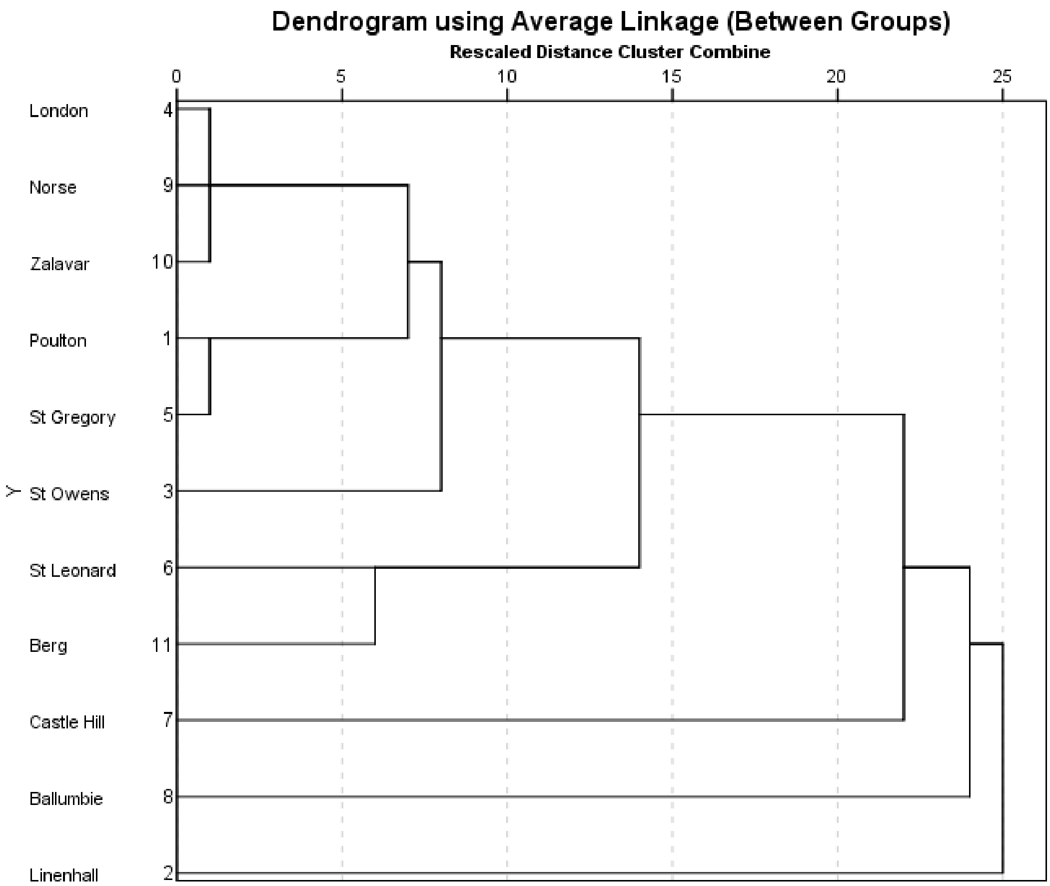


Figure 4.42: Between-groups linkage dendrogram for the female British and Howells' European samples

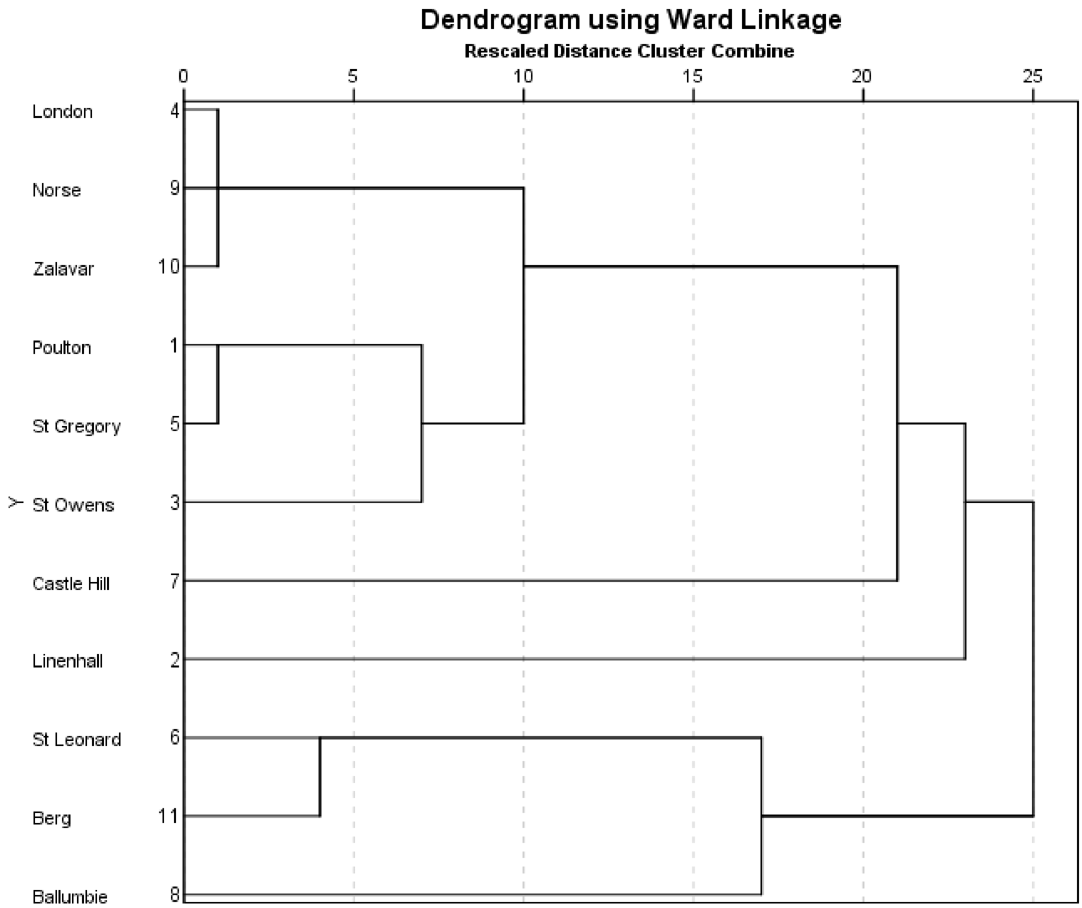


Figure 4.43: Ward's linkage dendrogram for the female British and Howells' European samples

## British and Howells Non-pooled Samples

The hierarchical cluster analysis involved, as for the previous analyses, also the selection of Howells' samples. To produce the two dendrograms in Figures 4.44 and 4.45, the four principal components extracted by the principal component analysis were used, which account for 83.2% of the total variation.

The two graphs agree in the results given, and the samples seem to cluster on the basis of geographical affinity. The two samples that share the most similarities are St Gregory and St Leonard, followed by London, which creates a branch together with St Owen, which seems to cluster later in the Ward linkage method. Another cluster is formed by the Norse and Zalavar samples, which are linked to the previously mentioned branch in the between-group linkage dendrograms, while Ward's method tends to connect it with the cluster formed by Poulton and Castle Hill. In both the graphs, Linenhall does not seem to closely cluster with any other sample, although the fusion of its linkage is located at a greater distance than the ones above with St Owen. A further cluster is formed by Poulton and Castle Hill, while Ballumbie is connected to the Berg sample. The only exception for the British samples is Guisborough, which clusters with the Buriats, also reiterating the results given by the previous analyses. This pair seems to reconnect in both dendrograms with the European group, but the fusion point is located relatively distant in the graphs.

The Howells non-European samples tend to cluster on the basis of geographical affinities. A branch is formed by the eastern groups, which are connected into a group formed by different clusters. The first one is formed by the Shang Dynasty and the Guam samples. Also, this group is linked to the Easter Island with a more distant fusion of the linkages. Another cluster is formed by the Hainan Island sample and the Yauyos, which is not an eastern group but can have some morphological affinities with Asian samples. A further cluster that is separate from the European and the eastern groups are formed by the Zulu and the Australian samples. These two groups demonstrate to have several morphological similarities, which are also confirmed from the discriminant function and the principal component analysis. Finally, the Bushmen result to be slightly isolated in the dendrograms produced with Ward's method, but still linked to the previously mentioned cluster. On the other hand, the between-groups linkage locates this sample as an outlier, as can be seen in Fig. 4.44.

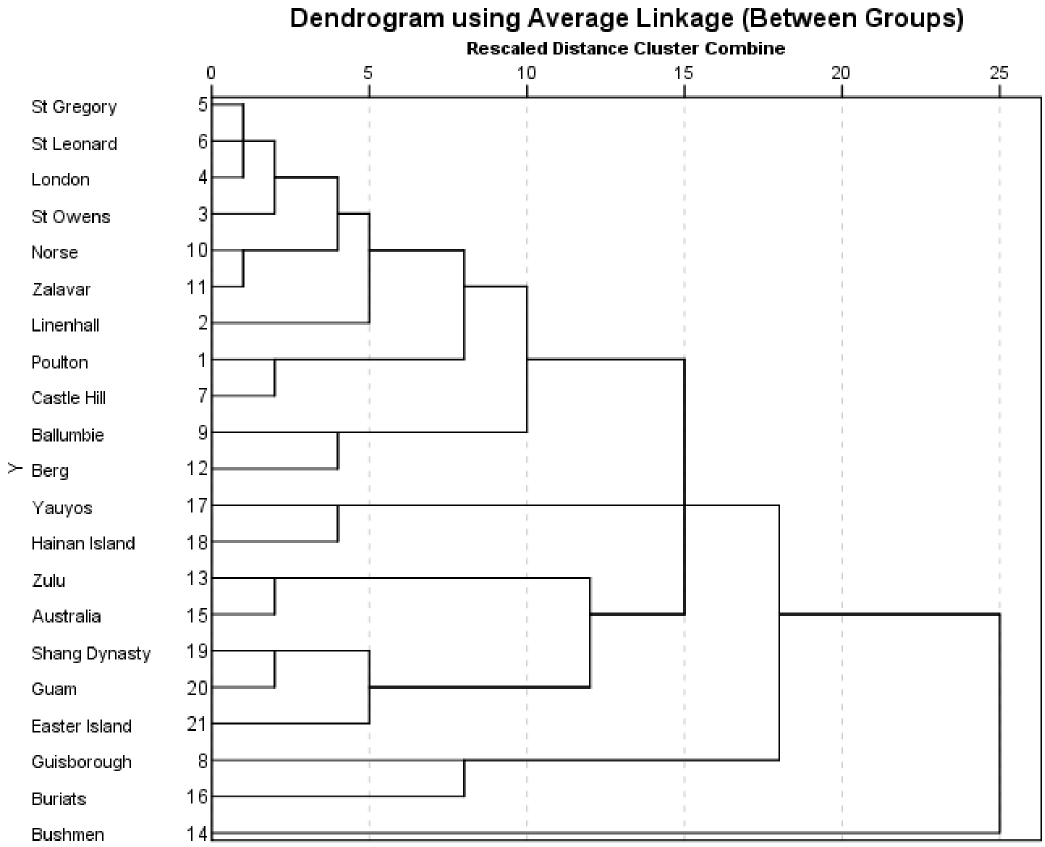


Figure 4.44: Between-groups linkage dendrogram for the non-pooled British and Howells' samples

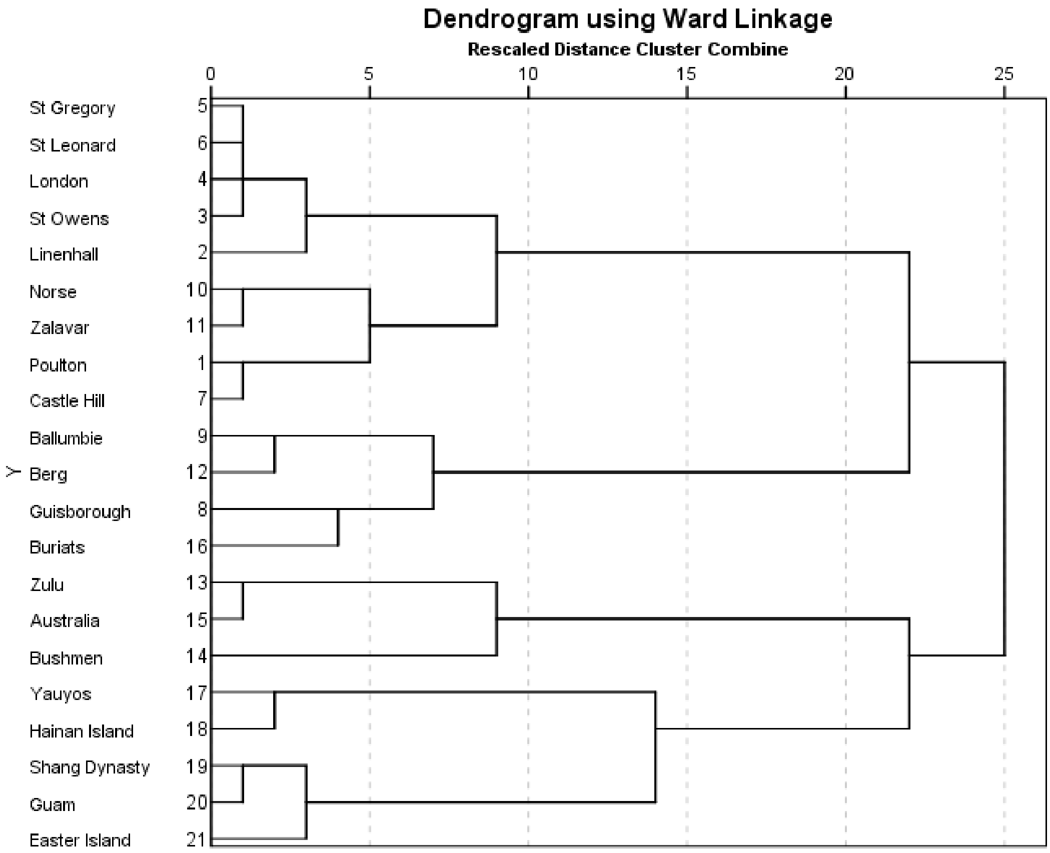


Figure 4.45: Ward's linkage dendrogram for the non-pooled British and Howells' samples

## British and Howells Male Samples

The graphs showing the comparison between the British and the Howells male samples are shown in Figures 4.46 and 4.47. The four components that were extracted by the principal component analysis were used and these account for 82.03% of the total variation.

The first cluster is formed by London and St Gregory, which also is connected to St Leonard. In both graphs, these samples are associated with St Owen, Ballumbie and Linenhall, which show linkages fusion in different positions. Different clusters are formed by Norse and Zalavar and Poulton and Castle Hill, which are all linked into a branch connecting to the other British samples. As for the non-pooled samples, Guisborough is located in two different locations in each method. The between groups linkage locates the sample as an outlier but connected by a distant point of fusion with the branch formed by the Hainan Island, Shang Dynasty and Yauyos samples. The Ward linkage clusters Guisborough with the Berg and the Buriats sample. Regarding the non-European samples, the eastern males seem to split in two different groups. The Hainan Island and the Shang Dynasty form a cluster, which is also connected with the Yauyos sample. On the other hand, the Guam and the Easter Island form another cluster, which is not connected to the other Asian samples. This last group is part of a branch that is connected to the cluster formed by the Zulu and Australian group.

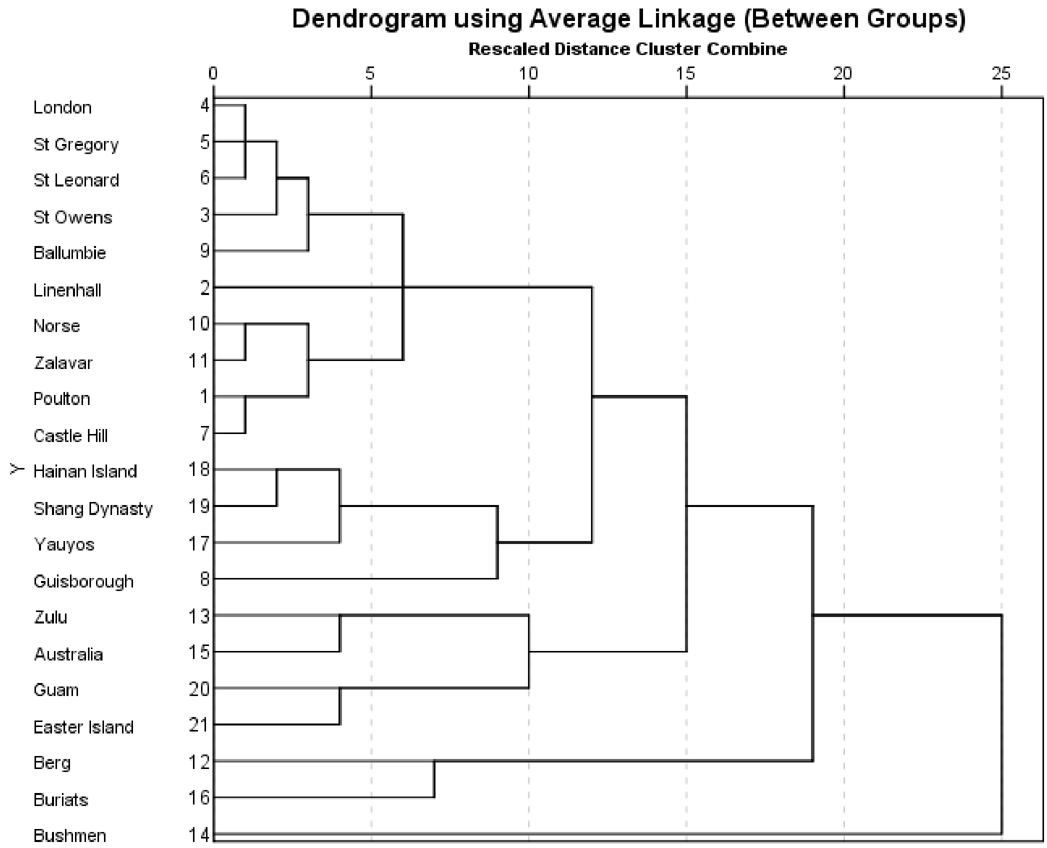


Figure 4.46: Between-groups linkage dendrogram for the male British and Howells' samples

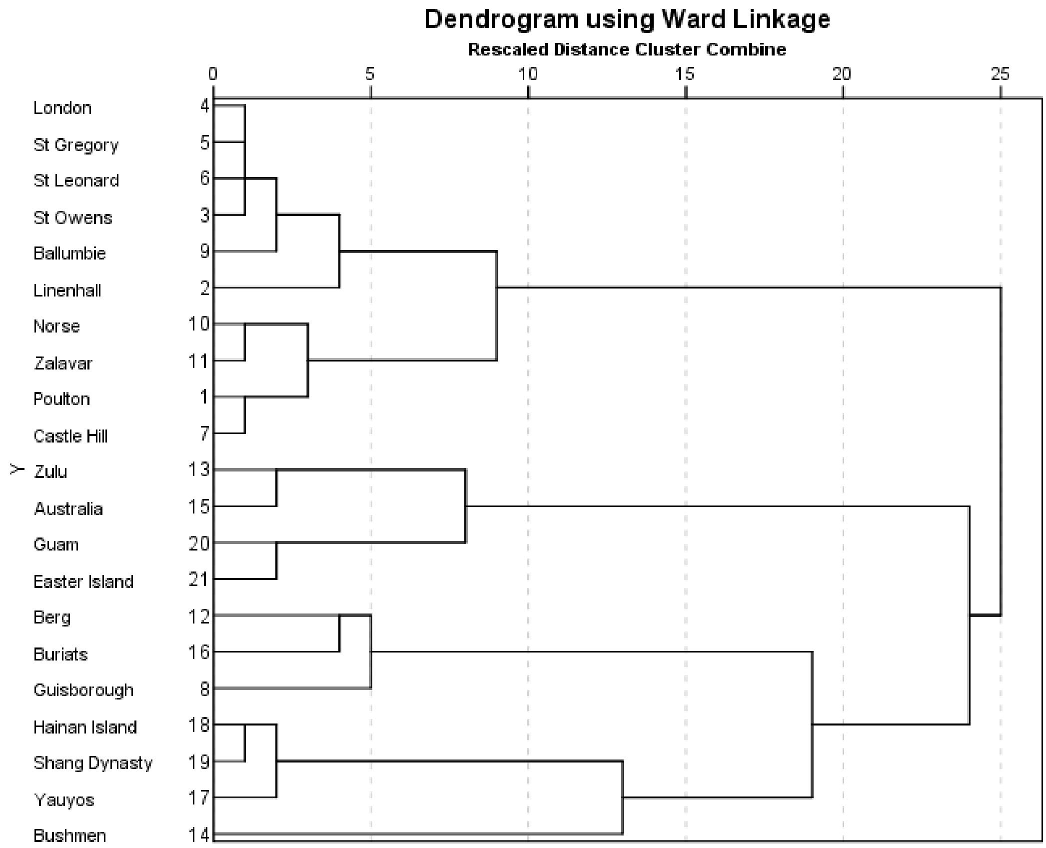


Figure 4.47: Ward's linkage dendrogram for the male British and Howells' samples

The Bushmen result as an outlier in the between-groups linkage, which is not directly connected to any other sample. In the case of Ward's linkage instead, this sample is part of a branch with a reasonably distant fusion, which includes the group formed by the Hainan Island, Shang Dynasty and Yauyos.

## British and Howells Female Samples

The final stage of the hierarchical cluster analysis involves the comparison between the female samples. Just as for the previous analyses, it was not possible to include the female sample from Guisborough due to the unavailability of some of the measurements. The graphs in Figures 4.48 and 4.49 were produced using the four principal components extracted by the principal component analysis, which account for 82.6% of the total variation.

The two most similar samples are in both graphs St Owen and St Gregory, which form a bigger branch together with Poulton. The second pair that is clustered by the analysis is the Norse and Zalavar samples, which further connect to the above-described branch. Another cluster is formed by St Leonard, Berg and Ballumbie, which do not seem to link to the primary European cluster. Linenhall is represented as a sort of outlier if compared to the European samples, which is connected to the first cluster by a distant fusion of the linkages. A further outlier is represented by Castle Hill, which, in the between-groups linkage is connected to Linenhall, while in Ward's linkage is isolated and connected to Poulton, but with a very distant linkage fusion. In both graphs, London seems to share more similarities with the Yauyos group, rather than the European samples. The Guam and Easter Island groups seem to agree in both graphs, being cluster together, while the Hainan Island sample is linked to London and the Yauyos group in Fig. 4.48, while in Fig. 4.49 it belongs to the eastern samples' group. Finally, the Zulu and Australian samples maintain their cluster as in the previous analyses, while the Bushmen seem to be an outlier in the between-groups linkage. In Ward's linkage instead, the Bushmen are part of this last branch that connects the sample with a fusion that is at a great distance, showing that their similarities are less if compared to these samples. The Buriats as well represent an outlier, as they do not seem to cluster with any other group in the first method, while in the second they report some similarities with the London sample.

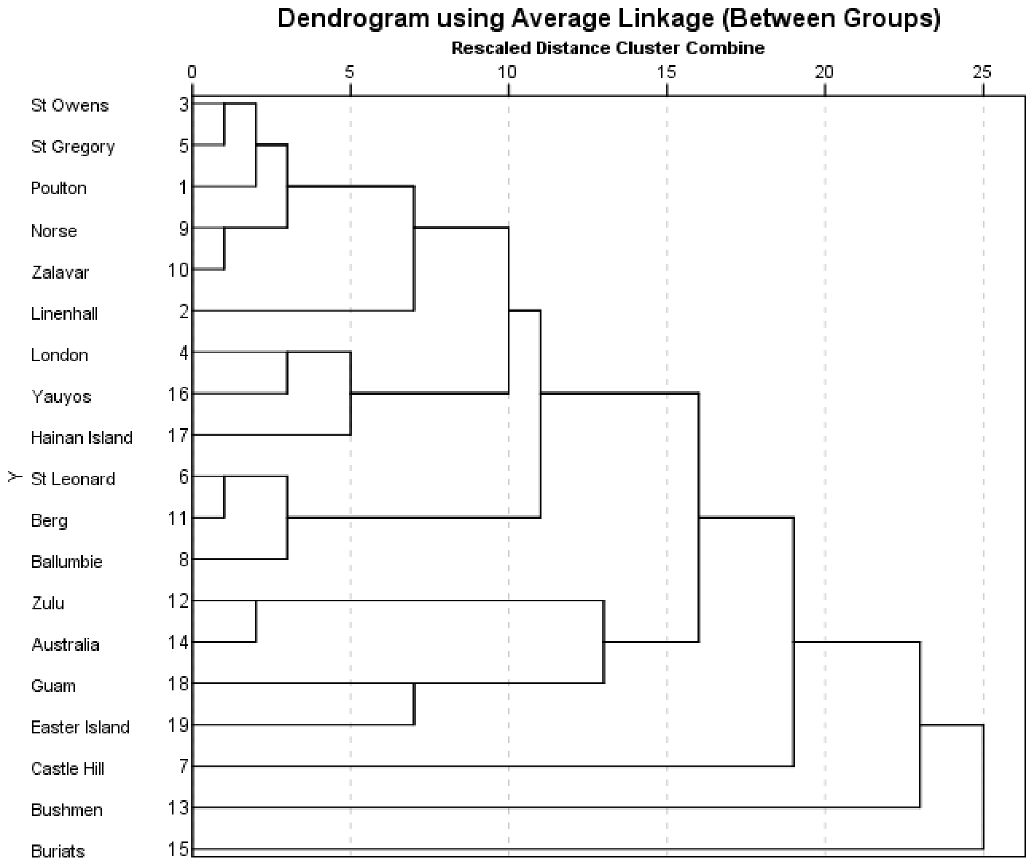


Figure 4.48: Between-groups linkage dendrogram for the female British and Howells' samples

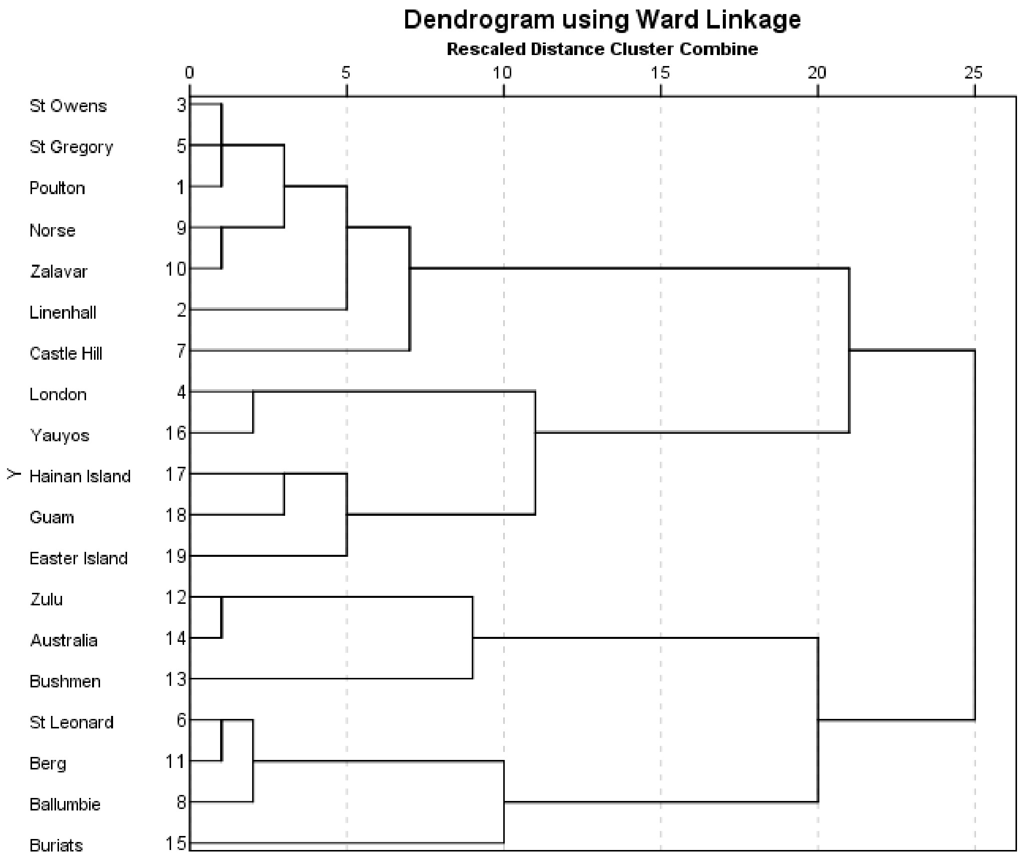


Figure 4.49: Ward's linkage dendrogram for the female British and Howells' samples

# 5. Discussion

## 5.1 Introduction

Chapter 5 discusses the importance of skeletal reconstruction and the results obtained by the statistical analysis. Section 5.2 debates the importance of cranial and skeletal reconstruction for research, teaching and display purposes. Section 5.3 interprets the results regarding the comparison between British samples. The aim is to understand the reasons that lead to differentiation between British samples from a morphological and historical point of view. The same is done for the comparison between British and Howells' European samples in section 5.4.1. Finally, section 5.4.2 discusses the variation that is encountered among the main Howells' population samples that were selected for this study. The aim is to understand if the discrimination follows a geographical pattern and whether craniometrics reflect geographical adaptation or genetic variability.

## 5.2 Skeletal and Cranial Reconstruction

Cranial reconstruction was essential for the implementation of this study. The restoration of 300 skulls was fundamental as most of them were recovered fragmented during the excavation. The damage of these elements is usually due to taphonomical events that affect the bone after the burial of the individual or can be the result of excavation and post-excavation damage (Borrini *et al*., 2012). Post-depositional damage can lead to fractures on the skull, and it can occur in different forms. The two main processes that affect the bones in a post-depositional environment are the pressure caused by soil after the decomposition of soft tissues and the compression after the collapse of the lid if the individual was interred in a coffin (Pokines and Baker, 2014a). The eventuality of individuals being buried into coffins is low for the Middle Ages, even if the pattern of distribution of these structures is not yet well understood. In a common funeral, the individual was placed into a coffin, after the activities of washing and dressing, to be brought in procession to the church. After the funeral, most of the individuals would have been removed from the coffin and buried in their shroud alone (Gilchrist and Sloane, 2005).

The gradual breakdown of a coffin allows the infiltration of sediments and the growth of roots in the internal side of the container that comes in contact with the remains. The collapse of the cover exposes the bones to the weight of the soil, causing damage and fracturing of the bones. Warping is also frequent, as the structure of the skull is weak and is combined with a small number of soft tissues that usually decomposes before the bone surface comes in contact with the coffin floor (Pokines and Baker, 2014a). Fractures are also caused in a non-coffin burial, where the subsequent pressure of the soil would lead to the fragmentation of the skull. Further damage to the remains can be caused by excavation or post-excavation activities. In fact, during the excavation and the lifting of the remains, the skull can be subject to damage and fractures can appear on the surface of the bone. Some damage can also be caused by the use of mechanical machinery during the opening of excavation, if the remains are particularly close to the surface (Fig. 5.1).

Figure 5.1: Example of excavation damage from Gloucester

Buried remains can be accidentally discovered by citizens during construction work, farming activities, gardening or digging by pets. If the bone has become more friable for a consequent loss of organic content, an impact from a shovel or any other tool can lead to a crack on the impact site (Pokines and Baker, 2014b). Once the remains are brought from the field to the laboratory, appropriate handling is crucial to avoid additional taphonomical damage (Cronyn, 1990). The effects of poor transport and storage are another reason for the appearance of fractures on the bones. The storage in hard boxes with an inadequate cushioning may result in further damage to the remains. All these post-mortem damage events can lead to a reduction of information on the biological profile, with a loss of intact surface morphology and the number of measurements that are allowed to be taken for metric estimates of sex, age, stature and ancestry (Pokines and Baker, 2014b).

For this reason, the reassembling of an anatomical part, especially the skull, is essential for the analysis of human remains. Bone reconstruction was very popular in the past, and it is frequent to come across the reassembling of the earlier recovered remains. However, some attempts of reconstruction of the bones that were carried out in the past are poor curation examples, which can be considered more as damage than care for human remains. The reason can be related to the fact that people with a poor knowledge of anatomy and training in the

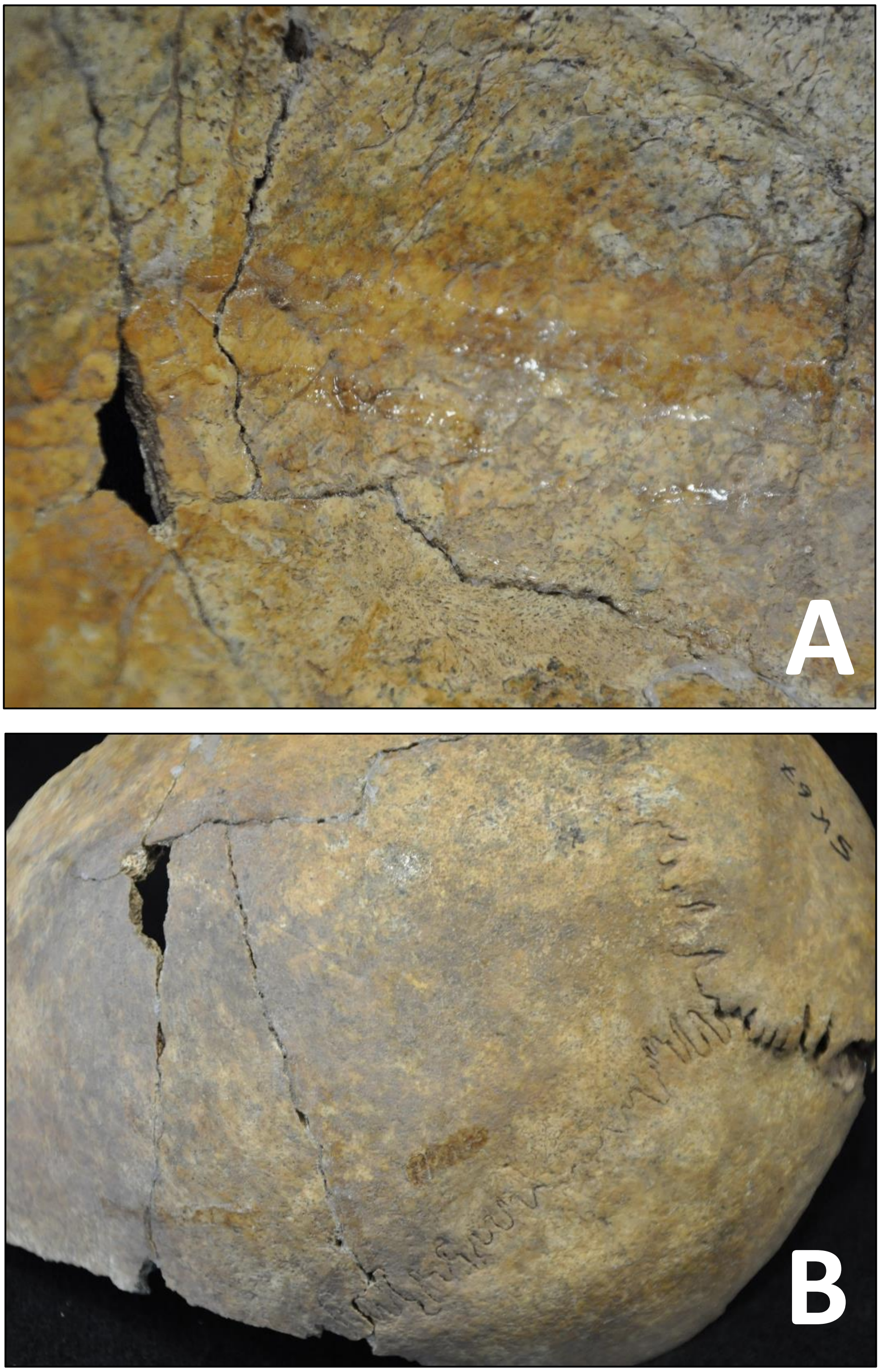


Figure 5.2 A and B: Example of poor cranial reconstruction from Skeleton 67 from Poulton

curation of skeletal material were allowed to carry out reconstruction, with poor final results (Fig. 5.2 A and B).

Another reason could be that the materials used for reconstruction were not adequate for this purpose (not reversible) and led to the deterioration of the sample. This was noted by the author when analysing some of the samples. Consequently, in the last years, reconstruction of human remains has been abandoned by researchers. With the increase in awareness of appropriate care of human remains, various guidelines have been published for the treatment and conservation of skeletal material. The main guidelines used in Great Britain are the Code of Practice published by the British Association of Biological Anthropology and Osteoarchaeology (2018). The code states that "*if a bone is broken, and if appropriate (i.e., for display purposes), it may be joined together using a reversible glue (HMG Paraloid B-72) and the process should be documented*". Mays, Brickley and Dodwell (2004) instead suggest that only minor reconstruction is worthwhile, to enable researchers to record measurements. Odegaard and Cassman (2006) discuss whether reconstruction is damaging the bone or any other analysis that could be done after the restoration of the sample and propose alternative solutions to the use of glue and adhesives. Their main concern is whether the glue would be damaging the surface of the bones in the long term, if it is reversible and if the application of this polymer is adding thickness to the overall structure of the bone. They also propose as an alternative to the use of Parafilm M. for the long bones and microcrystalline wax strips for the temporary reconstruction of the skulls. Another alternative that is proposed by the same authors is the scanning of the individual skeletal material so that reconstruction could be done virtually and made available for researchers that are not able to be physically present to conduct their research directly on the bones.

The methods above are proposed in order to avoid the damage to the skeletal material, which would result in an irreversible loss of information and permanent damage to the bone. At the same time, these solutions are not stable, and they do not ensure the correctness of the analysis of a specimen. The curatorial part of the present study involves, as suggested in the BABAO code of practice (2018), the use of a 60% solution of B72 mixed with acetone. Once the fragments have been appropriately washed with water, avoiding the persistence of any soil residue, and dried, the remains can be joined together. The compound used to reconstruct the fragmented elements is suitable for human remains, as it does not affect the integrity of the bone. Differently, from other glues that have been used in the past, this solution is reversible with acetone, and it can be removed immediately after the reconstruction, both when the glue is not dry yet, and after the glue has dried. If the compound is created with the right amount of components and the fragments are placed in a stable position to dry, it will not create a thickness between the fragments, as criticised by Odegaard and Cassman (2006). The solution needs to be liquid enough to not create a layer of solid glue between the bone portions, and its composition needs to be checked frequently, as the acetone tends to evaporate quickly.

The other method that was employed in the cranial reconstruction in this study is the replacement of missing parts with a customized wax. This compound was designed by Borrini (2007) and tested by him and the author at the Forensic Anthropology laboratory at the University of Florence. The wax, made of a mix of beeswax, paraffin, pine rosin, casting powder and calcium carbonate (please refer to section 3.3.1 for the exact quantity of each component), can be mixed with natural pigments to recreate bone's natural colour. This method is completely reversible and does not damage the bone. The wax does not leave any oily residue on the bones and can be easily removed from the specimen. The reason why this technique has been applied is due to the frequent loss of small parts of the cranium. The bones that are most damaged or lost during excavation are nasal and lacrimal bones and zygomatic processes. The integrity of these parts is significant for the stability of its whole structure.

It is crucial to reconstruct these elements in order to obtain stability in the skull. It is also fundamental that the reconstructed parts are recognisable from the bone, as it needs to be evident that some parts are missing. The reason for this is that craniometric measurements and other types of analyses cannot be recorded on a reconstructed area, as the wax is intended to improve the stability of the bone, not recreate the anatomical part. On the other hand, if the reconstruction is not done, a remarkable amount of data can be lost. It is important to underline that the reconstruction has to be made by trained anthropologists. To carry out this practice, it is fundamental that the person performing the reconstruction has excellent knowledge about the anatomy of the human skeleton. The incorrect placement of fragments during a reconstruction does not only lead to permanent damage of the specimen but would also affect future data collection and lead to wrong results. It is also essential that the conditions of the specimen are assessed before the reconstruction. In fact, the restoration of a warped skull or severely damaged by the burial environment, is not convenient because no metric analysis can be carried out.

The majority of the skeletal collections analysed presented less than 50% of complete skulls, which means that the ones that were analysed are only a small part of the samples representing the collection. The collections that were measured by the author reported a conspicuous number of fragmented skulls or showed poor attempts of cranial reconstruction made during the past (Fig. 5.4 A and B). These conditions inhibited the data recording, reducing the potential of the amount of data collected. Another sample from which the data was acquired from accessible sources was the one stored at the Museum of London. As it is clear from the data available, most of the skulls are not complete, and a remarkable number of specimens was


Figure 5.4 A and B: Examples of poor cranial reconstruction from St Gregory's sample

excluded from the statistical analysis. Similarly, the data published by Anderson (1994) on the human remains excavated from Guisborough priory, involved only 32 skulls out of 40 adults that were recovered. From these 32 adults, more were excluded from this study, as the completeness of the data did not reach 50%.

Many anthropological samples are stored in Universities and represent a valuable resource for students, researchers and lecturers. However, as described before, most of the collections are fragmentary, and this often represents an obstacle to the examination of the remains, especially if they present trauma or a pathological condition. In the case of cranial reconstruction, a complete skull collection is extremely advantageous for students and researchers to appreciate not only the variability within a population but also to analyse the cranial features as a whole. An example of useful cranial reconstruction could be represented by Skeleton 107 from Gloucester. The individual was analysed and published by Valoriani, Eliopoulos and Borrini (2017) as a case study of sharp force trauma in medieval Gloucester. The reconstruction allowed to observe better the sharp force trauma on the skull and the consequent radiating fractures caused by the impact of a sharp object. As the complete skeleton was reconstructed, a sharp force trauma was also identified on the right scapula, which would not have been possible to locate without a restoration of the anatomical part (Fig. 5.5).

Skeletal reconstruction is not only useful for research and teaching purposes but also for museum display. Many museums exhibit skeletal specimens, which have been excavated from different sites in Great Britain. The display of human remains can be a controversial topic if these are less than 100 years old. In the case of archaeological remains, these can be displayed if they do not outrage public decency (Woodhead, 2013). Museums are accessed by both experts and the general public, which is often not familiar with physical anthropology. Skeletal reconstruction would be a useful tool for the better comprehension of the remains by a wider

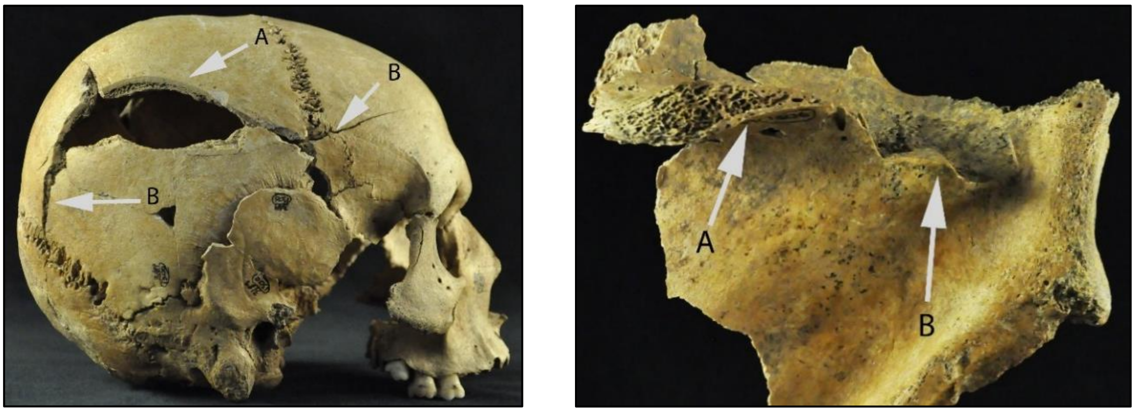


Figure 5.5: Skeleton 107 from Gloucester showing sharp force trauma following the reconstruction (from Valoriani, Eliopoulos and Borrini, 2017)

public. A fragmented skull would not be understood in its completeness by someone that is not familiar with human anatomy. If a fragmented skeleton with trauma or pathology was displayed, it would not be possible to appreciate and observe the condition, as the nature of the remains would not allow a vision in its complex. If the skeleton instead underwent a full restoration, the public, as well as researchers, would have the benefit of better observing the case. A further advantage of cranial reconstruction consists in offering the opportunity of carrying out facial reconstruction. There are many techniques used for facial reconstruction, and the digital option is very popular (Wilkinson, 2004). For the digital reconstruction, the skull needs to be laser scanned, so that the anthropologist can work on the digital copy. A fragmented skull can be reconstructed virtually, but every cranial fragment needs to be scanned. This method is time-consuming, and the equipment is expensive, which would constitute a limit for the researchers, Universities and Museums interested.

Cranial reconstruction would be suitable, as for a complete reconstruction takes around three hours for experts who are trained for the task. This would also be suitable for a later scanning of the skull, which would be faster than having to scan every fragment and then digitally reconstruct the sample. To carry out facial reconstruction, a complete skull is needed, as it is not possible to reconstruct the features of a face with an incomplete cranium. If a facial reconstruction is presented in a museum, it will increase the chance of engaging the visitors and make them aware of the history of a particular historical person. At the same time, facial reconstruction is also used in forensic cases. The recovery of fragmented remains is not an unusual event and to identify the individual, a biological profile needs to be done. In many cases, facial reconstruction would be a useful tool for the investigators to give a chance of recognising this person.

For this reason, in case of a fragmented skull, reconstruction is the easiest, quickest and accurate way to facilitate the identification of the remains. For many reasons, cranial reconstruction is essential, both in physical and forensic anthropology. This method should be reconsidered, as the loss of information is conspicuous and research should not be considered complete with the lack of information caused by the fragmentary nature of the remains.

## 5.3 Inter-Population Analysis: British Samples

The initial interpretation of the comparison between British samples is that there is no clustering based on geographical affinity.  This result is partly expected, as this analysis is not looking at an extensive geographical area or a wide range of time. A consistent geographical variation occurs when there is a bioclimatic effect on the population that leads to climatic adaptation with different anthropometric distributions (Beals *at al.*, 1984). The British samples are geographically close. It is therefore likely that the climate differences would not have an impact on these samples' cranial measurements variability, as there are no substantial differences between the northern and the southern regions. Furthermore, the samples analysed are not chronologically distant, as they all belong to the Middle Ages. Therefore, it is probable that the differences determined by the statistical analyses are not a consequence of climate adaptation or a change based on the period.

Previous studies regarding British samples proved that there is a temporal trend that leads to a microevolutionary change over time (Mays, 2000). The degree of variation between Neolithic and Bronze Age remains is reasonably high. It is therefore unlikely that the later population derived from the earlier (Brothwell, 2014). An example was adopted by Brothwell (2014) regarding the craniometric differences between the Anglo-Saxon groups and the later medieval samples. The author states that the discrepancies between the two cannot be explained in terms of rapid microevolution. Brothwell and Krzanowski (1974) underlined the differences between the early Neolithic and the Beaker/Food Vessel samples, strongly suggesting a significant change in population composition. They compared two further medieval groups, which are described as brachycephalic in contrast with the previous dolichocephalic samples. These seem to show a different vault morphology from the previous indigenous populations. The authors detected a further separation between Saxons and medieval samples. The theory of brachycephaly's prevalence (or at least high mesocephaly) in the Middle Ages is also confirmed by Tattersall (1968) and Goose (1981), who stated that, before and after this period, dolicocephalic skulls were predominant.

Anthropometric data provide a valuable source of information on biological similarities between historical populations (Relethford, 1988), and the differences observed among British medieval samples can be a result of migrations from outside this geographical area. The effect of regional changes as a result of population admixture has also been proved by Relethford (1988). The author analysed the craniometric variation in some modern Irish populations, comparing the results with blood group variation. He concluded that the results agree in both analyses and that the degree and pattern of population differentiation are due to the effects of English admixture.

The comparison among British samples suggests that there is some homogeneity in the craniofacial morphology during the Middle Ages. However, some groups show a few dissimilarities from the others and are worthy of consideration. During the data analyses, the sample from Guisborough seems to differentiate consistently from the others. The archaeological and historical records do not mention any occurrence of migration during the Middle Ages, neither the presence of Viking or Roman settlements in the previous periods. The discrepancy among craniometric data could be due to the small number of individuals available for examination. The number of skulls included consists of 32 individuals (18 males and 14 females). Another problematic aspect is the quantity of data available for this sample. As seen throughout the statistical analysis, the females lack most of the facial measurements, which is the reason why these have been excluded from some of the comparisons. The deficiency led to an analysis mainly based on the males, and the discrimination cannot be considered in its totality, especially when analysing the non-pooled samples.

Another sample that does not cluster with any other is Scarborough. From the classification results given by the DFA, it is clear that for both non-pooled and pooled samples the misclassification rate is low. That is, the similarities between Castle Hill and the other British groups are limited. These results are also confirmed in the early study made by Little (1943). The author describes the cranial series as “aberrant” (1943: 33) and underlines how this sample cannot belong to any of the populations that inhabited the British Isles since the Mesolithic times. Moreover, Little states that there is a significant difference between the Scarborough sample and the one form Hythe, which can also be observed in the results of this thesis. Further validation is proposed by Tattersall (1968), who states that the cranial series from Kent is considerably different in cranial length from the one from Castle Hill. Brothwell and Krzanowski (1974) included Scarborough in their comparison among British populations from different periods, and reiterate its dissimilarities even in relation to non-medieval samples.

Several hypotheses can explain the difference in measurements between Castle Hill and the other medieval samples. Most of the authors agree that this group’s origins could be found outside Britain. Little (1943) reports that Scarborough was a base for Vikings, who probably occupied the site until the 11$^{th}$ Century. The author also reports that the town was the only known settlement of Icelanders in England. By the late 13$^{th}$ century, Great Britain’s eastern ports were reached by a significant number of foreign sailors. Foreigners were mainly arriving from Flanders, northern France, Germany, Denmark and Norway. Scarborough was indeed the busiest port and hosted 235 naval landings just during 1305. It is estimated that approximately 4500 foreign fishermen were visiting Yorkshire fishing grounds each year. Furthermore, the eastern ports of Britain had commercial links with Iceland. The demand for dried cod and stockfish encouraged British fishers to exploit Icelandic fisheries (Kowaleski, 2003; 2007). This exchange of goods could have also brought to an exchange of people, who decided to establish in Scarborough.

Different hypotheses were suggested for the interpretation of the place-name for the town. Whaley (2010) offers different options for the origin of the name Scarborough, proposing as well as Icelandic and Old Norse toponym's origins. The Nordic form is *Skarðaborg* in both languages. The name originates from the word *borg*, which probably means "fortification", together with the word *Skarð* "gap, cleft". Different options are proposed for the first part of the name, which indicates an anthroponym or the landscape surrounding the town. In the first case, it could refer to *Skarði*, a personal name that appears in the early Nordic world as a forename or nickname. The second option could originate from the word *skarð*, indicating a topographical etymology linked to the landscape features of the area (Field, 1980; Room, 1988).

It is worth considering the difference that there is between the two sites of Guisborough and Castle Hill. The two towns are geographically close, but one is a coastal site, while the other is a rural town. As Anderson (1994) suggests in her report, the remains from Guisborough could represent a close breeding group. The difference between the two samples could be a consequence of a major influx of people in Scarborough's port, compared the rural town of Guisborough. Another explanation could be given by the different background and origin of the towns. The possible presence of a Nordic settlement in Scarborough before the Middle Ages could have brought a variation in this group's cranial measurements.

London's sample also appears as an outlier for most of the analysis. As the national centre for government and trading, London attracted people from all over Britain and Europe. It is important to remember that, likely many British towns, London had a Roman background. This could be the reason that makes London, St Gregory and St Owen share some similarities throughout the statistical analysis. As discussed in chapter 2, the city had different communities of foreigners that lived and worked there.  Many Italian merchants from Lucca lived in London, and they were well known for silk's trade (Lambert, 2018). There were also different communities from outside Europe, such as Muslims from North Africa and the Middle East, and Jewish groups (Ormrod, Lambert and Mackman, 2018).

Resident immigrants formed at least 6% of the population in London (Bolton, 1998). According to a study carried out by Lutkin (2016), between 1336 and 1584, 17376 foreign residents can be positively identified in the city, of which the majority were men. In London's suburbs, other 6725 foreigners were reported living in Southwark and Middlesex. The largest identified group was “Teutonic”, followed by Italians, French, Greek, Irish, Icelanders, Portuguese, and Danish. The first group brought to England highly specialised artisans, such as weavers, cobblers, cordwainers, cappers, hat makers, goldsmiths, tailors, and beer brewers. Italian merchants, factors and clerks were using the city as a trading outpost. French immigrants were instead mainly servants. Most of the foreigners might have used London as the first point of entry and then moved to other areas of the country to seek employment (Lutkin, 2016). It is also reported that immigrants who reached Britain in the $15^{th}$ and $16^{th}$ Centuries, founded several “alien fraternities”. Few examples of these ordinances can be found in the Fraternity of the Holy Trinity for German Blackfriars, the Fraternity of St Barbara for Brabanters and Lorrainers, and St Cornelius in Westminster for Dutch immigrants (Colson, 2010). Based on the record of the alien subsidies and information of the time, the foreign community did not remain a closed group. Though numerus immigrants relocated with their nuclear family, evidence suggests that many married into the local community (Lutkin, 2016).

The sample that most differs from the other British groups is the one from St Leonard, Hythe. The results for the Kentish sample’s statistical analysis demonstrate that there is a clear separation from the main British cluster. The comparison among the pooled samples confirms that there is a more significant difference between the males than the females, even if both groups show a considerable variation. This result is consistent with Stoessinger and Morant (1932), who also stress on the fact that the series from Hythe is widely removed from the other series analysed in their early study. The sample shows the highest cranial index, together with the cranial height/length ratio and the orbital index. The series reports the shortest cranial length and the narrowest orbits, which is also observed by the authors. Tattersal (1968) found that the sample differs from the other British samples at the 95% level of probability for the same indices and measurements.

Several authors (Parsons, 1908; Stoessinger and Morant, 1932; Wrathmell, 2012) agree that this variability reflects people’s movement from Continental Europe. The singularity of this group could not be linked to a battle, as the female sample is also reiterating the difference and there are no evident signs of trauma on the individuals. The authors believe that this sample may be considered alien in the sense that it cannot represent the population of the country at any time. As they find a similarity with the Spitafields collection, which resembles Italian crania, they suppose that the Hythe sample could represent direct descendants of the Roman marine and auxiliaries who stationed in the area in previous times (Stoessinger and Morant, 1932; Wrathmell, 2012). Additional information that is given by the authors is that in the town there were many Frenchmen, who reached 58% of people with known nationality among the foreigners (Ormrod, Lambert and Mackman, 2018) and people with a Flemish or Walloon origin. The influx could be a result of the town’s importance as one of the Cinque Ports. The major towns, especially on the southern coast, were indeed natural magnets for immigrants to England (Ormrod, Lambert and Mackman, 2018). In the 14th century, King Edward III encouraged skilled workers to move to the East Anglia's and Kent's historic centres of woollen cloth production. The latter, together with Sussex, Hampshire, Surrey and Middlesex report the highest concentration of immigrants in the country. The Cinque Ports and London covered 41.2% of the national figure for taxpayers (Edwards, 2002; Ormrod, Lambert and Mackman, 2018). The arrival of foreigners in Hythe would have therefore contributed to the variation in the skeletal morphology that can be detected by craniometric analysis.

Even though St Gregory and Hythe are located in the same region, they do not resemble each other as expected. Canterbury is not a port and, even if there was an influx of foreigners in the town, it happened in later times (16th and 17th centuries) (Edwards, 2002). As stated in section 2.2.12, Canterbury has a Roman background, just like Hythe. If the hypothesis proposed by Stoessinger and Morant (1932) was correct, the two samples would cluster together. It is true that, according to the discriminant function analysis, the highest misclassification rate for Hythe is found in St Gregory's sample. Yet, the correctly classified crania show high percentages around 70% of the cases. The results, therefore, indicate that probably the Roman background did not influence the conformation of the two samples.

Another important aspect of the pooled analysis is the difference between males and females. The scatterplots show that there are differences among British and Hythe's females, but it becomes stronger among male groups. The dissimilarity could thus be explained with a significant influx of men from Continental Europe. It could reflect that the town was one of the major ports in medieval times and sailors were mainly men. The same can be said for the arrival of skilled artisans mentioned above. The movement of the workforce would have been mainly made up by males even if a movement of women could have happened as part of the family. As reported by Kowaleski (2007), during the Middle Ages, labour shortages raised demand for sailors, and foreign men were recruited for ship crews. English kings employed foreign ships to transport troops or supplies for the Crown. The crews comprised Flemish, Dutch, Irish, Prussians, Portuguese, Spanish and Italians. Some of these people stayed in the ports for few days or weeks and often contributed to the local economy. However, other sailors chose to remain in Britain, especially in the ports (as confirmed by the alien subsidies).

Chester was also considered as one of the chief ports for the Irish trade and was one of the main ports of entry for Irish immigrants. As discussed in section 2.2.2, Chester witnessed the presence of Roman and Viking communities, and it is noticeable in the architectural component of the town. Yet, the sample does not resemble the one from Scarborough that also had a Viking background. Neither has it resembled the samples from London, Hythe or Gloucester. The result might indicate that the Roman background cannot be detected in any of these comparisons. Another hypothesis, which is the most likely, could be linked to the number of individuals in the sample. Linenhall is represented by ten individuals, which is a low number if compared to the other groups. The small quantity could, therefore, lead to misclassification or misinterpretation of the results.

Regarding the remaining samples, they all tend to cluster in a group that comprises Poulton, Linenhall, St Owen, St Gregory and Ballumbie. Poulton and Ballumbie represent rural towns' individuals, which probably had similar lifestyles. Gloucester and Canterbury are instead more open to the movement of people. As previously described, probably Canterbury experienced a later influx of peregrines, and it is likely that the sample is part of a cemetery that was used in earlier years. Gloucester, even being a Roman colony, did not experience the Viking occupation, similar to St Gregory. In fact, throughout the analysis, they never cluster with samples from sites with a Viking background. Gloucester was also known for its importance as an administrative and trading centre (see section 2.2.3), but probably its importance was obfuscated by the nearby port of Bristol. According to Kowaleski (2007), Bristol witnessed abundant immigration during the Middle Ages, while Gloucester attracted more people from the surrounding countryside.

Overall, it could be supposed that the samples from cities that witnessed waves of immigration immediately before and during the Middle Ages, tend to differ most from the samples considered more geographically isolated. Therefore, the variation in craniometric measurements proves the possible impact that immigration had on population history and human variability.

## 5.4 Comparison with W.W. Howells data set

### 5.4.1 British vs Howells' European samples

The clusters resulting from the comparison among British and European samples reflect geographical distance. Most of the British groups resemble each other, apart from the outliers (Guisborough, Castle Hill, London and Hythe). As noted in the previous section, Guisborough's removed position in the scatterplots can be a consequence of the smaller sample size which can lead to a deviation of the results. The high discrimination is also evident in the comparison among the British samples, where Guisborough persistently acts as an outlier. As discussed in section 5.3, there is no proof of immigration from other parts of Europe to this area. The only reason for the divergence of the site can be therefore explained with a smaller sample size in comparison with the other ones analysed.

A significant resemblance between the groups with a Viking background and the Norse sample would be expected. Again, the sample from Linenhall is smaller than the others included in this thesis, and this could have an impact on the final results. In the case of Scarborough's sample, the misclassification of the individuals in the Norse group is very low. As described in section 5.3, the Yorkshire port was one of the first Icelandic colonies. This could be a reason why there are no similarities between the two groups. Howells' dataset does not include other Viking groups, and it would be useful to compare the craniometrics from this sample to the data provided from a coeval sample from Iceland. It is proved that the presence of Scandinavian people has been a constant in British history, especially in many parts of the eastern coast (Ormrod, Lambert and Mackman, 2018). On the other hand, Scandinavians are scarce in the denization records. Icelanders are often listed with names that resemble the Scandinavian ones (e.g. Johnson, Deryckson), and therefore they are easily mistaken with other nationalities (Ormrod, Lambert and Mackman, 2018).

British individuals' overall misclassification in the European samples is poor, and it could be a consequence of the samples' origin. The other two samples come from central Europe (Hungary and Austria). According to Ormrod, Lambert and Mackman (2018), the majority of the immigrants in medieval Britain came from France, Low Countries, Germany, Italy and Greece. There is no evidence of migrants coming from the eastern area of Europe, and this could be an explanation of the difference in craniometric measurements. The minor misclassification reported by St Leonard in the Berg sample is linked to the neurocranial measurements. The Berg sample reports indeed a brachycranic skull, a characteristic that distinguishes this group from the other Europeans (Howells, 1973; Carson, 2006). The same can be said for Hythe that acts as an outlier for the entire statistical analysis and reports a peculiar round and short skull. The resemblance does not imply that the town housed Austrian immigrants. Further analysis should be carried out for a comparison between Hythe and medieval samples from territories closer to Britain (e.g. Low Countries and France).

Another sample that has a high misclassification in the European group, especially for the females, is London. The capital was the city with a significant flow of foreign people (see also section 5.3). According to historical records (Ormrod, Lambert and Mackman, 2018), this influx, however, did not involve Scandinavian or eastern Europeans in particular. The majority of the immigrants joining the city were mostly from Italy, France and Low Countries. The trading links with Bordeaux seemed to attract many visitors from Gascony. Another significant community in the capital was the Dutch, also called "Teutonics", in the 1483 tax returns. At the beginning of the 15th century, 309 oath takers were based in London, while 204 lived in Surrey and 110 in Middlesex. Yet, the most significant group of immigrants in London was formed by the Italians. The trade with Southern Europe was well established, for both commercial and religious reasons. Italians belonged to richer social classes. Between 1440 and 1483, 1150 Italians were taxed in London and they were from the major trading cities such as Genova, Venice, Florence, Lucca, Milano and Ferrara (Ormrod, Lambert and Mackman, 2018). All these groups are not part of Howells' data set and the comparison to prove the presence of these people in the city was not possible. On the other hand, this could be an explanation of the difference between London, other British samples and European ones.

Studies involving European craniometric variation in the Middle Ages are still scarce, as the majority point towards the analysis of variation among continents. Crognier (1981) analysed the differences between anthropometric measurements in European and Mediterranean modern samples, also taking into consideration few craniometric measurements (head maximum length and breadth, and cephalic index). His results were compared with climatic dissimilarities in the different areas to evaluate whether the measurements changed based on different environments. The hypothesis proposed by the author was confirmed, with 17% of the total variation between European populations explained by climatic adaptation. A similar study was published by Sokal and Uytterschaut (1987) and Derish and Sokal (1988). The authors found that even though Europe is represented by a continuum of populations (none of the groups has been isolated from each other), genetic and morphological differences exist among regions, and these are linked to geography and language. Bakken *et al.* (2011) found that a significant skull and brain variation along NW-SE cline resembles genetic and archaeological evidence. The suggestion of a craniometric and genetic cline could be explained with a movement of prehistoric populations who contributed to the variation in Europe. A further theory proposed by the authors is that local environmental factors and selection produced a clinal variation or affected the variation after a gene flow occurred.

## 5.4.2 British vs Howells' samples

Even though there are discrepancies in the measurements driving the differences in the male and female samples, the clusters formed by the different statistical analyses reiterate a separation based on geographical distribution. Both in non-pooled and pooled samples' analysis, British populations cluster with the Europeans. On the other hand, Far Eastern groups (Hainan Island, Shang Dynasty and Guam) form another cluster, while African samples are far removed from the others, close to the Australian one. The Yauyos is somewhat always located in between European and Far Eastern samples. Easter Island and Buriats instead, act as outliers for the entire statistical analysis. The results are consistent with the classification proposed by Howells (1973; 1989). In his statistical analysis, the European groups tend to tightly cluster together, with the native American populations showing the lowest distance from them. African samples do not result in a tight cluster as the European samples, but they are still reasonably close to each other. The Buriats reiterate the results of this study, showing the greatest distance from the other populations (Howells, 1973; 1989). According to Howells (1973) and Relethford (2010), Europeans and Americans are similar, so that there is no distinction in their analysis. In this case, with the addition of the British samples, there is a clear distinction between the UK groups and other Europeans. However, in a broader view of the samples analysed, they are still closer to other Europeans than to other groups. This because European populations share a common ancestry if compared to the other World populations, and therefore they are more likely to resemble each other (Roseman, 2004).

Skull breadth is of primary importance for the distinction between populations, followed by facial and nasal heights (Howells, 1973). The resemblance of Yauyos and European samples can be explained by their maximum cranial breadth and facial measurements. Both groups show medium values for both dimensions so that the statistical analysis associates them. They, however, differ from each other on the third principal component, which is linked to nasal breadth, even though the correlation is not strong (-.556) (see also Howells, 1973). Native Americans are also characterised by a broad cranial base and lower face, together with short and high vaults (Howells, 1989). Maximum cranial breadth is also fundamental for the differentiation of the Buriats, especially from the Africans. The Siberian sample reports a great value for this measurement, together with facial height. On the other side, Zulu and Bushmen are characterised by a long skull and short face.

The Easter Island sample shows a constant separation from the other groups. Both for non-pooled, male and female samples, this group results as the most isolated. Even though Howells (1989) analysed more than one Polynesian sample, the separation is consistent with his analysis. The difference underlined both by the DFA and PCA can be linked to the isolation-by-distance model. The theory predicts that genetic similarity (which is reflected by craniometrics) between populations will decrease as the geographic distance increases (Cavalli-Sforza *et al.*, 1994; Relethford, 2004). Geographic isolation also limits migration, so that the genetic similarity between populations decreases (Morton, 1973; Relethford, 2004). When a population sample is removed far away from a centroid, could be because the exchange of migrants with other populations is low or it consisted in a small group of people and therefore the drift was faster (Relethford and Harpending, 1994).

A similarity that is not expected is the one between the African and Australian samples. As observed by Howells (1989) and Guglielmino-Matessi, Gluckman and Cavalli-Sforza (1979), the Australian group is not significantly removed by the Africans. In Howells' analysis, these two samples cluster together on the first function, which is also correlated with temperature variables. Both African and Australian groups show the lowest means for the maximum cranial breadth and upper face height, which differently from Buriats, is correlated with warmer environments.

There is a clear separation into the geographic regions proposed by Howells, and the clusters prove that craniometric variation is geographically structured. Human biological variation is reflected by traits that are affected by natural selection (e.g. skin colour) and neutrally distributed traits (e.g. craniometrics) (Relethford, 2009). The theories behind the reasons that brought to a morphological differentiation are numerous. The literature that proposes various hypotheses for the phenotypical difference between populations is extensive, and the main hypotheses are divided between adaptation and genetic drift. The theory that the morphology of the splanchnocranium is linked to environmental factors, while temporal bone and neurocranium are more correlated with genetic factors, has been supported by several authors (Guglielmino-Matessi, Gluckman and Cavalli-Sforza, 1979; Beals *et al.*, 1984; Jantz and Meadows Jantz, 2000; Roseman, 2004; Roseman and Weaver, 2004; Carson, 2006; Harvati and Weaver, 2006).

Facial form, especially the shape of the nose, has been linked to climatic adaptation through a combination of evolutionary responses to the environment and genetic adaptation (Roseman, 2004; Roseman and Weaver, 2004; Harvati and Weaver, 2006). Differences between samples are strongly associated to mean temperatures during the year's coldest months (Howells, 1989; Roseman, 2004). When Howells' groups are analysed, the Buriat sample is consistently far removed from the others. They indeed report the greatest nasal height and the highest neurocranial breadth. The nasal shape is linked to the thermoregulatory breathing hypotheses that are used to explain the among-region differences in nasal morphology. Tall and narrow noses are indicative of a colder environment, while short and broad noses are linked to warmer environments (Roseman, 2004). A further hypothesis links the maximum neurocranial breadth with environmental factors. Natural selection for a colder environment is supposed to lead to brachycephalization (Guglielmino-Matessi, Gluckman and Cavalli-Sforza, 1979; Beals *et al.*, 1984; Roseman, 2004). The bioclimatic model proposed by Beals *et al.* (1984) predicts that the cranial capacity also increases with distance from the equator and it is correlated to the decrease in solar radiation. The hypothesis is supported by the position of Buriats in the scatterplot resulting from the DFA. Regarding the British samples, these also report a broader skull if compared to the groups associated with warm environments. These results are consistent with the bioclimatic hypothesis.

On the other hand, craniometric and DNA variation produce a similar pattern of population relationship. That is, the geographic configuration is reflected by craniometric variation in accordance with the underlying pattern of genetic relationships between populations (Roseman, 2004; Relethford, 2009). According to Relethford (1994), there is a low level of among-region variation in modern humans. It is however unlikely that selection produced the same amount of variation in different traits, such as craniometric and mitochondrial DNA, which is considered neutral. The comparison between molecular distances and craniometric data showed that the morphology of the entire cranium is significantly correlated with the molecular matrix (Harvati and Weaver, 2006; Smith, 2009). The separation by geographical areas is consistent with the results of this thesis. In fact, according to Smith (2009) populations from the same continent tend to share small morphological distance values, due to a close genetic relation.

Even though it has been proven that different factors lead to variability between cranial measurements among populations, this study found that craniometrics are an indicator of population history. A factor that can complicate the understanding of the causes of human variation can be that climatic variables may pattern geographically, making the association between climate, genetic relationships and cranial measurements difficult to distinguish (Smith, 2009). It is clear though that the entire cranial shape is a good indicator of human population history (González-José *et al.*, 2004; Roseman, 2004; Harvati and Weaver, 2006; von Cramon-Taubadel, 2014) and that the analysis of craniometric measurements reflects the geographical distribution of human population samples. It is possible that the interaction between cranial morphology and climate could be a result of a correlation of these with neutral patterns of interregional difference resulting from population history and structure (Relethford, 1994; Relethford and Harpending, 1994; Roseman, 2004).

# 6. Conclusions

## 6.1 Summary and Conclusions

The research presented for this thesis yielded to the conclusion that there are differences in craniometric measurements among British medieval samples. The dissimilarities for the non-pooled and male samples are driven mainly by the facial measurements on the first principal component, while on the second principal component, the discrimination is based on neurocranial measurements. The female sample is instead mainly discriminated by neurocranial measurements. These differences led to the identification of a few outlier samples: Scarborough, London and Hythe. The reason for the craniometric differences could be linked to a migration of people from outside Britain. The findings of this thesis reflect historical records of immigrants arriving and living in these cities. Scarborough is defined as one of Britain's main eastern ports in the Middle Ages, with foreigners mainly arriving from Iceland, Flanders, northern France, Germany, Denmark and Norway (Kowaleski, 2003; 2007). Another hypothesis could be linked to Scarborough's Nordic origins, which reflect the name-place *Skarðaborg* (Whaley, 2010).

Another outlier is represented by London's sample. The city was the national centre for government and trading, which attracted a conspicuous number of foreign people. Mainly, these people were identified as "Teutonic", followed by Italians, French, Greek, Irish, Icelanders, Portuguese, and Danish (Lutkin, 2016). The number of immigrants living and working in the city is confirmed by the records of the alien subsidies and information of the time.

Hythe, which was one of the Cinque Ports, results as far removed from the other samples in the statistical analysis. The hypothesis of the presence of immigrant communities is supported by several authors (Stoessinger and Morant, 1932; Tattersal, 1968; Ormrod, Lambert and Mackman, 2018). In fact, in the town, there were many French foreigners and people with a Flemish or Walloon origin.

The further comparison between British and Howells' European samples leads to separation by geographical distance. The European groups included in the analysis do not resemble the outliers (Scarborough, London and Hythe) or any other British sample. The reason for this separation could be found in the origin of the individuals analysed. The Nordic origin suggested for Scarborough is not the same for Howells' Norse group. In fact, the Nordic people that were present in the Yorkshire port were mainly Icelandic. The other Howells' samples originate from Central Europe (Hungary and Austria). However, the majority of the immigrants in medieval Britain came from France, Low Countries, Germany, Italy and Greece (Ormrod, Lambert and Mackman, 2018). There is no evidence of migrants coming from the eastern area of Europe. Thus, this could be an explanation of the difference in craniometric measurements. The results support the theories proposed by other authors (Crognier, 1981; Sokal and Uytterschaut, 1987; Derish and Sokal, 1988; Bakken *et al.,* 2011) that suggest that craniometric variation in Europe reflects an adaptation to climatic dissimilarities in different regions.

Finally, the analysis of the British and Howells' main population samples reiterates a separation based on geographical distribution. The British samples this time cluster with the European groups, as these populations share a common ancestry, and therefore they are more likely to resemble each other (Roseman, 2004). The Far Eastern groups (Hainan Island, Shang Dynasty and Guam) instead cluster together, just like the Africans (Zulu and Bushmen). Australians are close but still removed from the Africans, while the Yauyos are located in between the Far Eastern and the European samples. The only outliers in this analysis are represented by the Buriats and Easter Island. The results support the geographical structure of craniometric variation proposed by Howells (1989). In fact, the distribution of the samples in the graphs reflects a climatic adaptation through a combination of evolutionary responses to the environment and genetic adaptation (Roseman, 2004; Roseman and Weaver, 2004; Harvati and Weaver, 2006). An example is given by the Buriats, which report the greatest nasal height and the highest neurocranial breadth that can be associated to the mean temperatures during the year's coldest months (Howells, 1989; Roseman, 2004). Cranial capacity also increases with distance from the equator, and it is associated with the decrease in solar radiation (Beals *et al.*, 1984). On the other hand, craniometric variability also reflects DNA distribution patterns (Roseman, 2004; Relethford, 2009). To conclude, it is likely that the interaction between cranial morphology and climate could be the effect of a correlation of these with neutral patterns of interregional difference resulting from population history and structure (Relethford, 1994; Relethford and Harpending, 1994; Roseman, 2004).

## 6.2 Research Hypotheses

The most systematic way to answer the hypotheses proposed in section 3.1 of this thesis is to identify and explain them below. The results of this thesis are briefly summarised in relation to the hypothesis to which they relate.

- **Null Hypothesis 1:** *There are no statistically significant differences in the craniometric measurements among the British medieval samples.*

  The first null hypothesis is rejected, as the statistical analyses detected a significant difference in craniometric measurements among British medieval samples. Based on the rejection of the first null hypothesis, alternative hypotheses are then proposed, and these are the following.

- **Alternative Hypothesis 1:** *There are differences in the craniometric measurements among the British medieval samples*.

The first alternative hypothesis is supported by the statistical analyses. British medieval samples do not cluster based on geographical proximity. However, discrimination could be a consequence of different craniometric measurements resulting from a movement of people from outside Britain. The samples recovered from cemeteries located in towns with a historical record of resident immigrants are identified as outliers by the statistical analysis. These samples can be identified as Hythe, Scarborough and London. As differences are identified by the statistical analysis, the following alternative hypotheses were proposed:

- **Alternative Hypothesis 1a:** *If there are differences among British medieval samples, the differences are determined by the neurocranial measurements*.
- **Alternative Hypothesis 1b:** *If there are differences among British medieval samples, the differences are determined by the facial measurements*.
- **Alternative Hypothesis 1c:** *If there are differences among British medieval samples, the differences are determined by both the neurocranial and facial measurements*.

Alternative hypotheses 1a, 1b and 1c, were proposed to understand what measurements drive the difference among British samples. On the first principal component, the non-pooled samples differ mainly on the facial measurements (e.g. nasal height, height of the upper face and nasion-bregma chord). On the second principal component, significant loadings are associated with the neurocranium (e.g. bregma-lambda chord and parietal longitudinal arch). The male samples reiterate these results. There is however a discrepancy in the female sample analysis that shows major discrimination based on the neurocranial measurements (e.g. bregma-lambda chord, parietal longitudinal arch, lambda-opisthion chord and occipital arch). The second principal component is associated with orbital height instead. Although the presence of this discrepancy, the discriminant function analysis and hierarchical cluster analysis show the same subdivision of the samples.

The comparison was also carried out among British samples and Howells' dataset. A second null hypothesis was proposed and is the following:

- **Null Hypothesis 2:** *There are no differences between the British medieval samples and the W.W. Howells dataset groups*.

The second null hypothesis is rejected, as the statistical analyses detected a significant difference both among British and Howells' European groups and British and Howells' main human population samples. Following the rejection of the second null hypothesis, alternative hypotheses are proposed below:

- **Alternative Hypothesis 2:** *There are differences in the craniometric measurements among British medieval samples and the W. W. Howells dataset groups. These samples will cluster based on their geographical proximity.*

The second alternative hypothesis is supported both for the comparison with the European and Howells' main human samples. There is a clear separation among British and European samples based on geographical proximity. The majority of British samples resemble each other, apart from Guisborough, Castle Hill, London and Hythe. The reasons could be detected in a major presence in these towns of foreign people. However, there is no evidence of migration from the areas where Howells' samples belong to (Norway, Austria and Hungary). For this reason, it is possible that the groups do not resemble each other.

In regard to the discrimination among British and Howells' main human groups, the clustering is indeed based on geographical distance. In this case, British samples tend to cluster with Europeans, mainly because, compared to other populations, they share a common ancestry. Peruvian Yauyos are in between the European and the Far Eastern samples, which form a separate cluster. Finally, the Africans are removed from the others, but close to each other. Australians, Buriats and Easter Island are isolated on the graphs. The reasons for the resemblance of geographical distribution are linked both to climatic adaptation and genetic drift. Samples associated with an adaptation to cold climates show brachycephaly (Buriats), while the ones associated with warmer climates report dolichocephaly (Zulu, Bushmen and Australians). Similarly, the nasal shape is associated with climate. The results are consistent with the pattern showed by DNA variability. Because differences in cranial measurements among British and Howells' samples were detected, the following hypotheses were then proposed:

- **Alternative Hypothesis 2a:** *If there are differences among British medieval samples and the W. W. Howells dataset groups, the differences are determined by the neurocranial measurements.*
- **Alternative Hypothesis 2b:** *If there are differences among British medieval samples and the W. W. Howells dataset groups, the differences are determined by the facial measurements.*

- **Alternative Hypothesis 2c:** *If there are differences among British medieval samples and the W. W. Howells dataset groups, the differences are determined by both the neurocranial and facial measurements.*

Alternative hypotheses 2a, 2b and 2c, were proposed to understand which measurements drive the difference among British samples and Howells' main human groups. For both non-pooled and male samples the discrimination on the first principal component is driven by cranial base length, nasion-bregma chord and nasal height, while on the second axis it is mainly correlated to the maximum cranial length. Females instead are mainly divided on the base of the lambda-opisthion chord and nasion-bregma chord, while the second component is correlated with maximum neurocranial and nasal breadth. Even though there is a discrepancy between sexes, the geographical subdivision is consistent among the samples. The discrimination seems to reflect the adaptation to different environments and reiterates the pattern followed by mean annual temperatures.

# 6.3 Research Limitations

Even though the analysis was carried out on a remarkable number of individuals (946 skulls from 16 British medieval samples), this study was not exempt from limitations. The primary restriction encountered during the data collection is the poor preservation of the skeletal remains. As already discussed in section 5.2, human remains are usually recovered fragmented, and the skull is the anatomical part that is most affected by taphonomical agents. Because of the fragmentary status of the cranium, the data collection was limited. As a solution for the fragmentary nature of the remains, a reconstruction technique that is not invasive and is entirely reversible was proposed. The procedure was only adopted for the restoration of the samples stored at Liverpool John Moores University, while further complete skulls were part of other more extensive samples which also comprise fragmented material. For this reason, the number of individuals analysed could have been higher if the reconstructive method was adopted for all the skeletal remains in the UK.

A further limitation faced for data collection is linked to the distribution of the samples across Britain. The majority of the skeletal remains available for this thesis are located in England. The reduced availability is due to the different preservation of the skeletal material across geographical areas, and the number of archaeological investigations carried out. The presence of acidic soils in Wales is a reason that led to the poor preservation of the bones in Welsh cemeteries (Hemer *et al.*, 2013). Another mechanism affecting the preservation of human remains is linked to a cemetery's continuity of use or its subsequent obliteration by the following building on the land (author's personal observation). The continuous use of a cemetery can bring to grave's disturbance and a loss of integrity and information about the individual. The same can be said about the successive building over a land that was occupied by a cemetery. An example could be represented by Linenhall, which was uncovered during a building process. The lack of samples dating to the Middle Ages is also encountered in Scotland. The deficiency could be linked to the scarcity of excavation projects carried out in comparison to the southern regions.

A further issue is represented by the number of individuals in each collection and their completeness. The problem regarding missing data was already discussed by Howells (1973), who proposed different methods. For this thesis, the input of means for each sample was adopted, but yet this does not give the missing real value. Another problem is the difference in sample sizes. A rule of thumb in statistical analyses is that the number of variables should not be higher than the number of individuals in the smallest sample (Tabachnick, Fidell and Ullman, 2007). Additional assumption is that the sample sizes analysed should comprise the same amount of individuals (Kovarovich *et al.*, 2011). However, these assumptions are often violated in archaeology for the various reasons described above. Human remains' reconstruction would be therefore crucial for the samples' correct analysis.

Accessibility to the skeletal collections could also constitute a limit for data collection. Most of the human remains are stored in Universities and museums. However, sometimes access is restricted by the institutions' policies or collections' unavailability. Several research projects might be carried out on a sample at the same time, so further access from other researchers is not possible due to the stress that could be applied to the remains following handling. The time-limited nature of doctoral research restricted the possibility of delaying data collection.

The lack of craniometric research carried out in Britain regarding medieval samples also affected the comparative data available for this thesis. As seen in previous chapters, most of the data available for comparison was published at the beginning of the 20$^{th}$ century. The accuracy of the methods used is therefore not always verifiable. However, as stated in chapter 3, craniometry is a discipline that has been used for centuries by anthropologists, and it is supposed that data collection methods have not changed over times. Another difficulty is represented by the uncertainty in the exact dating of some samples. For skeletal remains uncovered at the end of the 19$^{th}$ century or beginning of the 20$^{th}$ century, accurate stratigraphic excavation cannot be proved. Hythe's sample can be named as an example. The dating is considered as previous to the 17$^{th}$ century, but accurate dating is unknown. All these factors were considered before and during the data collection and acquisition, and even though they can constitute a limitation, they do not affect the quality of this research.

## 6.4 Future Suggestions

The results given by this thesis arise different questions and future suggestions that need further investigation. First, it would be beneficial to carry out skeletal reconstruction on other anthropological collections. As already stated in section 5.2, the reconstruction of skeletal assemblages would allow more extensive research to be performed. It would especially be a valuable tool to increase craniometric and ancestry examination that would lead to a better understanding of Britain's population history.

Secondly, as comparative methods, isotopic and DNA analyses are suggested. Even though the effectiveness of craniometric analysis was proven by this thesis, it is important to understand if it is validated by other scientific analyses. It is fundamental to understand whether British medieval craniometrics detect a difference in measurements from the first or later generation's migrants. Further craniometric analysis would be useful to understand the variation in the whole of British territory, especially for Scottish and Welsh samples. A more in-depth analysis of these regions would also help to comprehend the relationships with other British areas and non-British people. Dental traits' analysis would also represent a valid comparison to cranial measurements.

People movement can also be detected by material culture, historical documents and place names. For this reason, an accurate comparison between these fields and craniometric analysis is suggested. As identified in section 5.3, there is a correspondence between historical records and evidence with migration. Further comparative research could lead to the knowledge of foreign people who were living in Britain in the Middle Ages.

Finally, an additional comparison with skeletal samples from European regions where most migrants came from, would be beneficial. The analysis would confirm whether there is a craniometric correspondence between the outlier samples in this thesis and other European populations (e.g. Low Countries, France, Italy and Iceland). All these suggestions would help to value the significance of craniometric analysis in detecting population history and contribute to a change of the outdated definition of craniometrics.

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# Appendix 1. Data Collection Sheets

**SITE:**

**SKELETON:**

| **1.1 NEUROCRANIUM** | | |
|---|---|---|
| **1.1.1 Maximum length of the neural skull** | | |
| **1.1.2 Glabella-inion length** | | |
| **1.1.3 Glabella-lambda length** | | |
| **1.1.4 Cranial base length** | | |
| **1.1.5 Maximum neurocranial breadth** | | |
| **1.1.6 Biauricular breadth** | | |
| **1.1.7 Biasterionic diameter** | | |
| **1.1.8 Bimastoid breadth of the cranial base** | | |
| **1.1.9 Basion-bregma height** | | |
| **1.1.10 Total height** | | |
| **1.1.11 Porion-bregma height** | | |
| **1.1.12 Porion-vertex height** | | |
| **1.1.13 Horizontal cranial circumference** | | |
| **1.1.14 Horizontal cranial circumference above-ophryon** | | |
| **1.1.15 Transverse curve** | | |
| **1.1.16 Total longitudinal arch** | | |
| **1.1.17 Nasion-bregma arch** | | |
| **1.1.18 Parietal-longitudinal arch** | | |
| **1.1.19 Occipital arch** | | |
| **1.1.20 Nasion-bregma chord** | | |
| **1.1.21 Bregma-lambda chord** | | |
| **1.1.22 Lambda-opisthion chord** | | |
| **1.1.23 Foramen magnum length** | | |
| **1.1.24 Foramen magnum breadth** | | |

| 1.2 FACIAL SKULL | | |
|---|---|---|
| **1.2.1 Length of the face** | | |
| **1.2.2 Minimum frontal breadth** | | |
| **1.2.3 Maximum frontal breadth** | | |
| **1.2.4 Upper facial breadth** | | |
| **1.2.5 Bizygomatic facial breadth** | | |
| **1.2.6 Maximum bimaxillary breadth of the midface** | | |
| **1.2.7 Morphological height of the face** | | |
| **1.2.8 Height of the upper face** | | |

| 1.3 ORBITAL SKELETON | | |
|---|---|---|
| **1.3.1 Biorbital breadth** | | |
| **1.3.2 Interorbital breadth from dacryon** | | |
| **1.3.3 Interorbital breadth** | | |
| **1.3.4 Orbital breadth** | | |
| **1.3.5 Orbital height** | | |

| 1.4 NASAL SKELETON | | |
|---|---|---|
| **1.4.1 Nasal breadth** | | |
| **1.4.2 Nasal height** | | |
| **1.4.3 Nose-malar chord** | | |
| **1.4.4 Nose-malar breadth** | | |

| 1.5 MAXILLARY SKELETON | | |
|---|---|---|
| **1.5.1 Maxillo-alveolar length** | | |
| **1.5.2 Maxillo-alveolar breadth** | | |
| **1.5.3 Palate length** | | |
| **1.5.4 Palate breadth** | | |

# Appendix 2. Cranial Measurements Coding System

| 1.1 NEUROCRANIUM | | | | | |
|---|---|---|---|---|---|
| **Borrini Code** | **Martin & Saller Code** | **USA Standards Code** | **Howells Code** | **British Code** | **Fordisc Code** |
| 1.1.1 Maximum length of the neural skull | MS 1 | 1 | GOL | L | Maximum Ln |
| 1.1.2 Glabella-inion length | MS 2 | - | - | - | - |
| 1.1.3 Glabella-lambda length | MS3 | - | - | - | - |
| 1.1.4 Cranial base length | MS 5 | 5 | BNL | LB | Basion-Nasion Ln |
| 1.1.5 Maximum neurocranial breadth | MS 8 | 2 | XCB | B | Max Cranial Br |
| 1.1.6 Biauricular breadth | MS 11 | 9 | AUB | - | Biauricular Br |
| 1.1.7 Biasterionic diameter | MS 12 | - | ASB | Biast B | Biasteronic Breadth |
| 1.1.8 Bimastoid breadth of the cranial base | MS 13 | - | - | - | - |
| 1.1.9 Basion-bregma height | MS 17 | 4 | BBH | H’ | Basion-Bregma Ht |
| 1.1.10 Total height | MS 18 | - | - | H | - |
| 1.1.11 Porion-bregma height | MS 20 | - | - | PBH | - |

| | | | | | |
|---|---|---|---|---|---|
| 1.1.12 Porion-vertex height | MS 21 | - | - | - | - |
| 1.1.13 Horizontal cranial circumference | MS 23 | - | - | - | - |
| 1.1.14 Horizontal cranial circumference above-ophryon | MS 23-a | - | - | U | U |
| 1.1.15 Transverse curve | MS 24 | - | - | BQ′ | BQ′ |
| 1.1.16 Total longitudinal arch | MS 25 | - | - | S | - |
| 1.1.17 Nasion-bregma arch | MS 26 | - | - | $S_1$ | $S_1$ |
| 1.1.18 Parietal-longitudinal arch | MS 27 | - | - | $S_2$ | $S_2$ |
| 1.1.19 Occipital arch | MS 28 | - | - | $S_3$ | $S_3$ |
| 1.1.20 Nasion-bregma chord | MS 29 | 19 | FRC | $S'_1$ | Frontal Chord |
| 1.1.21 Bregma-lambda chord | MS 30 | 20 | PAC | $S'_2$ | Parietal Chord |
| 1.1.22 Lambda-opisthion chord | MS 31 | 21 | OCC | $S'_3$ | Occipital Chord |
| 1.1.23 Foramen magnum length | MS 7 | 22 | FOL | FL | Foramen Magnum Ln |
| 1.1.24 Foramen magnum breadth | MS 16 | 23 | - | FB | Foramen Magnum Br |

| 1.2 FACIAL SKULL | | | | | |
|---|---|---|---|---|---|
| 1.2.1 Length of the face | MS 40 | 6 | BPL | GL | Basion-Prostion Ln |
| 1.2.2 Minimum frontal breadth | MS 9 | 11 | - | B’ | Minimum Frontal Br |
| 1.2.3 Maximum frontal breadth | MS 10 | - | XFB | - | - |
| 1.2.4 Upper facial breadth | MS 43 | 12 | FMB | - | - |
| 1.2.5 Bizygomatic facial breadth | MS 45 | 3 | ZYB | J | Bizygomatic Br |
| 1.2.6 Maximum bimaxillary breadth of the midface | MS 46 | - | ZMB | GB | Zygomaxillary Br |
| 1.2.7 Morphological height of the face | MS 47 | - | - | - | - |
| 1.2.8 Height of the upper face | MS 48 | 10 | NPH | G’H | - |

| 1.3 ORBITAL SKELETON | | | | | |
|---|---|---|---|---|---|
| 1.3.1 Biorbital breadth | MS 44 | 17 | EKB | - | Biorbital Br |
| 1.3.2 Interorbital breadth from dacryon | MS 49-a | 18 | DKB | DC | Interorbital Br |
| 1.3.3 Interorbital breadth | MS 50 | - | - | - | - |
| 1.3.4 Orbital breadth | MS 51 | 15 | OBB | $O'_1$ | Orbital Br |
| 1.3.5 Orbital height | MS 52 | 16 | OBH | $O'_2$ | Orbital Ht |

| 1.4 NASAL SKELETON | | | | | |
|---|---|---|---|---|---|
| 1.4.1 Nasal breadth | MS 54 | 14 | NLB | NB | Nasal Br |
| 1.4.2 Nasal height | MS 55 | 13 | NLH | NH’L | Nasal Height |
| 1.4.3 Nose-malar chord | MS 44-a | - | - | - | - |
| 1.4.4 Nose-malar breadth | MS 44-1 | - | - | - | - |

| 1.5 MAXILLARY SKELETON | | | | | |
|---|---|---|---|---|---|
| 1.5.1 Maxillo-alveolar length | MS 60 | 8 | - | - | - |
| 1.5.2 Maxillo-alveolar breadth | MS 61 | 7 | MAB | - | - |
| 1.5.3 Palate length | MS 62 | - | - | $G'_1$ | $G'_1$ |
| 1.5.4 Palate breadth | MS 63 | - | - | $G'_2$ | $G'_2$ |

# Appendix 3. Cranial Landmarks

**UNPAIRED CRANIAL LANDMARKS ON THE MIDSAGITTAL PLANE**

| | | |
|---|---|---|
| Gnathion (gn) | The lowest median point on the lower border of the chin | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Pogonion (pg) | The most protruding point in the midline on the mandible | Bass, 1995; Borrini, 2013; Krogman & Isçan, 1986 |
| Alveolare (ids) | The lowest point on the alveolar margin between the first upper incisors | Bass, 1995; Borrini, 2013 |
| Prosthion (pr) | The most anterior point on the alveolar margin between the first two upper incisors | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Nasospinale (ns) | The midpoint on the line drawn between the lower rims of both nasal apertures | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Nasion (n) | The point on the nasofrontal suture on the midsagittal plane | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Glabella (g) | The most forward projecting point of the frontal bone on the supra-orbital ridges and above the nasion | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Bregma (b) | The point on intersection of the coronal and sagittal sutures | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Vertex (v) | The highest point of the skull on the midsagittal plane, as seen from norma lateralis | Bass, 1995; Borrini, 2013 |
| Lambda (l) | The intersection of the sagittal and lambdoidal sutures in the midline | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Opisthocranion (op) | The most posterior point on the skull | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Inion (i) | The intersection of the midsagittal plane with the height of the triangle formed by the nuchal crest lines | Bass, 1995; Borrini, 2013; Krogman & Isçan, 1986 |
| Opisthion (o) | The midpoint of the posterior margin of the foramen magnum | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Basion (ba) | The midpoint of the anterior margin of the foramen magnum | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Endobasion (endoba) | The most posterior point of the anterior border of the foramen magnum, internal to the basion | Bass, 1995; Borrini, 2013 |

| | | |
|---|---|---|
| Alveolon (alv) | The midpoint on the line drawn through the termini of the alveolar ridges | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994 |
| Staphylion (sta) | The midpoint on the line drawn tangent to the curves of the posterior margin of the palate | Bass, 1995; Borrini, 2013 |
| Orale (ol) | The midpoint on the line drawn tangent to the curves in the alveolar margin at the back of the two first incisors | Bass, 1995; Borrini, 2013; Krogman & Isçan, 1986 |
| Ophryon (on) | The deepest point immediately above the glabella | Borrini, 2013 |

**PAIRED CRANIAL LANDMARKS ON THE MIDSAGITTAL PLANE**

| | | |
|---|---|---|
| Euryon (eu) | The most widely separated points on the two sides of the skull | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Porion (po) | The uppermost lateral point in the margin of the external auditory meatus | Bass, 1995; Borrini, 2013; Krogman & Isçan, 1986 |
| Mastoidale (ms) | The apex of the mastoid process | Bass, 1995; Krogman & Isçan, 1986 |
| Dacryon (d) | The point on the median wall of the orbit at the junction of the lacrimomaxillary suture and the frontal bone | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Maxillofrontale (mf) | The point of intersection of the anterior lacrimal crest with the frontomaxillary suture | Bass, 1995; Borrini, 2013; Krogman & Isçan, 1986 |
| Alare (al) | The most lateral point on the nasal aperture taken perpendicular to the nasal height | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994 |
| Zygion (zy) | The most lateral point of the zygomatic process | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Ectoconchion (ec) | The point of maximum breadth on the lateral rim of the orbit | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994; Krogman & Isçan, 1986 |
| Ectomolare (ecm) | The most lateral point on the outer alveolar margin, located on the second upper molar | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994 |
| Endomolare (enm) | The point on the inner surface of the alveolar margin corresponding to the second upper molar | Bass, 1995; Borrini, 2013 |
| Frontotemporale (ft) | The most medial point on the incurve of the temporal line | Bass, 1995; Borrini, 2013; Buikstra & Ubelaker, 1994 |
| Frontomalare temporale (fmt) | The most lateral point on the fronto-zygomatic suture | Borrini, 2013; Buikstra & Ubelaker, 1994 |
| Auricolare (au) | The point on the lateral margin of the root of the zygomatic process at the deepest incurvature | Borrini, 2013; Buikstra & Ubelaker, 1994 |
| Asterion (ast) | The meeting point lambdoid, occipito-mastoid and parieto-mastoid sutures | Borrini, 2013; Krogman & Isçan, 1986 |
| Zygomaxillare (zm) | Lowest point on the zygomaxillary suture | Borrini, 2013; Krogman & Isçan, 1986 |
| Coronale (co) | Most lateral point on the coronal suture | Borrini, 2013 |

# <u>Appendix 4.</u> Measuring instruments

| MEASUREMENT | INSTRUMENT |
|---|---|
| **1.1.1 MAXIMUM LENGTH OF THE NEURAL SKULL** | Spreading calliper |
| **1.1.2 GLABELLA-INION LENGTH** | Spreading calliper |
| **1.1.3 GLABELLA-LAMBDA LENGTH** | Spreading calliper |
| **1.1.4 CRANIAL BASE LENGTH** | Spreading calliper |
| **1.1.5 MAXIMUM NEUROCRANIAL BREADTH** | Spreading calliper |
| **1.1.6 BIAURICULAR BREADTH** | Spreading calliper |
| **1.1.7 BIASTERIONIC DIAMETER** | Sliding calliper |
| **1.1.8 BIMASTOID BREADTH OF THE CRANIAL BASE** | Sliding calliper |
| **1.1.9 BASION-BREGMA HEIGHT** | Spreading calliper |
| **1.1.10 TOTAL HEIGHT** | Spreading calliper; Mollison's craniophor; auricular head spanner |
| **1.1.11 PORION-BREGMA HEIGHT** | Spreading calliper; Mollison's craniophor; auricular head spanner |
| **1.1.12 PORION-VERTEX HEIGHT** | Spreading calliper; Mollison's craniophor; auricular head spanner |
| **1.1.13 HORIZONTAL CRANIAL CIRCUMFERENCE** | Measuring tape |
| **1.1.14 HORIZONTAL CRANIAL CIRCUMFERENCE ABOVE-OPHRYON** | Measuring tape |
| **1.1.15 TRANSVERSE CURVE** | Measuring tape |
| **1.1.16 TOTAL LONGITUDINAL ARCH** | Measuring tape |
| **1.1.17 NASION-BREGMA ARCH** | Measuring tape |
| **1.1.18 PARIETAL-LONGITUDINAL ARCH** | Measuring tape |
| **1.1.19 OCCIPITAL ARCH** | Measuring tape |
| **1.1.20 NASION-BREGMA CHORD** | Sliding calliper |
| **1.1.21 BREGMA-LAMBDA CHORD** | Sliding calliper |
| **1.1.22 LAMBDA-OPISTHION CHORD** | Sliding calliper |
| **1.1.23 FORAMEN MAGNUM LENGTH** | Sliding calliper |
| **1.1.24 FORAMEN MAGNUM BREADTH** | Sliding calliper |
| **1.2.1 LENGTH OF THE FACE** | Spreading calliper |
| **1.2.2 MINIMUM FRONTAL BREADTH** | Spreading calliper |
| **1.2.3 MAXIMUM FRONTAL BREADTH** | Spreading calliper |
| **1.2.4 UPPER FACIAL BREADTH** | Sliding calliper |
| **1.2.5 BIZYGOMATIC FACIAL BREADTH** | Spreading calliper |
| **1.2.6 MAXIMUM BIMAXILLARY BREADTH OF THE MIDFACE** | Sliding calliper |
| **1.2.7 MORPHOLOGICAL HEIGHT OF THE FACE** | Sliding calliper |
| **1.2.8 HEIGHT OF THE UPPER FACE** | Sliding calliper |
| **1.3.1 BIORBITAL BREADTH** | Sliding calliper |
| **1.3.2 INTERORBITAL BREADTH FROM DACRYON** | Sliding calliper |
| **1.3.3 INTERORBITAL BREADTH** | Sliding calliper |
| **1.3.4 ORBITAL BREADTH** | Sliding calliper |
| **1.3.5 ORBITAL HEIGHT** | Sliding calliper |
| **1.3.1 BIORBITAL BREADTH** | Sliding calliper |
| **1.3.2 INTERORBITAL BREADTH FROM DACRYON** | Sliding calliper |
| **1.3.3 INTERORBITAL BREADTH** | Sliding calliper |
| **1.3.4 ORBITAL BREADTH** | Sliding calliper |
| **1.3.5 ORBITAL HEIGHT** | Sliding calliper |
| **1.4.1 NASAL BREADTH** | Sliding calliper |
| **1.4.2 NASAL HEIGHT** | Sliding calliper |
| **1.4.3 NOSE-MALAR CHORD** | Measuring tape |
| **1.4.4 NOSE-MALAR BREADTH** | Measuring tape |
| **1.5.1 MAXILLO-ALVEOLAR LENGTH** | Spreading calliper |
| **1.5.2 MAXILLO-ALVEOLAR BREADTH** | Sliding calliper |
| **1.5.3 PALATE LENGTH** | Sliding calliper |
| **1.5.4 PALATE BREADTH** | Sliding calliper |

# Appendix 5. Cranial indices
(after Bass, 1995)

## Cranial Index

Cranial Index: (maximum cranial breadth x 100)/maximum cranial length

Range: Dolichocrany ≤ 74.99 = Narrow or long headed
Mesocrany 75-79.99 = Average
Brachycrany 80-84.99 = Round headed

## Cranial Length/Height Index

Cranial Length/Height Index: (basion-bregma height x 100)/maximum cranial length

Range: Chamaecrany ≤ 69.99 = Low skull
Orthocrany 70-74.99 = Average
Hypsicrany ≥75= High skull

## Cranial Length/Height Index

Cranial Breadth/Height Index: (basion-bregma height x 100)/maximum cranial breadth

Range: Tapeinocrany ≤ 91.99 = Low skull
Metriocrany 92-97.99 = Average
Hypsicrany ≥98= High skull

## Nasal Index

Nasal Index: (nasal breadth x 100)/nasal height

Range: Leptorrhiny ≤ 47.99 = Narrow nasal aperture
Mesorrhiny 48-52.99 = Average
Platyrrhiny ≥53 = Broad nasal aperture

## Orbital Index

Orbital Index: (orbital height x 100)/orbital breadth

Range: Chamaeconchy ≤ 82.99 = Wide orbits
Mesoconchy 83-89.99 = Average
Hypsiconchy ≥89 = Narrow orbits

# <u>Appendix 6.</u> Cranial measurements recorded by the author

## Gloucester

### 1.1 NEUROCRANIUM

| SKELETON | SEX | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.1.6 | 1.1.7 | 1.1.8 | 1.1.9 | 1.1.10 | 1.1.11 | 1.1.12 | 1.1.13 | 1.1.14 | 1.1.15 | 1.1.16 | 1.1.17 | 1.1.18 | 1.1.19 | 1.1.20 | 1.1.21 | 1.1.22 | 1.1.23 | 1.1.24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11** | M | 188 | 180 | 184 | | | | 115 | | | | | | | | | 375 | 128 | 135 | 112 | 114 | 94 | | | |
| **24** | M? | 192 | 177 | 188 | | 146 | 124 | | 99 | | | 110 | 117 | | | 304 | 389 | 133 | 136 | 120 | 121 | 120 | 100 | | |
| **25** | M | | | | | | 128 | 119 | 100 | | | 120 | | | | | | | 141 | 122 | | 128 | 98 | | |
| **26** | F | 174 | 168 | 167 | 92 | 136 | 122 | 105 | 105 | 123 | 127 | 106 | 115 | 500 | 488 | 286 | 346 | 118 | 121 | 107 | 103 | 106 | 91 | 35 | 30 |
| **28** | M | 185 | 177 | 177 | 104 | 145 | 128 | 109 | 107 | 134 | 135 | 113 | 115 | 532 | 526 | 306 | 370 | 122 | 123 | 125 | 109 | 112 | 102 | 30 | 26 |
| **29** | M | | | 188 | | 139 | | 97 | | | | 115 | 120 | | | | | 127 | 133 | | 113 | 118 | | | |
| **31** | M | | | | | | 121 | 111 | 100 | | | | | | | | | | | 111 | | | 91 | 30 | 25 |
| **32** | F | 174 | 160 | 170 | 92 | 146 | 122 | 108 | 100 | 131 | 132 | 107 | 112 | | | 304 | 371 | 127 | 127 | 117 | 113 | 112 | 97 | 29 | 29 |
| **34** | M | 186 | 180 | 180 | 97 | 153 | 134 | 115 | 105 | 130 | 132 | 112 | 113 | 544 | 532 | 309 | 376 | 127 | 131 | 116 | 110 | 116 | 97 | 36 | 32 |
| **35** | M | 183 | 180 | 180 | 104 | 150 | 127 | 117 | 110 | 132 | 135 | 114 | 119 | 532 | 523 | 316 | 371 | 125 | 131 | 115 | 113 | 116 | 97 | 30 | 28 |
| **37** | M | | | | | | | | | | | | | | | | | | | | | | | | |
| **38** | M | 198 | 182 | 191 | 100 | 145 | 124 | 112 | 105 | 137 | 137 | 119 | 122 | 549 | 542 | 321 | 402 | 144 | 132 | 126 | 123 | 120 | 101 | 35 | 24 |
| **39** | F | | | | | | 119 | 111 | | | | | | | | | | | | 115 | | | 89 | 33 | 28 |
| **40** | M | | | | | | 138 | 119 | 110 | | | | | | | | | 128 | | 121 | 111 | | 106 | 37 | 33 |
| **42** | F | | | | | 136 | 115 | 114 | 105 | 133 | | 112 | | | | 301 | | | 120 | 118 | | 108 | 98 | 35 | 28 |
| **46** | M | 170 | 167 | 166 | 95 | | 134 | 114 | 114 | 140 | 138 | 112 | 116 | | | | 361 | 124 | 120 | 117 | 107 | 105 | 98 | 33 | 31 |
| **54** | F | 176 | 166 | 166 | 101 | 140 | 123 | 110 | 106 | 121 | 121 | 104 | 107 | 510 | 504 | 293 | 343 | 118 | 102 | 123 | 104 | 95 | 103 | 33 | 28 |
| **56** | F | 183 | 173 | 173 | 96 | 136 | 122 | 101 | 98 | 129 | 128 | 110 | 111 | 511 | 509 | 297 | 366 | 131 | 117 | 118 | 114 | 107 | 92 | 34 | 25 |
| **57** | M | | | | | | | | | | | | | | | | | | | 110 | | | 88 | | |
| **58** | M | 194 | 183 | 186 | | 145 | | 113 | | | | 118 | 120 | 552 | 533 | | 382 | 133 | 124 | 125 | 116 | 113 | 106 | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **59** | M | 173 | 160 | 170 | | 150 | 131 | 117 | 102 | | | 114 | 119 | 518 | 511 | 308 | 363 | 122 | 122 | 119 | 108 | 111 | 102 | | |
| **60** | F | | | | | | | 107 | | | | | | | | | | | 128 | | | 113 | | | |
| **61** | F | 166 | 159 | 161 | 95 | 137 | 120 | 111 | 105 | 130 | 134 | 108 | 112 | 492 | 484 | 289 | 348 | 119 | 113 | 116 | 104 | 100 | 99 | 30 | 30 |
| **62** | M | | | | | | | | | | | | | | | | | 124 | | | 111 | | 102 | 120 | 106 |
| **77** | F | 186 | 175 | 175 | 101 | | | | | 131 | | | | | | | 366 | 124 | 122 | 120 | 107 | 110 | 92 | 33 | 29 |
| **78** | M | | | | | 149 | 131 | 119 | 112 | 142 | | | 117 | | | 315 | | | 124 | 123 | | 113 | 102 | 34 | 30 |
| **83** | M | 193 | 181 | 184 | 107 | 137 | 127 | 111 | 111 | 128 | 127 | 111 | 115 | 539 | 531 | 302 | 376 | 130 | 125 | 122 | 112 | 112 | 95 | 34 | 30 |
| **85** | M | 190 | 177 | 187 | 98 | 135 | 114 | 101 | 93 | 123 | 124 | 113 | 115 | 533 | 519 | 304 | 381 | 128 | 138 | 117 | 114 | 121 | 93 | 32 | |
| **98** | F | | | | | | 121 | 99 | 98 | 126 | | 108 | | | | | | | 114 | 100 | | 102 | 84 | 34 | 26 |
| **100** | F | 181 | 166 | 175 | 95 | 139 | 116 | 110 | 102 | 133 | | 112 | 117 | 520 | 510 | 301 | 366 | 123 | 123 | 120 | 111 | 111 | 101 | | |
| **107** | M | 182 | 169 | 171 | 104 | | 128 | 113 | 106 | 138 | 139 | 116 | 123 | 523 | 510 | 313 | 371 | 125 | 120 | 126 | 113 | 105 | 112 | 32 | 33 |
| **108** | M | | | | | | | | | | | | | | | | | | | | | | | | |
| **110** | M | 182 | 172 | 174 | | 146 | 124 | 113 | 112 | | | 116 | 116 | 529 | 521 | 308 | 368 | 127 | 115 | 126 | 116 | 104 | 104 | | |
| **112** | M | 187 | 185 | 178 | 100 | 145 | 130 | 122 | 111 | 134 | | 115 | | 538 | 533 | 308 | 378 | 130 | 117 | 131 | 113 | 107 | 104 | 36 | 36 |
| **113** | F? | | | | | | | | | | | | | | | | | | 138 | | | 117 | | | |
| **114** | M | 193 | 183 | 186 | 103 | 145 | 133 | 125 | | 135 | 139 | 116 | 122 | 545 | 538 | 309 | 386 | 131 | 125 | 130 | 117 | 113 | 105 | 38 | 32 |
| **115** | F? | | | | | | | | | | | | | | | | | | | | | | | | |
| **116** | F | 173 | 160 | 167 | 99 | 135 | 121 | 109 | 105 | 128 | 128 | 112 | 114 | 502 | 493 | 295 | 351 | 120 | 115 | 119 | 108 | 104 | 99 | 33 | 29 |
| **125** | M | 182 | 173 | 175 | | 147 | 132 | 110 | 110 | | | 111 | | 540 | 531 | 304 | 380 | 130 | 131 | 119 | 111 | 118 | 94 | | |
| **129** | M | 181 | 169 | 171 | 101 | 150 | 125 | 117 | 101 | 131 | 171 | 114 | 120 | 527 | 522 | 307 | 367 | 123 | 126 | 118 | 108 | 111 | 99 | 33 | 32 |
| **130** | M | 184 | 170 | 176 | 98 | | 124 | 111 | 103 | 131 | 134 | 109 | 116 | | | | 373 | 127 | 125 | 124 | 111 | 110 | 101 | 34 | 28 |
| **133** | F | 186 | 179 | 173 | | | | | | | | 120 | | | | | 361 | 121 | 130 | 110 | 107 | 118 | 91 | | |
| **134** | F | | | | | | 120 | 111 | 100 | | | | | | | | | | 120 | 117 | | 108 | 97 | | |
| **135** | F | 176 | 161 | 174 | 87 | 136 | 112 | 102 | 96 | 124 | 125 | 109 | 114 | 500 | 496 | 294 | 369 | 121 | 128 | 121 | 107 | 113 | 96 | 33 | 33 |
| **136** | M | 180 | 171 | 173 | 100 | | 126 | 106 | 101 | 127 | 128 | 108 | 111 | | | | 360 | 122 | 129 | 109 | 109 | 112 | 89 | 32 | 28 |
| **139** | M | 181 | 172 | 171 | 103 | 140 | 117 | 103 | 98 | 133 | | 113 | 114 | 511 | 514 | 306 | 371 | 124 | 120 | 130 | 109 | 110 | 101 | 33 | 28 |
| **143** | M | 187 | 174 | 176 | | 141 | 125 | 110 | 101 | | | 114 | 119 | 533 | 528 | 307 | 370 | 128 | 122 | 120 | 111 | 109 | 99 | | |
| **146** | F | 185 | 170 | 169 | | 129 | 110 | 107 | 96 | | | 106 | 111 | 524 | 513 | 294 | 365 | 126 | 103 | 137 | 112 | 95 | 109 | | |
| **148** | M | 194 | 182 | 187 | | 139 | 117 | 109 | 91 | | | 120 | | 535 | 532 | 314 | 388 | 128 | 137 | 123 | 111 | 125 | 102 | | |
| **150** | M | 186 | 166 | 176 | | 141 | 126 | 122 | 109 | | | 105 | 106 | 534 | 524 | 286 | 367 | 124 | 120 | 125 | 109 | 109 | 100 | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **151** | M | 170 | 163 | 163 | 95 | 146 | 126 | 126 | 109 | 129 | 130 | 109 | 114 | 507 | 503 | 299 | 351 | 114 | 122 | 115 | 104 | 105 | 92 | 34 | 28 |
| **152** | M | 184 | 180 | 177 | 102 | 146 | 130 | 113 | 112 | 134 | 132 | 113 | 118 | 530 | 522 | 306 | 371 | 129 | 121 | 122 | 114 | 109 | 100 | 33 | 30 |
| **159** | M | 188 | 185 | 181 | 109 | 143 | 124 | 116 | 110 | 138 | 140 | 112 | 118 | 542 | 531 | 301 | 369 | 130 | 124 | 115 | 114 | 110 | 99 | 38 | |
| **161** | M | 186 | 176 | 180 | | 149 | 129 | 123 | 102 | 133 | | 115 | | 546 | 533 | 310 | | | 128 | 126 | | 114 | 102 | 33 | 31 |
| **167** | M | 176 | 162 | 173 | 90 | 145 | 125 | 107 | 101 | 117 | | 106 | | | | 297 | | | 130 | 113 | 105 | 111 | 89 | 31 | 25 |
| **168** | F | 182 | 170 | 176 | | | | 107 | | | | | | | | | | | 126 | 112 | | 113 | 93 | | |
| **170** | M | 174 | 164 | 171 | 101 | 149 | 126 | 105 | 108 | 132 | 133 | 115 | 116 | 514 | 508 | 315 | 365 | 128 | 124 | 113 | 113 | 109 | 98 | 32 | 24 |
| **171** | F | 175 | 164 | 170 | 102 | 150 | 128 | 110 | 100 | 118 | 119 | 108 | 111 | 519 | 513 | 302 | 354 | 122 | 123 | 109 | 105 | 109 | 89 | 33 | 30 |
| **173** | M | 182 | 167 | 176 | 94 | 149 | 128 | 117 | 99 | 131 | 130 | 113 | 118 | 536 | 526 | 308 | 376 | 127 | 125 | 125 | 113 | 112 | 102 | 33 | 29 |
| **174** | M | 198 | 190 | 186 | | 141 | 121 | 101 | 95 | | | 110 | 114 | | | 302 | 389 | 134 | 125 | 131 | 116 | 111 | 101 | | |
| **178** | F | 188 | 174 | 185 | 106 | 141 | | | | 122 | | | | | | | | | 142 | 109 | | 123 | 92 | 35 | 27 |
| **182** | F | 177 | 171 | 171 | | 132 | 112 | 104 | 93 | | | 103 | 110 | 501 | 499 | 287 | 350 | 115 | 123 | 117 | 99 | 109 | 93 | | |
| **183B 183.1** | M | 186 | 178 | 177 | 110 | 134 | 119 | 111 | 116 | 125 | 125 | 104 | 105 | 517 | 504 | 281 | 360 | 128 | 109 | 123 | 113 | 99 | 103 | 35 | 31 |
| **183A 183.2** | M? | 180 | 169 | 176 | | | 131 | 114 | 108 | | | 115 | 115 | | | | 373 | 130 | 126 | 117 | 114 | 112 | 97 | | |
| **184** | F | 184 | 172 | 179 | | 131 | 112 | 99 | 97 | | | 111 | 117 | 519 | 509 | 288 | 362 | 124 | 128 | 110 | 109 | 114 | 92 | | |
| **196 (1326) 196.1** | M | 192 | 178 | 190 | 98 | 153 | 130 | 119 | 104 | 144 | 144 | 120 | 126 | 556 | 548 | 328 | 401 | 137 | 146 | 117 | 119 | 126 | 104 | 37 | 31 |
| **196 (1353) 196.2** | F | 181 | 180 | 175 | 104 | 146 | 122 | 105 | 103 | 130 | 132 | 112 | 117 | | | 311 | 363 | 130 | 125 | 111 | 113 | 108 | 92 | 34 | 30 |
| **196 (1038) 196.3** | M? | | | | | | | | | | | | | | | | | | | | | | | | |
| **196 (1069) 196.4** | F | 181 | 168 | 179 | 94 | 140 | 118 | 103 | 91 | 126 | 125 | 113 | 118 | 518 | 511 | 310 | 381 | 130 | 131 | 120 | 111 | 115 | 98 | 35 | 27 |
| **197 (1230) 197.1** | M | 187 | 176 | 182 | 102 | 142 | 126 | 115 | 104 | 133 | 135 | 111 | 118 | 535 | 523 | 298 | 378 | 125 | 130 | 124 | 112 | 116 | 103 | 32 | 29 |
| **1511A 151.1** | M | 188 | 171 | 181 | 105 | 150 | 127 | 111 | 112 | 139 | 141 | 118 | 121 | 541 | 532 | 324 | 379 | 130 | 128 | 120 | 115 | 116 | 100 | 35 | 31 |
| **197 (1155) 197.2** | M | 186 | 179 | 173 | 103 | 133 | 121 | 105 | 100 | 124 | 125 | 110 | 112 | 521 | 516 | 294 | 367 | 121 | 116 | 130 | 105 | 104 | 103 | 37 | 26 |
| **GLA 43 43** | F | 172 | 157 | 169 | 88 | 140 | 116 | 111 | | 125 | | 107 | | 504 | 501 | 299 | 370 | 128 | 130 | 112 | 106 | 113 | 94 | 30 | 27 |
| **GLA 45 45** | M | 182 | 167 | 172 | 101 | 140 | 126 | 112 | | 132 | 137 | 110 | 117 | 524 | 512 | 297 | 365 | 123 | 124 | 118 | 110 | 108 | 102 | 36 | |
| **DIS 1 1.1** | M | 188 | 172 | 182 | 96 | | | | | 123 | | | | | | | 370 | 130 | 122 | 118 | 113 | 108 | 93 | 36 | |
| **DIS 2 2.1** | M | 183 | 161 | 177 | 95 | 131 | 119 | 106 | 102 | 129 | | 109 | | | 507 | 288 | 373 | 121 | 129 | 123 | 106 | 115 | 101 | 33 | 31 |
| **DIS 3 3.1** | F | 184 | 169 | 179 | 94 | 141 | 118 | 114 | 100 | 126 | 126 | 108 | 111 | 522 | 517 | 291 | 367 | 120 | 130 | 117 | 106 | 115 | 94 | 36 | 30 |
| **DIS 4 4.1** | M | 198 | 181 | 189 | 95 | 144 | 127 | 107 | 108 | 118 | | 110 | | 553 | 538 | 305 | 396 | 133 | 128 | 135 | 113 | 115 | 99 | 36 | |
| **DIS 5 5.1** | F? | 183 | 172 | 174 | 97 | 132 | 113 | 99 | 96 | 127 | | 106 | | 512 | 509 | 287 | 371 | 123 | 128 | 120 | 106 | 113 | 96 | 32 | 30 |

## 1.2 FACIAL SKULL, 1.3 ORBITAL SKELETON, 1.4 NASAL SKELETON AND 1.5 MAXILLARY SKELETON

| SKELETON | SEX | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.2.5 | 1.2.6 | 1.2.7 | 1.2.8 | 1.3.1 | 1.3.2 | 1.3.3 | 1.3.4 | 1.3.5 | 1.4.1 | 1.4.2 | 1.4.3 | 1.4.4 | 1.5.1 | 1.5.2 | 1.5.3 | 1.5.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11** | M | | 101 | | | | | | | | | | | | 25 | | | | | 64 | | 43 |
| **24** | M? | | | 119 | 103 | | 83 | | | 94 | | | | 33 | | | 93 | | | | | |
| **25** | M | | | | | | | | | | | | | | | | | | | | | |
| **26** | F | | 91 | 116 | 97 | | | | | | | | | 29 | | | | | | | | |
| **28** | M | 93 | 105 | 120 | 117 | | 100 | 124 | 76 | 110 | 32 | | 46 | 38 | 25 | 57 | 108 | 123 | 56 | 70 | 46 | 48 |
| **29** | M | | 105 | 131 | 107 | | 98 | | 83 | 99 | | 22 | 43 | 40 | 23 | 59 | 99 | 120 | | | | |
| **31** | M | | | | | | | | | | | | | | | | | | 50 | 62 | | 44 |
| **32** | F | 88 | | | | | 89 | 104 | 70 | 95 | 19 | 17 | 42 | 35 | 22 | 51 | 95 | 103 | | | | |
| **34** | M | 98 | 104 | 127 | 109 | | 95 | | 70 | 101 | 21 | 19 | 42 | 30 | 29 | 50 | 99 | 112 | | | 46 | |
| **35** | M | | 103 | 126 | 111 | | | 117 | | 104 | 30 | | 43 | 33 | | | 103 | 120 | | | | |
| **37** | M | | | | | | | | | | | | | | | | | | | | | |
| **38** | M | 100 | 92 | 121 | 102 | | 97 | 126 | 71 | | | 25 | 34 | 28 | | 49 | | | | | | |
| **39** | F | | | | | | | | | | | | | | | | | | | | | |
| **40** | M | | 94 | | | | | | | | | | | | | | | | | | | |
| **42** | F | | 91 | 114 | 103 | | | | | | | | | | | | | | | | | |
| **46** | M | 92 | | | | | | 106 | 59 | | | | 44 | 30 | | 45 | | | 50 | | 41 | 43 |
| **54** | F | 100 | 98 | 122 | 102 | | 94 | 114 | 70 | 99 | 24 | 22 | 41 | 35 | 23 | 50 | 99 | 113 | 53 | | | |
| **56** | F | | 96 | 116 | 103 | 127 | 90 | 100 | | 95 | | | | 32 | | 48 | 95 | 105 | | | | |
| **57** | M | | | | | | | | | | | | | | | | | | | | | |
| **58** | M | | 102 | 123 | 108 | | 94 | | | 97 | | | | 39 | | | | | | | | |
| **59** | M | | 100 | 123 | 106 | | 90 | 110 | 67 | 98 | 24 | 22 | 40 | 33 | 24 | 48 | 98 | 111 | 54 | | | |
| **60** | F | | 103 | | 106 | | 87 | | | 100 | | | | | | | | | 50 | 39 | | 59 |
| **61** | F | 87 | 98 | 117 | 104 | | | 105 | 65 | | 24 | 22 | 42 | 37 | 24 | 51 | | | | 57 | | 39 |
| **62** | M | | | | | | | | | | | | | | | | | | | | | |
| **77** | F | 95 | | | | | | 115 | 75 | | 23 | 21 | 40 | 34 | 24 | 54 | | | 54 | 61 | 44 | 39 |
| **78** | M | | 102 | 126 | 111 | | | | | | | | | 33 | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **83** | M | 108 | 102 | 124 | 108 | | 100 | 125 | 75 | 101 | 24 | 22 | 41 | 40 | 25 | 53 | 100 | | 58 | 65 | | 43 |
| **85** | M | 101 | 96 | 120 | 102 | | 94 | 112 | 67 | 93 | | | 38 | 33 | | 49 | 93 | 103 | | | | |
| **98** | F | | | | | | | | | | | | | | | | | | | 54 | 40 | |
| **100** | F | | 101 | 120 | 103 | | 89 | | | | 23 | | | | | | | | | | | |
| **107** | M | 98 | 97 | 119 | 108 | | 89 | 113 | 68 | 98 | 23 | 21 | 41 | 33 | 22 | 51 | 100 | 109 | 53 | 64 | | 41 |
| **108** | M | | | | | | | | | | | | | | | | | | 54 | 59 | 46 | 38 |
| **110** | M | | 94 | 120 | 106 | | 95 | | 72 | 95 | 21 | 19 | 41 | 35 | 26 | 55 | 95 | 110 | | | 39 | |
| **112** | M | | 102 | 122 | 109 | | | | | | | | | | | | | | | | | |
| **113** | F? | | | | | | | | | | | | | | | | | | | | | |
| **114** | M | 99 | 96 | 123 | 101 | | | | 65 | | 25 | | | 32 | 24 | 48 | | | 53 | | | |
| **115** | F? | | | | | | | | | | | | | | | | | | | | | |
| **116** | F | 101 | 91 | 116 | 99 | 127 | 92 | 103 | 65 | 92 | 19 | 18 | 39 | 33 | 22 | 48 | 93 | 103 | 55 | 60 | 43 | 44 |
| **125** | M | | 102 | 126 | 106 | | 96 | | 67 | 98 | | | 41 | 35 | | 51 | 98 | 108 | | | 42 | |
| **129** | M | 89 | | 120 | 101 | | 90 | 119 | 72 | | | | 40 | 37 | 24 | 51 | | | 52 | 61 | 40 | 40 |
| **130** | M | 94 | 93 | | 103 | | 82 | 109 | 60 | 93 | | | | 31 | | 42 | 93 | | | | 40 | |
| **133** | F | | 103 | 118 | 105 | | | | | | 25 | | | | | | | | | | | |
| **134** | F | | 98 | | 107 | | | | | | | | 41 | 33 | | | | | | | | |
| **135** | F | | 86 | 112 | 95 | | 93 | | | 89 | | | 38 | 32 | | | 90 | 99 | | | | |
| **136** | M | 96 | 97 | 120 | 105 | | 97 | | 68 | 96 | 24 | 23 | 40 | 32 | 24 | 49 | 97 | 110 | 57 | 64 | 46 | 41 |
| **139** | M | 91 | 99 | 125 | 103 | | 91 | 112 | 69 | | | | | 32 | | 53 | | | 51 | | | 39 |
| **143** | M | | 97 | 125 | 101 | | 94 | 109 | 65 | | | | 42 | 33 | 23 | 48 | | | | | | |
| **146** | F | | 97 | 115 | 103 | | 90 | 107 | 66 | 93 | 22 | 19 | 39 | 34 | 24 | 50 | 92 | 102 | | | | |
| **148** | M | | 95 | 122 | 102 | | | | | | | | | | | | | | | | | |
| **150** | M | | 97 | 121 | 103 | 127 | 91 | | | 98 | 25 | 21 | 42 | 32 | | | 97 | 111 | | | | |
| **151** | M | 85 | 93 | 115 | 101 | | 96 | 107 | 67 | 96 | 22 | | | 31 | 25 | 51 | 96 | | 48 | 61 | 40 | 40 |
| **152** | M | | 101 | 116 | 106 | | 97 | 112 | | 99 | | 22 | 41 | 32 | | | 99 | 115 | | | | |
| **159** | M | | 99 | 123 | 11 | | 99 | 126 | | 104 | | | | 36 | | | 104 | | | | | 35 |
| **161** | M | | 97 | 124 | 109 | | | | | | | | | | | | | | | | | |
| **167** | M | | | | | | | | | | | | | 32 | | | | | | | | |
| **168** | F | | 97 | 117 | 102 | | | | | | | | | | | | | | | | | |

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| **170** | M | 93 | 93 | 122 | 103 | | 95 | | 69 | 95 | 24 | 22 | 38 | 34 | 23 | 52 | 95 | 107 | | | | |
| **171** | F | 91 | 98 | 125 | 102 | | 88 | 107 | 64 | 98 | 26 | 21 | 41 | 35 | 23 | 47 | 98 | 111 | 55 | 65 | 46 | 42 |
| **173** | M | 93 | 102 | 126 | 109 | | 101 | 121 | 69 | 99 | | | 42 | 35 | 26 | 49 | 98 | 109 | 59 | | 43 | |
| **174** | M | | 97 | 126 | 108 | 132 | 89 | | | 99 | 24 | 23 | 41 | 40 | | | 99 | 112 | | | | |
| **178** | F | | 101 | | 106 | | | | | | | | | | 24 | | | | | | | |
| **182** | F | | 95 | 116 | 101 | | | 101 | | | | | 38 | 34 | | | | | | | | |
| **183B 183.1** | M | 101 | 94 | 150 | 103 | | 101 | | | 96 | 23 | 20 | 39 | 31 | 22 | 51 | 96 | 106 | 53 | | | |
| **183A 183.2** | M? | | 104 | 132 | 111 | | | | | | 26 | 26 | 40 | 32 | | | | | | | | |
| **184** | F | | 95 | 113 | 101 | | 84 | 105 | 61 | 91 | 23 | 19 | 38 | 32 | 26 | 48 | 92 | 106 | 55 | 57 | | 33 |
| **196 (1326) 196.1** | M | | 104 | 131 | 110 | | | | | 101 | 25 | 21 | 42 | 32 | | | 101 | 111 | | | | |
| **196 (1353) 196.2** | F | 104 | | | | | | | 67 | | | | | | | 50 | | | | | | |
| **196 (1038) 196.3** | M? | | 91 | 115 | 102 | | 92 | | 68 | 93 | 25 | 24 | 36 | 33 | 23 | 49 | 94 | 105 | 54 | 60 | 44 | 40 |
| **196 (1069) 196.4** | F | 86 | 94 | 119 | 97 | | 89 | | 73 | 90 | 22 | 19 | 38 | 37 | 22 | 55 | 90 | 104 | 52 | | 42 | |
| **197 (1230) 197.1** | M | 100 | 96 | 120 | 102 | | 96 | | 70 | 94 | | 22 | 38 | 36 | | 51 | 94 | 105 | 58 | 61 | | |
| **1511A 151.1** | M | 101 | 105 | 130 | 109 | | 93 | 123 | 71 | 101 | 22 | 21 | 43 | 36 | 22 | 51 | 101 | 118 | 58 | | 47 | 41 |
| **197 (1155) 197.2** | M | 97 | 95 | 117 | 102 | | 97 | | 74 | 97 | 26 | 24 | 38 | 33 | 26 | 53 | 98 | 111 | 57 | 67 | | 47 |
| **GLA 43 43** | F | | 100 | 121 | 102 | | | | | | 25 | | | | | | | | | | | |
| **GLA 45 45** | M | 93 | 97 | 115 | 106 | | 99 | | 66 | 101 | 26 | 24 | 41 | 33 | 26 | 49 | 100 | 115 | 51 | 60 | 40 | 37 |
| **DIS 1 1.1** | M | 93 | | | | | | | | | | | 38 | 39 | | 50 | | | | | | |
| **DIS 2 2.1** | M | 95 | | 114 | | | | | 67 | | 23 | 20 | 40 | 35 | 25 | 47 | | | | | 44 | |
| **DIS 3 3.1** | F | | 91 | 118 | 94 | 119 | 80 | | | 91 | 17 | 17 | 41 | 38 | 24 | 52 | 91 | 104 | | | 40 | |
| **DIS 4 4.1** | M | | 100 | 124 | 108 | | | | | | | 23 | | | | | | | | | | |
| **DIS 5 5.1** | F? | | 97 | 116 | 100 | | | | | | | | | | | | | | | | | |

# Poulton

## 1.1 NEUROCRANIUM

| SKELETON | SEX | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.1.6 | 1.1.7 | 1.1.8 | 1.1.9 | 1.1.10 | 1.1.11 | 1.1.12 | 1.1.13 | 1.1.14 | 1.1.15 | 1.1.16 | 1.1.17 | 1.1.18 | 1.1.19 | 1.1.20 | 1.1.21 | 1.1.22 | 1.1.23 | 1.1.24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **50** | M | 180 | 172 | 172 | 92 | 142 | 131 | 116 | 111 | 122 | 122 | 105 | 109 | 520 | 519 | 293 | 370 | 125 | 120 | 125 | 109 | 109 | 104 | 40 | 35 |
| **53** | M | 191 | 176 | 189 | 107 | 145 | 127 | 114 | 107 | 132 | 133 | 112 | 116 | 559 | 542 | 310 | 389 | 135 | 133 | 121 | 120 | 118 | 100 | 33 | 30 |
| **67** | F | | | | | | 115 | 110 | 103 | | | | | | | | | | | 114 | | | 94 | | |
| **82** | M | 193 | 188 | 186 | 107 | 145 | 130 | 115 | 110 | 136 | 136 | 114 | 117 | 552 | 544 | 312 | 394 | 132 | 142 | 120 | 113 | 123 | 94 | 33 | 30 |
| **83** | M | 192 | 184 | 185 | 107 | 139 | 122 | 110 | 97 | 133 | 132 | 113 | 116 | 535 | 532 | 305 | 380 | 132 | 126 | 118 | 118 | 111 | 95 | 34 | 29 |
| **84** | F | 194 | 182 | 188 | 105 | 141 | 119 | 107 | 95 | 137 | 139 | 119 | 126 | 541 | 540 | 314 | 398 | 135 | 145 | 118 | 117 | 126 | 99 | 38 | 31 |
| **86** | M | 189 | 177 | 183 | 107 | 137 | 117 | 108 | 96 | 125 | 126 | 110 | 116 | 532 | 523 | 302 | 368 | 130 | 126 | 112 | 116 | 113 | 93 | 34 | 25 |
| **90** | M | | | | | 136 | 121 | 108 | 98 | 131 | | | | | | | | | | 119 | | 117 | 98 | 34 | |
| **93** | F | 177 | 164 | 174 | 100 | 141 | 115 | 112 | 97 | 131 | 133 | 117 | 124 | 510 | 504 | 307 | 365 | 125 | 130 | 110 | 112 | 113 | 94 | 30 | 24 |
| **94** | M | 192 | 189 | 188 | | 143 | 123 | 119 | 103 | | | 111 | | 543 | 536 | 306 | | 134 | 138 | | 116 | 123 | | | |
| **95** | F | 170 | 159 | 166 | | 145 | 131 | 108 | 103 | | | 105 | 111 | 503 | 495 | 285 | 348 | 122 | 110 | 116 | 112 | 118 | 100 | | |
| **96** | F | 185 | 169 | 177 | | 140 | 123 | 105 | 98 | | | 112 | 117 | 521 | 522 | 308 | 381 | 136 | 131 | 114 | 114 | 115 | 93 | | |
| **103** | M | | | | | 135 | 110 | 108 | 95 | 115 | | 104 | | | | 300 | | | 129 | 106 | | 115 | 86 | 33 | 31 |
| **110** | M | 189 | 171 | 178 | | 135 | 115 | 114 | 94 | | | 112 | 116 | 530 | 519 | 301 | 371 | 122 | 121 | 128 | 108 | 106 | 103 | | |
| **112** | M | 181 | 175 | 180 | 95 | 141 | 120 | 108 | 94 | 128 | 129 | 109 | 111 | 525 | 517 | 298 | 376 | 134 | 128 | 114 | 116 | 113 | 98 | 33 | 28 |
| **114** | M | 193 | 176 | 182 | | 146 | 130 | 112 | 107 | | | 115 | 119 | 548 | 541 | 316 | 380 | 125 | 126 | 129 | 112 | 113 | 104 | | |
| **119** | M | 184 | 176 | 177 | | 149 | 128 | 118 | 103 | | | 121 | 119 | 538 | 526 | 320 | 370 | 134 | 130 | 106 | 117 | 114 | 91 | | |
| **121** | M | 191 | 183 | 189 | 103 | 137 | 120 | 114 | | 135 | 135 | 117 | 120 | 537 | 524 | 311 | 386 | 130 | 128 | 128 | 118 | 117 | 104 | 34 | 28 |
| **122** | M | 188 | 176 | 181 | 102 | 147 | 129 | 118 | 115 | 138 | | 115 | | 546 | 537 | 307 | 383 | 132 | 131 | 120 | 116 | 116 | 100 | 38 | 30 |
| **123** | M | 176 | 176 | 174 | 104 | 150 | 126 | 116 | 108 | 130 | | 112 | | | | 312 | 365 | 120 | 134 | 111 | 108 | 116 | 91 | 35 | 34 |
| **125** | M | | | | | 156 | 133 | 121 | 111 | | | 119 | | | | 326 | | | 127 | 137 | | 113 | 107 | | |
| **131** | M | 188 | 174 | 180 | 97 | 158 | 136 | 119 | 119 | 135 | 135 | 114 | 121 | | | 332 | 387 | 130 | 134 | 123 | 116 | 117 | 100 | 37 | 32 |
| **132** | F | 181 | 170 | 175 | | 136 | 118 | 104 | 90 | | | 111 | | 513 | 509 | 300 | 373 | 129 | 118 | 126 | 114 | 106 | 99 | | |

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| **134** | F | | | | | 147 | 122 | 108 | 98 | 115 | | | | | | 312 | | | 110 | 111 | | 100 | 91 | 33 | 25 |
| **140** | M | | | | | | 133 | 116 | 107 | | | | | | | | | | | 117 | | | 94 | | |
| **142** | F | | | | | 142 | 120 | 111 | 94 | | | | | | | 314 | | | 145 | 112 | | 125 | 95 | | |
| **155** | M | 177 | 170 | 171 | 91 | 143 | 127 | 111 | | 124 | 124 | 108 | 112 | 521 | 506 | 298 | 355 | 121 | 116 | 118 | 110 | 103 | 95 | 35 | 29 |
| **156** | M | 201 | 190 | 192 | | 146 | 120 | 109 | 100 | | | | | | 553 | 324 | 398 | 135 | | 130 | 118 | | 102 | | |
| **166** | F | 180 | 171 | 174 | 102 | 146 | 129 | 115 | 108 | 134 | 134 | 114 | 116 | 524 | 522 | 312 | 369 | 133 | 120 | 116 | 117 | 108 | 99 | 39 | 29 |
| **169** | M | 185 | 180 | 177 | 101 | 150 | 127 | 115 | 106 | 134 | 134 | 116 | 120 | 546 | 540 | 318 | 382 | 134 | 121 | 126 | 113 | 112 | 105 | 39 | 28 |
| **171** | M? | | | | | 144 | | 119 | | | | | | | | | | | 121 | 118 | 108 | 88 | | | |
| **173** | F? | | | | | 149 | 127 | 114 | 111 | | | | | | | | | | | 111 | | | 91 | 31 | 26 |
| **174** | M | 179 | 170 | 172 | 98 | 147 | 118 | 109 | 102 | 134 | 134 | 112 | 135 | 525 | 522 | 306 | 374 | 123 | 130 | 121 | 107 | 114 | 102 | 32 | 25 |
| **176** | M | 179 | 171 | 169 | 95 | 149 | 125 | 108 | 106 | 121 | 126 | 108 | 114 | 526 | 517 | 303 | 361 | 117 | 123 | 121 | 102 | 107 | 96 | 35 | 29 |
| **187** | M? | | | | | 154 | 134 | 116 | 111 | | | | | | | 325 | | | 120 | | | 110 | | | |
| **189** | M | 189 | 175 | 177 | | | 122 | 103 | 103 | | | | 109 | | | | 371 | | | 124 | | | 99 | | |
| **209** | M | 192 | 178 | 185 | 100 | 148 | 124 | 115 | 102 | 135 | | 117 | | 553 | 545 | 323 | 391 | 137 | 117 | 137 | 119 | 113 | 103 | 38 | 32 |
| **219** | M | 172 | 159 | 166 | | 146 | 122 | 108 | 101 | | | 109 | 114 | 515 | 512 | 302 | 361 | 125 | 116 | 120 | 105 | 103 | 97 | | |
| **227** | M | 180 | 168 | 173 | 95 | 137 | 118 | 105 | 101 | 127 | 127 | 108 | 110 | 525 | 515 | 296 | 361 | 122 | 130 | 109 | 105 | 115 | 91 | 33 | 28 |
| **230** | M | 179 | 170 | 172 | | 152 | | 115 | | | | | | 531 | 529 | | 385 | 129 | 133 | 123 | 113 | 116 | 93 | | |
| **246** | M | 193 | 183 | 183 | | 136 | | 102 | | | | | | | | | 372 | 126 | 130 | 116 | 112 | 116 | 94 | | |
| **268** | F | 172 | 159 | 167 | | 151 | 125 | 116 | 100 | | | 110 | 117 | 520 | 512 | 301 | | 123 | 126 | | 107 | 109 | | | |
| **286** | M | 195 | 183 | 189 | | 145 | 124 | 111 | 102 | | | 123 | 125 | 558 | 552 | 334 | 386 | 128 | 139 | 119 | 111 | 127 | 98 | | |
| **288** | M | 206 | 185 | 198 | | 151 | 129 | 111 | 110 | | | 116 | 121 | 578 | 578 | 326 | 422 | 143 | 146 | 133 | 121 | 130 | 101 | | |
| **292** | M | 196 | 182 | 184 | | 153 | 140 | 121 | 120 | | | 115 | 119 | 563 | 549 | 315 | | | 125 | 140 | | 114 | 105 | | |
| **293** | F? | 183 | 158 | 173 | 87 | 143 | 124 | 118 | 102 | 131 | 126 | 112 | 115 | 532 | 517 | 301 | 370 | 130 | 107 | 133 | 117 | 99 | 102 | 36 | 33 |
| **295** | M | 181 | 177 | 170 | 94 | 146 | 124 | 111 | 101 | 140 | 140 | 116 | 116 | 531 | 528 | 316 | 373 | 135 | 127 | 111 | 112 | 112 | 91 | 41 | 33 |
| **297** | M | 191 | 180 | 186 | | 153 | 133 | 122 | 115 | | | 116 | | 551 | 542 | 318 | 381 | 137 | 128 | 121 | 119 | 115 | 103 | | |
| **298** | M | 192 | 178 | 186 | | 145 | 127 | 116 | 104 | | | 119 | | 554 | 550 | 321 | 395 | 135 | 130 | 130 | 116 | 116 | 106 | | |
| **303** | M | 178 | 174 | 170 | | 149 | 129 | 116 | 107 | | | 112 | 116 | 532 | 523 | 308 | 365 | 121 | 119 | 125 | 107 | 105 | 100 | | |
| **305** | M | 182 | 174 | 173 | | 143 | | 113 | | | | | | | 523 | | 361 | 126 | 122 | 113 | 105 | 110 | 89 | | |
| **306** | F | 176 | 158 | 171 | | 144 | 121 | 110 | 102 | | | 111 | 118 | 519 | 512 | 298 | | 121 | 129 | | 107 | 129 | | | 29 |
| **309** | F | 177 | 165 | 169 | 96 | | 123 | 108 | 104 | 128 | 130 | 111 | 116 | | | | 364 | 125 | 115 | 124 | 112 | 100 | 100 | 31 | 27 |

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| **310** | M | 186 | 177 | 175 | 103 | 156 | 136 | 120 | 122 | 135 | 134 | 114 | 116 | 546 | 545 | 324 | 379 | 138 | 113 | 128 | 117 | 106 | 102 | 41 | 35 |
| **313** | F | 189 | 180 | 179 | 96 | 142 | 121 | 111 | 99 | 128 | 126 | 106 | 107 | 538 | 528 | 283 | 374 | 131 | 123 | 120 | 118 | 111 | 95 | 35 | 30 |
| **318** | M | 183 | 169 | 174 | | 148 | 128 | 113 | 108 | | | 110 | 114 | 533 | 529 | 302 | | 127 | 118 | | 109 | 108 | | | |
| **324** | F | 173 | 164 | 169 | 94 | 144 | 122 | 112 | 99 | 115 | 114 | 107 | 109 | 511 | 505 | 298 | 350 | 121 | 117 | 112 | 105 | 105 | 89 | 32 | 27 |
| **325** | F | | 159 | 173 | | 154 | 126 | 116 | 106 | | | 117 | 124 | | | 318 | 376 | 132 | 125 | 119 | 113 | 107 | 96 | | |
| **336** | M | 191 | 183 | 180 | 100 | 156 | 126 | 110 | 108 | 142 | 140 | 126 | 127 | 553 | 545 | 338 | 401 | 137 | 143 | 121 | 118 | 125 | 92 | 34 | 27 |
| **337** | F | 176 | 164 | 175 | 93 | 133 | 110 | 109 | 97 | 129 | 131 | 110 | 115 | 519 | 508 | 296 | 370 | 125 | 139 | 106 | 109 | 119 | 87 | 33 | 25 |
| **340** | M | 194 | 175 | 185 | 104 | 143 | 122 | 117 | 102 | 145 | | 123 | | | 536 | 318 | 394 | 137 | 130 | 127 | 118 | 120 | 102 | 40 | 30 |
| **342** | M | 183 | 174 | 173 | | 150 | | 120 | | | | | | 537 | 533 | | | 128 | 121 | | 112 | 120 | | 40 | 30 |
| **346** | M | | | | | 151 | 129 | 114 | 109 | 127 | 128 | 113 | 113 | | | 313 | | | 131 | 119 | | 118 | 93 | 32 | 29 |
| **352** | M | 181 | 178 | 168 | 105 | 144 | 123 | 114 | 105 | 135 | | 116 | | 526 | 525 | 321 | 367 | 123 | 124 | 120 | 107 | 109 | 95 | 35 | 32 |
| **354** | M | 190 | 182 | 183 | | 138 | 123 | 113 | 97 | | | 111 | 111 | 538 | 523 | 300 | 370 | 132 | 121 | 117 | 114 | 111 | 93 | | |
| **366** | F | 173 | 166 | 169 | 102 | 150 | 122 | 112 | 106 | 133 | 133 | 114 | 117 | 516 | 514 | 320 | 364 | 132 | 120 | 112 | 113 | 106 | 99 | 36 | 30 |
| **371** | M? | 180 | 167 | 170 | 99 | 139 | 126 | 106 | 106 | 121 | 120 | 105 | 106 | 516 | 515 | 290 | 358 | 125 | 116 | 117 | 108 | 103 | 92 | 34 | |
| **372** | M | | | | | 155 | 136 | 116 | 115 | | | 117 | | | | 323 | | | 130 | 114 | | 114 | 94 | | |
| **375** | M? | 177 | 163 | 172 | 99 | 146 | 128 | 119 | 100 | 115 | 118 | 110 | 112 | 527 | 522 | 303 | 350 | 122 | 117 | 111 | 104 | 106 | 88 | 36 | 31 |
| **380** | M | 182 | 165 | 180 | 93 | 143 | 128 | 110 | 109 | 125 | 126 | 107 | 110 | 532 | 524 | 295 | 369 | 129 | 120 | 120 | 112 | 109 | 99 | 38 | 33 |
| **381** | F | 186 | 172 | 180 | | 139 | 121 | 109 | 97 | | | 111 | 111 | 525 | 526 | 307 | 369 | 130 | 129 | 110 | 110 | 116 | 89 | | |
| **382** | F | 175 | 164 | 169 | | 149 | 129 | 106 | 109 | | | 107 | 109 | 516 | 512 | 292 | 355 | 124 | 116 | 115 | 106 | 105 | 96 | | |
| **391** | F | 170 | 160 | 162 | 99 | 147 | 130 | 114 | 102 | 124 | 124 | 106 | 108 | 514 | 505 | 296 | 328 | 116 | 109 | 103 | 104 | 99 | 88 | 38 | 30 |
| **392** | F? | 182 | 158 | 176 | 96 | 140 | 122 | 109 | 102 | 130 | 131 | 110 | 116 | 521 | 515 | 297 | 371 | 134 | 121 | 115 | 116 | 110 | 95 | 39 | 32 |
| **395** | F | 178 | 154 | 173 | 94 | 134 | 118 | 108 | 103 | 131 | 132 | 105 | 112 | 510 | 498 | 288 | 357 | 119 | 122 | 116 | 107 | 110 | 99 | 38 | |
| **408** | M | | | | | 142 | 123 | 114 | 102 | 125 | | 114 | | | | 316 | | | 136 | 115 | | 122 | 88 | 32 | 31 |
| **419** | M | 188 | 170 | 183 | | 143 | 127 | 115 | 106 | | | 106 | 107 | 538 | 527 | 282 | 371 | 128 | 123 | 120 | 115 | 113 | 96 | | |
| **423** | M | 203 | 180 | 200 | 103 | 154 | 129 | 117 | 103 | 132 | | 115 | | 580 | 561 | 316 | 396 | 142 | 127 | 127 | 130 | 117 | 102 | 40 | 37 |
| **432** | M? | 187 | 172 | 181 | 95 | 152 | 133 | 117 | 117 | 129 | 128 | 112 | 116 | | | 310 | 386 | 141 | 127 | 118 | 121 | 113 | 96 | 33 | 35 |
| **428** | F | 182 | 173 | 177 | 89 | 150 | 134 | 114 | 113 | 135 | | 116 | | 534 | 532 | 312 | 385 | 135 | 126 | 124 | 118 | 112 | 103 | 41 | 30 |
| **435** | M | 185 | 175 | 176 | 102 | 147 | 123 | 109 | 108 | 138 | | 118 | 119 | | | 322 | 376 | 132 | 127 | 117 | 108 | 114 | 99 | 34 | |
| **436** | M | 186 | 173 | 180 | 112 | 138 | 112 | 109 | 92 | 136 | 136 | 114 | 116 | 525 | 522 | 304 | 369 | 130 | 129 | 110 | 114 | 115 | 92 | 36 | 28 |
| **443** | M | 189 | 176 | 183 | | 147 | 125 | 112 | 103 | | | 116 | 121 | 551 | 541 | 320 | 380 | 129 | 123 | 128 | 114 | 112 | 102 | | |

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| **447** | M | 185 | 173 | 184 | 109 | 134 | 121 | 104 | 98 | 128 | 129 | 112 | 113 | 526 | 514 | 290 | 377 | 140 | 127 | 110 | 120 | 114 | 92 | 32 | 29 |
| **458** | F | | | | 101 | 146 | 129 | 110 | 104 | 130 | 131 | 111 | 114 | | | 297 | | | 126 | 112 | 108 | 111 | 92 | 33 | 30 |
| **460** | M | 185 | 170 | 178 | | 145 | | 111 | | | | | | | | | 354 | 117 | 120 | 117 | 106 | 111 | 92 | | |
| **467** | M | 186 | 174 | 180 | | 145 | 122 | 115 | 100 | | | 104 | 109 | 536 | 529 | 293 | 366 | 134 | 120 | 112 | 117 | 107 | 90 | | |
| **479** | M | 190 | 180 | 188 | 102 | 148 | 118 | 107 | 98 | 128 | 133 | 113 | 117 | 548 | 539 | 317 | 376 | 131 | 130 | 115 | 116 | 117 | 97 | 39 | |
| **481** | M | 167 | 157 | 163 | 88 | 147 | 125 | 112 | 105 | 120 | 120 | 111 | 112 | 508 | 504 | 307 | 350 | 125 | 117 | 108 | 111 | 103 | 89 | 40 | 31 |
| **483** | M | 186 | 177 | 173 | 102 | 136 | 125 | 113 | 101 | 127 | | 108 | | 524 | 522 | 291 | 370 | 124 | 110 | 136 | 107 | 104 | 102 | 29 | 28 |
| **484** | M | 193 | 183 | 180 | | 143 | 123 | 116 | 107 | | | 112 | | 550 | 544 | 311 | 387 | 133 | 120 | 134 | 115 | 110 | 102 | | |
| **487** | F | 181 | 161 | 177 | 92 | 136 | 120 | 110 | 98 | 122 | 122 | 105 | 108 | 517 | 509 | 282 | 362 | 129 | 126 | 107 | 113 | 112 | 88 | 33 | 27 |
| **513** | M | 181 | 167 | 172 | 99 | 144 | 129 | 110 | 100 | 131 | 131 | 114 | 114 | 520 | 513 | 307 | 379 | 127 | 114 | 138 | 112 | 104 | 108 | 32 | 27 |
| **515** | M | 182 | 172 | 175 | 99 | 136 | 126 | 113 | 98 | 129 | 129 | 112 | 114 | 513 | 507 | 301 | 367 | 133 | 116 | 118 | 116 | 103 | 93 | 34 | 29 |
| **522** | M | 196 | 180 | 196 | | 154 | 134 | 124 | 111 | | | 115 | | 566 | 557 | 315 | 395 | 137 | 137 | 121 | 119 | 125 | 97 | | |
| **524** | M | 189 | 165 | 175 | 90 | 134 | 112 | 102 | 88 | 119 | 158 | 106 | 106 | | | 288 | 363 | 122 | 122 | 119 | 108 | 111 | 92 | 33 | |
| **526** | F | 179 | 164 | 172 | | 135 | 116 | 107 | 94 | | | 117 | | | | 311 | 370 | 125 | 122 | 123 | 113 | 111 | 97 | | |
| **532** | M? | | | | | 152 | | 111 | | | | | | | | | | | 132 | 117 | | 112 | 93 | | |
| **536** | F | 191 | 168 | 188 | | 147 | 127 | 109 | 104 | | | 116 | 118 | 540 | 544 | 315 | 394 | 142 | 137 | 115 | 118 | 119 | 93 | | |
| **537** | M | 178 | 166 | 174 | 98 | 142 | 118 | 106 | 98 | | | | | 515 | 512 | | | | | 116 | | | 92 | 34 | 27 |
| **538** | M | 187 | 173 | 180 | 111 | 146 | | 108 | | 138 | | | | 534 | 525 | | 377 | 131 | 123 | 123 | 115 | 110 | 100 | 32 | 28 |
| **545** | F | 174 | 159 | 165 | 92 | 149 | 118 | 120 | 103 | 126 | 126 | 108 | 111 | 515 | 514 | 302 | 359 | 124 | 124 | 111 | 107 | 110 | 91 | 33 | 29 |
| **548** | M | 182 | 161 | | | 154 | 124 | 121 | 107 | | | 105 | 112 | 541 | 533 | 293 | 371 | 125 | | | 109 | | | | |
| **555** | F | 183 | 171 | 180 | 98 | 143 | 127 | 112 | 106 | 135 | 136 | 116 | 121 | 527 | 526 | 310 | 385 | 134 | 133 | 118 | 118 | 114 | 99 | 33 | 28 |
| **559** | M | 177 | 166 | 174 | 92 | 146 | 118 | 114 | 98 | 120 | | | | 515 | 505 | 290 | | | 142 | 116 | | 121 | 95 | 32 | 26 |
| **560** | M? | 196 | 175 | 186 | | 148 | 122 | 119 | 106 | | | 113 | 119 | 557 | 555 | 315 | 397 | 134 | 142 | 119 | 117 | 119 | 99 | | |
| **566** | M | 178 | 171 | 172 | | 155 | 131 | 119 | 113 | | | 113 | 118 | 539 | 534 | 317 | 377 | 130 | 122 | 125 | 111 | 106 | 98 | | |
| **569** | M | 179 | 162 | 172 | | 147 | 129 | 112 | 102 | | | 109 | | 522 | 519 | 296 | 376 | 130 | 125 | 121 | 112 | 114 | 98 | | |
| **570** | M? | 175 | 153 | 171 | | 140 | 116 | 112 | 97 | | | 106 | | 519 | 512 | 310 | 362 | 123 | 114 | 125 | 105 | 104 | 104 | | |
| **572** | M | | | | | 146 | 126 | 111 | 109 | 134 | | | | | | 320 | | | 123 | 124 | | 112 | 99 | 33 | 30 |
| **576** | F | 178 | 158 | 172 | 95 | 145 | 116 | 116 | 99 | 127 | 126 | 114 | 115 | 518 | 514 | 311 | 378 | 126 | 125 | 127 | 111 | 113 | 103 | 31 | 28 |
| **578** | M | 175 | 162 | 171 | 98 | 158 | 127 | 112 | 103 | 129 | 129 | 116 | 116 | 535 | 531 | 332 | 365 | 126 | 122 | 117 | 107 | 110 | 93 | 33 | 28 |
| **585** | M | 185 | 171 | 183 | 100 | 149 | 130 | 118 | 111 | 140 | 140 | 117 | 123 | 550 | 534 | 321 | 377 | 128 | 128 | 121 | 114 | 114 | 106 | 40 | 35 |

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| **587** | F | 185 | 163 | 175 | 101 | 150 | 130 | 115 | 103 | 136 | | 116 | | | 533 | 320 | 380 | 132 | 136 | 112 | 114 | 120 | 93 | 33 | 29 |
| **589** | M | 182 | 164 | 178 | | 150 | 132 | 122 | 114 | | | 115 | 119 | 545 | 532 | 311 | 381 | 124 | 138 | 119 | 110 | 122 | 96 | | |
| **592** | M | 183 | 171 | 180 | 95 | 159 | | 116 | | 121 | | | | 550 | 545 | | 381 | 121 | 136 | 124 | 108 | 119 | 98 | 36 | 32 |
| **596** | M | 187 | 171 | 180 | 94 | 144 | 125 | 108 | 104 | 126 | 127 | 113 | 117 | 528 | | 302 | 374 | 126 | 133 | 115 | 113 | 117 | 92 | 34 | 31 |
| **597** | M | 180 | 165 | 177 | 89 | 153 | 141 | 125 | 119 | 137 | | 118 | | | 531 | 323 | 383 | 134 | 140 | 109 | 116 | 121 | 94 | 39 | 33 |
| **598** | M | 178 | 165 | 174 | 92 | 140 | 117 | 103 | 96 | 125 | 126 | 110 | 116 | | | 296 | 373 | 124 | 121 | 128 | 107 | 107 | 100 | 33 | |
| **599** | F? | 179 | 162 | 172 | | 151 | 135 | 119 | 108 | | | 109 | 113 | 526 | 516 | 300 | 366 | 124 | 130 | 112 | 111 | 113 | 91 | | |
| **605** | F | 173 | 159 | 166 | 93 | 143 | 124 | 107 | 103 | 127 | | 109 | | 512 | 507 | 299 | 359 | 130 | 117 | 112 | 111 | 109 | 95 | 34 | 32 |
| **608** | M | 189 | | 182 | 100 | 144 | | 117 | 100 | 134 | | 122 | | 537 | 534 | 317 | 387 | 131 | 134 | 122 | 114 | 121 | 95 | 33 | 27 |
| **615** | F | 187 | 166 | 180 | 100 | | | 105 | | 120 | | | | | | | 372 | 132 | 124 | 116 | 112 | 111 | 92 | 35 | 28 |
| **616** | M | 194 | 181 | 186 | 107 | 141 | 127 | 116 | 100 | 138 | 140 | 120 | 122 | 542 | 531 | 310 | 394 | 131 | 137 | 126 | 115 | 123 | 104 | 34 | 33 |
| **617** | M | 186 | 176 | 180 | 95 | 149 | 133 | 118 | 110 | 136 | 136 | 120 | 122 | 542 | 539 | 323 | 395 | 133 | 138 | 124 | 116 | 121 | 97 | 34 | 30 |
| **622** | F | 175 | 161 | 169 | 93 | 137 | 117 | 105 | 97 | 119 | | 105 | 107 | 499 | 499 | 290 | 353 | 122 | 118 | 113 | 107 | 106 | 93 | 31 | |
| **632** | F | 190 | 175 | 180 | 95 | 149 | 123 | 108 | 104 | 121 | | 106 | | | 544 | 308 | 387 | 132 | 122 | 133 | 109 | 110 | 101 | 33 | 29 |
| **639** | M | 195 | 183 | 189 | | 153 | 128 | 114 | 113 | | | 117 | 119 | 556 | 551 | 320 | 407 | 146 | 138 | 123 | 124 | 123 | 100 | | |
| **643** | M? | | | | | 144 | 114 | 103 | 92 | 122 | | | | | | 308 | | | 129 | 111 | | 113 | 94 | 40 | 27 |
| **649** | M | 182 | 173 | 174 | 104 | 149 | 126 | 114 | 111 | 138 | | 113 | | 537 | 529 | 310 | 368 | 115 | 135 | 118 | 102 | 119 | 101 | 37 | 33 |
| **658** | M | 197 | 177 | 190 | 107 | 148 | 128 | 113 | 110 | 144 | 146 | 122 | 126 | 554 | 551 | 324 | 402 | 133 | 141 | 128 | 107 | 126 | 116 | 37 | 31 |
| **663** | F | 183 | 167 | 177 | | 144 | 119 | 106 | | | | 115 | 118 | 529 | 518 | 306 | 366 | 129 | 120 | 117 | 116 | 108 | 97 | | |
| **675** | F | 194 | 187 | 189 | 96 | 131 | 110 | 99 | 101 | 121 | 121 | 109 | 109 | 528 | 522 | 290 | 384 | 131 | 143 | 110 | 112 | 129 | 87 | 35 | |
| **678** | F | 182 | 180 | 176 | | 144 | 123 | 110 | 101 | | | 105 | 108 | 528 | 519 | 292 | 356 | 120 | 125 | 116 | 108 | 113 | 95 | | |
| **679** | F | 180 | 164 | 177 | 92 | 140 | 119 | 101 | 95 | 128 | 128 | 109 | 110 | 518 | 518 | 298 | 370 | 137 | 127 | 116 | 115 | 111 | 88 | 30 | 25 |
| **685** | F | 170 | 156 | 164 | 96 | 140 | 119 | 109 | 98 | 127 | 125 | 111 | 111 | 501 | 497 | 301 | 350 | 123 | 117 | 110 | 107 | 106 | 91 | 31 | 29 |
| **688** | M | 179 | 177 | 172 | 95 | 146 | 130 | 111 | 106 | 127 | 126 | 114 | 116 | 528 | 524 | 315 | 377 | 135 | 132 | 110 | 113 | 116 | 90 | 35 | 31 |
| **691** | M | 194 | 174 | 186 | 112 | 145 | 126 | 110 | 107 | 138 | 140 | 113 | 116 | 543 | 542 | 309 | 376 | 123 | 131 | 122 | 109 | 119 | 102 | 36 | 27 |
| **696** | M | 184 | 176 | 179 | 96 | 149 | 123 | 111 | 107 | 142 | 141 | 121 | 122 | 531 | 532 | 326 | 389 | 139 | 135 | 115 | 116 | 119 | 95 | 34 | 32 |
| **697** | M | 176 | 162 | 171 | | 148 | 130 | 115 | 102 | | | 114 | 115 | | | 309 | 360 | 127 | 123 | 110 | 112 | 112 | 90 | | |
| **698** | M | 181 | 173 | 174 | 103 | 141 | 116 | 108 | 101 | 138 | 142 | 112 | 118 | 520 | 511 | 298 | 364 | 121 | 123 | 120 | 109 | 109 | 98 | 36 | 32 |
| **700** | M | 184 | 170 | | 100 | 151 | 133 | 120 | 111 | 134 | | 113 | | | 536 | 316 | 380 | 123 | | | 107 | | | 31 | 29 |
| **702** | M | 191 | 187 | 181 | 109 | 142 | 126 | 119 | 107 | 139 | 139 | 119 | 121 | 546 | 526 | 308 | 373 | 131 | 122 | 120 | 117 | 111 | 104 | 37 | 34 |

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| **705** | M | 181 | 162 | 173 | 94 | 137 | 121 | 107 | 102 | 124 | 125 | 111 | 112 | 508 | 509 | 297 | 361 | 126 | 118 | 117 | 110 | 109 | 93 | 35 | 32 |
| **711** | M | 176 | 167 | 167 | 104 | 135 | 127 | 112 | 109 | 137 | 138 | 112 | 114 | 508 | 497 | 290 | 350 | 111 | 124 | 115 | 103 | 113 | 95 | 37 | 32 |
| **713** | M | 195 | 183 | 191 | 98 | 143 | 129 | 109 | | 141 | | 121 | | 551 | 549 | 317 | 407 | 142 | 140 | 125 | 122 | 126 | 101 | 33 | 29 |
| **721** | F | 185 | 172 | 181 | 97 | 133 | 122 | 112 | 103 | 131 | 132 | 110 | 112 | 522 | 516 | 287 | 375 | 129 | 124 | 122 | 111 | 116 | 97 | 34 | 28 |
| **725** | M | 190 | 170 | 182 | | 146 | 118 | 107 | 101 | | | 119 | 119 | 538 | 540 | 324 | 399 | 138 | 139 | 122 | 118 | 127 | 98 | | 29 |
| **733** | M | 180 | | 176 | | 148 | 128 | 120 | 112 | | | 115 | 117 | 532 | 523 | 317 | 368 | 127 | 124 | 117 | 114 | 110 | 99 | | |
| **737** | M | 189 | 180 | 186 | | 140 | 116 | 115 | 100 | | | 121 | 119 | 543 | 541 | 328 | 396 | 140 | 142 | 114 | 119 | 126 | 94 | | |
| **739** | M | 197 | 182 | 188 | | 140 | 114 | 109 | 95 | | | 118 | 123 | 540 | 542 | 312 | 398 | 135 | 130 | 133 | 119 | 116 | 104 | | |
| **740** | M? | 193 | 172 | 186 | | 143 | 126 | 114 | 104 | | | 108 | | 552 | 544 | 301 | 381 | 126 | 131 | 124 | 109 | 118 | 95 | | |
| **744** | M | 196 | 180 | 186 | | 153 | 120 | 116 | 92 | | | 119 | 122 | 562 | 560 | 332 | 402 | 141 | 126 | 135 | 121 | 113 | 96 | | |
| **752** | F | 181 | 167 | 176 | 93 | 144 | 116 | 115 | 99 | 125 | 124 | 106 | 113 | 519 | 514 | 294 | 371 | 128 | 128 | 115 | 112 | 114 | 94 | 34 | 28 |
| **755** | M | 183 | 173 | 176 | | 144 | 118 | 110 | 90 | | | 111 | | 531 | 520 | 306 | 373 | 128 | 122 | 123 | 114 | 108 | 102 | | |
| **756** | M | | | | | 153 | 137 | 125 | 120 | | | 122 | 123 | | | 321 | | | 124 | 120 | | 110 | 97 | | |
| **762** | M | 178 | 178 | 174 | | 147 | 126 | 115 | 104 | | | 119 | 119 | 535 | 530 | 327 | 366 | 129 | 128 | 109 | 114 | 114 | 87 | | |
| **775** | M | 182 | 165 | 180 | 100 | 139 | 117 | 102 | 95 | 131 | 131 | 114 | 116 | 521 | 510 | 306 | 360 | 125 | 130 | 105 | 113 | 116 | 89 | 38 | 30 |
| **778** | M? | 172 | 157 | 163 | 95 | 140 | 115 | 114 | 99 | 131 | 131 | 111 | 114 | 502 | 498 | 296 | 354 | 118 | 121 | 115 | 106 | 109 | 93 | 35 | 27 |
| **797** | M | 179 | 170 | 173 | 95 | 161 | 135 | 119 | 116 | 135 | 133 | 124 | 124 | 542 | 540 | 343 | 386 | 135 | 131 | 120 | 117 | 117 | 95 | 34 | 31 |
| **798** | F | 177 | 162 | 171 | 102 | 138 | 118 | 99 | 103 | 141 | 142 | 114 | 115 | 509 | 508 | 306 | 363 | 126 | 121 | 116 | 113 | 109 | 96 | 36 | |

## 1.2 FACIAL SKULL, 1.3 ORBITAL SKELETON, 1.4 NASAL SKELETON AND 1.5 MAXILLARY SKELETON

| SKELETON | SEX | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.2.5 | 1.2.6 | 1.2.7 | 1.2.8 | 1.3.1 | 1.3.2 | 1.3.3 | 1.3.4 | 1.3.5 | 1.4.1 | 1.4.2 | 1.4.3 | 1.4.4 | 1.5.1 | 1.5.2 | 1.5.3 | 1.5.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **50** | M | 93 | 92 | 130 | 97 | | 91 | 104 | 67 | 91 | 23 | 21 | 36 | 31 | 23 | 54 | 91 | 100 | 57 | 63 | | 45 |
| **53** | M | 98 | 101 | 131 | 108 | 135 | 90 | 118 | 72 | 98 | 22 | 21 | 41 | 39 | 24 | 55 | 97 | 116 | 52 | 58 | 44 | 41 |
| **67** | F | | | | | | | | | | | | | | | | | | | | | |
| **82** | M | 99 | 103 | 130 | 110 | 137 | 100 | 112 | 69 | 101 | 27 | 25 | 41 | 32 | 24 | 49 | 101 | 115 | 56 | | 47 | |
| **83** | M | 102 | 104 | 120 | 107 | | 92 | 115 | 71 | 100 | 21 | 20 | 44 | 35 | 24 | 52 | 100 | 117 | 53 | 57 | | 35 |
| **84** | F | 95 | 96 | 120 | 102 | 127 | 90 | 119 | 73 | 95 | 25 | 21 | 40 | 34 | 22 | 54 | 94 | 111 | 53 | | 43 | |
| **86** | M | | 102 | 121 | 105 | 125 | 86 | 110 | | 96 | | | 42 | 35 | | | 96 | 114 | | | | |
| **90** | M | | | | | | | | | | | | | 34 | 23 | | | | | | | |
| **93** | F | 90 | 90 | 116 | 98 | 123 | 90 | 101 | 63 | 93 | 19 | 15 | 42 | 36 | 23 | 54 | 93 | 104 | | | | |
| **94** | M | | 95 | 125 | 102 | | | | | | | | | | | | | | | | | |
| **95** | F | | 88 | 117 | 97 | | 91 | 101 | 62 | | 21 | 21 | 39 | 32 | 23 | 48 | | | 47 | 58 | | 40 |
| **96** | F | | 102 | 129 | 102 | | 91 | 107 | 69 | 95 | 24 | 21 | 40 | 32 | 25 | 52 | 96 | 108 | | | | |
| **103** | M | | | | | | | | | | | | | | | | | | | | | |
| **110** | M | | 97 | 115 | 103 | | | | 62 | | 21 | 19 | 41 | 34 | 30 | 51 | | | | 55 | | 36 |
| **112** | M | 92 | 99 | 125 | 107 | 124 | 102 | 99 | 66 | 100 | 24 | 22 | 41 | 33 | 23 | 47 | 100 | 112 | 57 | | 44 | |
| **114** | M | | 103 | 125 | 111 | | 83 | | | 102 | | | | 32 | | | | | | | | |
| **119** | M | | 101 | 124 | 108 | | 71 | | | 99 | | | 43 | 30 | | | | | | | | |
| **121** | M | 95 | 96 | 121 | 106 | 134 | 103 | | 69 | 99 | 25 | 22 | 43 | 36 | 30 | 56 | 100 | 114 | | | | |
| **122** | M | | 99 | 126 | 106 | | | | | | | | | | | | | | | | | |
| **123** | M | | | 130 | | | | | | | | | | | | | | | | | | |
| **125** | M | | | | | | | | | | | | | | | | | | | | | |
| **131** | M | 86 | | | | | 104 | 120 | 71 | | | | | | 25 | 56 | | | | | 40 | |
| **132** | F | | 97 | 116 | 103 | | | 108 | | | | | | | | | | | | 61 | | 39 |
| **134** | F | | | | | | | | | | | | | | | | | | | | | |
| **140** | M | | | | | | | | | | | | | | | | | | | | | |
| **142** | F | | | 126 | | | | | | | | | | | | | | | | | | |

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| **155** | M | 89 | 98 | 120 | 150 | | 97 | 122 | 75 | 100 | 126 | | | 35 | | 55 | 100 | 112 | 54 | 61 | | 39 |
| **156** | M | | 103 | 126 | 105 | | | | | | 23 | 21 | 39 | | | | | | | | | |
| **166** | F | 97 | 101 | 129 | 106 | 132 | 93 | 116 | 74 | 98 | 27 | 25 | 41 | 34 | 26 | 55 | 97 | 113 | | | | |
| **169** | M | 97 | 102 | 131 | 111 | 136 | 99 | 114 | 69 | 103 | 22 | 20 | 44 | 33 | 28 | 48 | 105 | 114 | 57 | 63 | 46 | 40 |
| **171** | M? | | | | | | | | | | | | | | | | | | | | | |
| **173** | F? | 88 | | | | | | | | | | | | | | | | | 53 | 61 | | 41 |
| **174** | M | 96 | 99 | 129 | 106 | | 89 | | 69 | | | 21 | 42 | 37 | 25 | 49 | | | | | | |
| **176** | M | 96 | 98 | 128 | 106 | | | 117 | 73 | | | | 42 | 34 | 27 | 54 | | | 53 | | 43 | |
| **187** | M? | | | 132 | | | | | | | | | | | | | | | | | | |
| **189** | M | | 95 | 120 | 102 | | 89 | | 65 | 97 | 25 | 22 | 40 | 33 | 26 | 50 | 97 | 110 | 51 | 58 | 40 | 39 |
| **209** | M | | 100 | 125 | 106 | | 90 | | | | | | | | | | | | 55 | 61 | | 38 |
| **219** | M | | 99 | 120 | 104 | | 85 | | 61 | 99 | 24 | 23 | 42 | 32 | 22 | 47 | 99 | 112 | | | | |
| **227** | M | | 103 | 124 | 107 | | 98 | 112 | | 99 | 25 | 24 | 40 | 34 | 23 | 48 | 100 | 112 | | 61 | | 39 |
| **230** | M | | 101 | 126 | 108 | | 94 | 118 | | 99 | | | | 32 | | 49 | 100 | | | 62 | | |
| **246** | M | | 91 | 114 | 100 | | | | | | | | | | | | | | | | | |
| **268** | F | | 101 | 121 | 107 | | 90 | 104 | 66 | 98 | 21 | 19 | 42 | 36 | 23 | 49 | 99 | 113 | 53 | | | |
| **286** | M | | 106 | 130 | 108 | | 87 | | | 102 | | | | | | | 101 | | | | | |
| **288** | M | | 113 | 146 | 117 | | | 118 | 73 | | | | 39 | 35 | 27 | 53 | | | | | | |
| **292** | M | | 107 | 132 | 112 | 152 | 108 | | | 106 | | | | 38 | | | | | | | | |
| **293** | F? | | 97 | 122 | 106 | | | 113 | | 100 | 19 | 18 | 43 | 35 | 25 | | 100 | 111 | | | | |
| **295** | M | 84 | 98 | 127 | 105 | | 93 | 115 | 70 | 98 | 27 | 24 | 38 | 29 | 25 | 54 | 98 | 108 | 51 | 63 | 42 | 41 |
| **297** | M | | 102 | 130 | 103 | | | | | | | | | | | | | | | | | |
| **298** | M | | 109 | 136 | 110 | | | | | | | | | 34 | | | | | | | | |
| **303** | M | | 98 | 125 | 107 | | 95 | | 72 | 102 | 26 | 24 | 41 | 35 | 25 | 49 | 102 | | 57 | | 43 | |
| **305** | M | | 99 | 121 | 106 | | | | | | | | | | | | | | | | | |
| **306** | F | | 92 | 117 | 97 | | 86 | 100 | 59 | 93 | | 22 | 37 | 30 | 23 | 44 | 94 | 101 | | | | |
| **309** | F | 89 | | | | | 86 | | 69 | | 21 | 18 | 38 | 33 | 21 | 51 | | | 50 | 58 | 40 | 38 |
| **310** | M | | 103 | 132 | 109 | | | | | | | 30 | 37 | | | | | | | | 44 | |
| **313** | F | | 105 | 123 | 109 | | 85 | 102 | | 103 | | | 43 | 39 | | | 102 | 123 | | | | |
| **318** | M | | 94 | 121 | 100 | 131 | 81 | 106 | | 93 | | | | 30 | | 44 | 93 | | | | | |

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| **324** | F | 88 | 95 | 121 | 100 | 124 | 83 | 122 | 72 | | | | | 36 | 26 | 50 | | | | | 39 | |
| **325** | F | | 100 | 127 | 106 | | 92 | 109 | | 97 | | | 37 | 34 | | | | | | | | |
| **336** | M | 94 | 101 | 126 | 108 | 134 | 91 | 104 | 64 | 101 | | 22 | 42 | 30 | 24 | 45 | 100 | 113 | 50 | | | |
| **337** | F | 95 | 96 | | 102 | | 83 | 110 | 65 | 93 | | 21 | 37 | 31 | | 43 | 93 | | | | | |
| **340** | M | | 93 | 115 | 101 | | | | | | | | 45 | 37 | | | | | | | 41 | |
| **342** | M | | 104 | 126 | 107 | | 92 | | | 97 | | | | 33 | | | 96 | | | | | |
| **346** | M | | 106 | 126 | 115 | 133 | 88 | | | 105 | | | | 31 | | | | | | | | |
| **352** | M | | 103 | 131 | 110 | | | | | | 35 | 32 | 39 | 35 | | | | | | | | |
| **354** | M | | 98 | 121 | 106 | | 101 | 120 | 70 | 97 | 28 | 26 | 38 | 35 | 26 | 50 | 96 | 107 | 54 | 63 | 43 | 40 |
| **366** | F | 85 | 92 | 125 | 98 | | 94 | 116 | 69 | 93 | 19 | 17 | 40 | 37 | 23 | 53 | 93 | 105 | 48 | 62 | 41 | 41 |
| **371** | M? | 92 | 96 | 124 | 106 | | 95 | | 63 | 98 | | 20 | 42 | 31 | 23 | 46 | 98 | 114 | 52 | 58 | | 38 |
| **372** | M | | | | | | | | | | | | | | | | | | | | 44 | |
| **375** | M? | 103 | 108 | 127 | 113 | 139 | 98 | 107 | 66 | 103 | 29 | 25 | 42 | 31 | 28 | 47 | 104 | 120 | 59 | | 50 | |
| **380** | M | | 94 | 115 | 101 | | 99 | | | 96 | | | 40 | 32 | | | 96 | 106 | | | | |
| **381** | F | | 98 | | 101 | | | | | 88 | | | | 30 | | | | | | | | |
| **382** | F | | 94 | 120 | 102 | | 90 | 106 | 66 | 98 | | | 41 | 34 | 25 | 51 | 99 | | | 60 | | 43 |
| **391** | F | 88 | 103 | 117 | 111 | | | | | | 27 | 24 | 42 | 36 | 28 | 52 | | | | | | |
| **392** | F? | 95 | 88 | 118 | 99 | | 94 | 101 | 64 | 91 | | | 36 | 32 | 23 | 48 | 92 | | | | | |
| **395** | F | 91 | 89 | 115 | 99 | | 87 | | 64 | 95 | | | | 34 | 24 | 48 | 95 | | | | | |
| **408** | M | | 104 | 124 | 110 | | | | | | | | | 34 | | | | | | | | |
| **419** | M | | 91 | 115 | 106 | | 93 | | | 103 | | | | 35 | | 56 | 102 | | | | | |
| **423** | M | | 108 | 133 | 116 | | | | | | | | | | | | | | | | | |
| **432** | M? | | | 126 | | | | | | | | | | 38 | | | | | | | | |
| **428** | F | | 95 | | 104 | | | | | | | | | | | | | | | | | |
| **435** | M | | | | | | | | | | | | 43 | 35 | | | | | | 66 | | 44 |
| **436** | M | 95 | 100 | 123 | 103 | | 87 | 108 | 68 | 94 | 22 | 23 | 40 | 34 | 25 | 53 | 94 | 115 | | | | |
| **443** | M | | 105 | 126 | 111 | 139 | 90 | | | 104 | 28 | 26 | 43 | 36 | | | 105 | 116 | | | | |
| **447** | M | 95 | 100 | 116 | 107 | 127 | 92 | 119 | 72 | 101 | | | | 37 | | 50 | 102 | | | | | |
| **458** | F | 96 | | | | 135 | 92 | 111 | 71 | 98 | 24 | 24 | 41 | 34 | 26 | 52 | 98 | 111 | 53 | 66 | 42 | 43 |
| **460** | M | | 100 | 119 | 108 | | | | 72 | | | | | 38 | 27 | 53 | | | | | 41 | |

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| **467** | M | | 99 | 125 | 106 | | | | | | | | | 35 | | | | | | | | |
| **479** | M | 93 | 94 | 125 | 103 | | 92 | 126 | 77 | 93 | 19 | 19 | 41 | 39 | 23 | 54 | 94 | 105 | 55 | 63 | 44 | 41 |
| **481** | M | | 102 | 126 | 108 | | 101 | | | 102 | 26 | 25 | 41 | 31 | | | 102 | 115 | | | | |
| **483** | M | | 97 | | 101 | | | | | | | | | | | | | | 46 | | 40 | |
| **484** | M | | 103 | 125 | 112 | | | | | | | | | | | | | | | | | |
| **487** | F | 90 | 104 | 122 | 109 | 124 | 94 | 108 | 67 | 100 | 24 | 22 | 43 | 35 | 25 | 49 | 100 | 114 | 51 | 60 | 41 | 38 |
| **513** | M | 95 | 101 | 120 | 107 | | 98 | 105 | 62 | 103 | 27 | 26 | 41 | 31 | 27 | 45 | 102 | 114 | 55 | 65 | 45 | |
| **515** | M | 91 | 99 | 118 | 104 | | 81 | 116 | 70 | 98 | | | 42 | 37 | 25 | 53 | 97 | 115 | 51 | 61 | 41 | 42 |
| **522** | M | | 109 | 136 | 110 | 144 | | | | | | | | 32 | 24 | | | | | | | |
| **524** | M | 95 | | | | | 95 | 110 | 68 | 96 | 23 | 23 | 39 | 36 | 22 | 46 | 96 | 107 | | 63 | 44 | 44 |
| **526** | F | | | 121 | | | | | | | | | | | | | | | | | | |
| **532** | M? | | 98 | | 105 | | | | | | | | | | | | | | | | | |
| **536** | F | | 104 | 137 | 104 | | 89 | | 64 | 99 | | | 41 | 33 | 25 | 42 | 99 | | | | 40 | |
| **537** | M | 95 | 95 | | 101 | | 85 | 107 | 64 | 92 | 20 | 18 | 39 | 32 | 23 | 48 | 92 | 103 | 51 | | 40 | |
| **538** | M | 85 | 98 | 120 | 103 | | 95 | 126 | 75 | 95 | 22 | 20 | 41 | 35 | 23 | 54 | 96 | | 52 | | | |
| **545** | F | 87 | 95 | 123 | 101 | | 82 | | 58 | 92 | | 21 | 38 | 32 | | 43 | 93 | 99 | 48 | 57 | | 38 |
| **548** | M | | 104 | 126 | 111 | | 90 | 112 | 65 | 102 | | | 43 | 36 | 25 | | 102 | | | 55 | | 36 |
| **555** | F | | 103 | 126 | 107 | | 90 | 114 | | 100 | | 22 | 42 | 35 | 24 | 49 | 100 | 114 | | | | 39 |
| **559** | M | | 89 | | 97 | | | | | | | | | | | | | | | | | |
| **560** | M? | | 99 | 128 | 104 | | | | | | | | 42 | 39 | | 51 | | | | | | |
| **566** | M | | 95 | 128 | 105 | | 90 | 118 | | 98 | 20 | 19 | 42 | 39 | 24 | 54 | 98 | | | | 46 | |
| **569** | M | | 97 | 126 | 103 | | | | | | | | | | | | | | | | | |
| **570** | M? | | 100 | | 102 | | | | | | | | | | | | | | | | | |
| **572** | M | | | | | | | | | | | | | | | | | | | | | |
| **576** | F | 92 | 96 | 115 | 100 | 125 | 85 | | 66 | 93 | 26 | 23 | 37 | 31 | | 50 | 94 | 104 | | | 43 | |
| **578** | M | 93 | 106 | 141 | 108 | 137 | 100 | 113 | 66 | 102 | 27 | 26 | 42 | 33 | | 48 | 102 | 118 | 53 | 63 | 46 | 42 |
| **585** | M | 87 | 102 | 125 | 115 | | 99 | | 78 | 104 | | | 46 | 37 | | 57 | 105 | | | | 44 | |
| **587** | F | | | 133 | | | | | | | | | | | | | | | | | | |
| **589** | M | | 98 | 123 | 106 | 140 | 92 | 109 | 62 | 99 | | 19 | 42 | 29 | 23 | 46 | 99 | 114 | | | 40 | |
| **592** | M | | 101 | 130 | 108 | | | | | | | 27 | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **596** | M | 89 | | | 104 | 132 | 90 | 117 | 71 | 99 | 29 | 25 | 41 | 37 | 24 | 50 | 100 | 114 | 49 | 61 | 40 | 42 |
| **597** | M | 90 | | 130 | | | | 126 | 74 | | | | | 30 | | 55 | | | 54 | | 46 | |
| **598** | M | | | 113 | | | 96 | | | 97 | | | | | | | | | | | | |
| **599** | F? | | 96 | 114 | 103 | | 94 | | 68 | 99 | 22 | 18 | 43 | 33 | 25 | 51 | 98 | 112 | | | 41 | |
| **605** | F | | 95 | | 103 | | | | | | | | 40 | 32 | | | | | | | | |
| **608** | M | | | 125 | 103 | | | | | | | | | | | | | | | | | |
| **615** | F | 92 | | | 100 | | | | 64 | | | 21 | 43 | 38 | 23 | 49 | | | | | | |
| **616** | M | 104 | 101 | 121 | 109 | 138 | 99 | 115 | 70 | 102 | 26 | 23 | 42 | 32 | 27 | 50 | 102 | 118 | 56 | | 45 | 46 |
| **617** | M | 95 | 101 | 129 | 110 | | 98 | 132 | 72 | 104 | 26 | 21 | 43 | 33 | 26 | 53 | 103 | 114 | 58 | 71 | 45 | 44 |
| **622** | F | | 90 | 116 | 94 | | 83 | 108 | 66 | 88 | | | 38 | 37 | 21 | 50 | 88 | | | 58 | 36 | |
| **632** | F | | 102 | 131 | | | | | | | | | | | | | | | | | | |
| **639** | M | | 92 | | 103 | | 96 | | 75 | 97 | | 19 | 42 | 39 | | 53 | 97 | 114 | | | | |
| **643** | M? | | | | | | | | | | | | | | | | | | | | | |
| **649** | M | | 104 | 124 | 107 | | | | | | | | 42 | 32 | | | | | | | | |
| **658** | M | 101 | 98 | 126 | 104 | | 96 | 106 | 64 | 100 | 26 | 24 | 42 | 29 | 24 | 46 | 100 | 118 | | | | |
| **663** | F | | | 119 | 104 | | | | | | 25 | 21 | | 36 | | | | | | | | |
| **675** | F | 93 | 90 | 112 | 97 | | 87 | | 68 | 92 | 18 | 16 | 40 | 32 | 23 | 45 | 93 | 106 | | | 41 | |
| **678** | F | | 95 | 120 | 101 | | 94 | 121 | 77 | 94 | 18 | 17 | 42 | 36 | | 57 | 94 | 109 | 55 | 61 | | 40 |
| **679** | F | 91 | 105 | 121 | 108 | | 90 | 110 | 67 | 99 | 24 | 22 | 41 | 33 | 27 | 47 | 99 | 109 | | 56 | 44 | 38 |
| **685** | F | 92 | 96 | 119 | 104 | | 89 | 101 | 64 | 96 | | 20 | 39 | 33 | 25 | 46 | 96 | 107 | 49 | 60 | | 39 |
| **688** | M | | 108 | 127 | 113 | | 88 | | | 102 | | | 43 | 31 | | | 103 | 120 | | | | |
| **691** | M | 108 | 105 | 128 | 109 | 133 | 102 | 107 | 67 | 98 | | 26 | 40 | 32 | 27 | 52 | 98 | 116 | 56 | 67 | 47 | 43 |
| **696** | M | 82 | 100 | 135 | 102 | 128 | 90 | 102 | 63 | 94 | 20 | 18 | 41 | 32 | 24 | 49 | 95 | 106 | | | 37 | 51 |
| **697** | M | | | | | | 91 | 122 | 68 | | | 20 | 41 | 33 | 22 | 49 | | | | | | |
| **698** | M | 91 | 90 | 115 | 96 | 126 | 82 | | 74 | 89 | | | 36 | 37 | 24 | 54 | 90 | 97 | | | 42 | |
| **700** | M | | | 132 | | | 98 | | | | | | | | | | | | 54 | 69 | 42 | 44 |
| **702** | M | 109 | 94 | 117 | 106 | | 95 | 118 | 72 | 99 | 19 | 20 | 42 | 34 | 24 | 51 | 98 | 116 | 60 | 62 | | 39 |
| **705** | M | 86 | 98 | 124 | 101 | | 80 | 113 | 69 | 95 | 23 | 21 | 40 | 37 | 23 | 51 | 96 | 106 | 47 | | | 36 |
| **711** | M | 97 | 93 | 111 | 106 | 136 | 98 | 106 | 65 | 100 | 25 | 22 | 41 | 33 | 25 | 51 | 101 | 114 | 57 | | 48 | |
| **713** | M | | 103 | 125 | 106 | | | | | | | 26 | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **721** | F | 88 | 89 | 110 | 98 | | 90 | | 64 | 93 | 18 | 17 | 39 | 32 | | 49 | 93 | 103 | | | | |
| **725** | M | | 98 | 126 | 101 | 126 | 94 | | | 93 | 22 | 22 | 40 | 32 | 24 | 51 | 93 | 107 | | | | |
| **733** | M | | 101 | 131 | 107 | | 99 | | | 100 | 23 | 22 | 41 | 34 | | | 100 | 115 | | | 45 | |
| **737** | M | | 102 | 132 | 106 | | | | | | | | | 31 | | | | | | | | |
| **739** | M | | 94 | | 98 | 120 | 94 | 132 | 78 | 92 | 18 | 17 | 40 | 37 | 24 | 57 | 92 | 105 | 55 | 64 | 41 | 38 |
| **740** | M? | | 98 | 124 | 105 | | | | | | | | | | | | | | | | | |
| **744** | M | | 101 | 135 | 105 | | 95 | 124 | 73 | 100 | 22 | 20 | 43 | 38 | 24 | 54 | 100 | 114 | | | | |
| **752** | F | 87 | 88 | 110 | 96 | 119 | 89 | 112 | 71 | 91 | 20 | 19 | 39 | 35 | 24 | 51 | 91 | 102 | 52 | 55 | 40 | 38 |
| **755** | M | | 95 | 116 | 107 | | | | | | | | | | | | | | | | | |
| **756** | M | | 95 | 126 | 108 | | 102 | | | 101 | | | 45 | 31 | 24 | | 102 | 115 | 56 | | | 46 |
| **762** | M | | 107 | 131 | 109 | 133 | 97 | 110 | 66 | 100 | 23 | 22 | 41 | 32 | 24 | 56 | 100 | 113 | 52 | 64 | 45 | 41 |
| **775** | M | 97 | 97 | 116 | 106 | | 88 | 125 | 74 | 99 | 26 | 24 | 41 | 35 | | | 98 | 114 | 56 | 60 | | 38 |
| **778** | M? | 92 | 93 | 119 | 98 | 114 | 87 | | 59 | 91 | 20 | 19 | 38 | 31 | 21 | 44 | 91 | 102 | | | 39 | |
| **797** | M | 100 | 104 | 135 | 111 | | 101 | | 70 | 105 | | 23 | 43 | 31 | 24 | 53 | 104 | | | | | |
| **798** | F | | | | | | | | | | | | | | | | | | | | | |

# Linenhall

## 1.1 NEUROCRANIUM

| SKELETON | SEX | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.1.6 | 1.1.7 | 1.1.8 | 1.1.9 | 1.1.10 | 1.1.11 | 1.1.12 | 1.1.13 | 1.1.14 | 1.1.15 | 1.1.16 | 1.1.17 | 1.1.18 | 1.1.19 | 1.1.20 | 1.1.21 | 1.1.22 | 1.1.23 | 1.1.24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | M | 185 | 171 | 178 | | 144 | 129 | 120 | | | | 108 | 109 | 531 | 522 | 301 | | 130 | 126 | | 114 | 112 | | | |
| **2** | F | 176 | 156 | 170 | 86 | 144 | 117 | 111 | 98 | 121 | 123 | 109 | 113 | 512 | 510 | 311 | 371 | 126 | 126 | 119 | 107 | 113 | 94 | 30 | 29 |
| **3** | M | 164 | 150 | 162 | | | | | | | | | | 521 | 513 | | 383 | 129 | 130 | 124 | 109 | 116 | 102 | | |
| **4** | M | 173 | 159 | 165 | 100 | 142 | 125 | 113 | 104 | 134 | | 112 | 117 | 506 | 494 | | 350 | 101 | 130 | 119 | 93 | 115 | 102 | 35 | 28 |
| **6** | M | 186 | 177 | 178 | 95 | 133 | 122 | 108 | 101 | 133 | | 114 | | 520 | 518 | 306 | 380 | 130 | 132 | 118 | 110 | 118 | 97 | 36 | 29 |
| **10** | M | 188 | 177 | 182 | | | 124 | 115 | 113 | | | 115 | | 537 | 530 | 305 | 373 | 135 | 123 | 115 | 116 | 112 | 99 | | |
| **11** | M | 169 | 156 | 166 | | 141 | 117 | 115 | 97 | | | | | | 505 | 306 | 378 | 125 | 133 | 120 | 109 | 113 | 98 | | |
| **14** | M | 173 | 163 | 170 | 91 | 141 | 127 | 106 | | 129 | | 109 | | 511 | 501 | 300 | 362 | 128 | 122 | 112 | 113 | 107 | 94 | 34 | 29 |
| **18** | F | 154 | 144 | 154 | | | | 109 | | | | | | 477 | 464 | | 338 | 115 | 117 | 106 | 100 | 105 | 89 | | |
| **19** | F | 180 | 171 | 174 | 99 | 140 | 119 | 105 | 103 | 130 | 130 | 111 | 113 | 519 | 516 | 303 | 366 | 128 | 118 | 120 | 109 | 109 | 98 | 31 | 27 |

## 1.2 FACIAL SKULL, 1.3 ORBITAL SKELETON, 1.4 NASAL SKELETON AND 1.5 MAXILLARY SKELETON

| SKELETON | SEX | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.2.5 | 1.2.6 | 1.2.7 | 1.2.8 | 1.3.1 | 1.3.2 | 1.3.3 | 1.3.4 | 1.3.5 | 1.4.1 | 1.4.2 | 1.4.3 | 1.4.4 | 1.5.1 | 1.5.2 | 1.5.3 | 1.5.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | M | | 105 | 124 | 106 | | | | 57 | | 25 | 22 | 40 | 34 | 23 | 46 | | | | | | |
| **2** | F | 78 | 99 | 128 | 103 | | 87 | 104 | 60 | 97 | 24 | 22 | 41 | 36 | 23 | 48 | 97 | 108 | 48 | 58 | 40 | 37 |
| **3** | M | | 105 | 130 | 117 | | | | | | | | | | | | | | | | | |
| **4** | M | 98 | 98 | 113 | 102 | | 89 | 117 | 69 | 97 | 23 | 19 | 40 | 30 | 24 | 48 | 95 | 104 | 55 | 62 | 47 | 43 |
| **6** | M | | 90 | 113 | 96 | | | | | | | | | | | | | | | | | |
| **10** | M | | 95 | 120 | 100 | | 85 | | | 92 | 22 | 19 | 39 | 36 | | | 92 | 103 | 53 | 60 | | 41 |
| **11** | M | | | 125 | | | | | | | | | | | | | | | | | | |
| **14** | M | | 95 | 117 | 103 | | | | | 97 | | | 42 | 32 | | | 97 | | 56 | | 47 | 42 |
| **18** | F | | 95 | 110 | 105 | | | | | | | | | | | | | | | 59 | 43 | 38 |
| **19** | F | 95 | 103 | 125 | 105 | | 94 | 110 | 67 | 99 | 28 | 23 | 41 | 32 | 24 | 49 | 98 | 111 | 54 | 64 | 44 | 42 |

# St Gregory

## 1.1 NEUROCRANIUM

| SKELETON | SEX | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.1.6 | 1.1.7 | 1.1.8 | 1.1.9 | 1.1.10 | 1.1.11 | 1.1.12 | 1.1.13 | 1.1.14 | 1.1.15 | 1.1.16 | 1.1.17 | 1.1.18 | 1.1.19 | 1.1.20 | 1.1.21 | 1.1.22 | 1.1.23 | 1.1.24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NGA12** | M | 180 | 173 | 175 | 96 | 138 | 127 | 113 | 105 | 132 | | 112 | | 518 | 509 | 299 | 367 | 130 | 119 | 120 | 118 | 104 | 101 | 36 | 29 |
| **NGA48** | M | 173 | 156 | 173 | 95 | 142 | 124 | 108 | 107 | 135 | | 113 | | 513 | 509 | 306 | 371 | 136 | 130 | 105 | 118 | 114 | 92 | 35 | 31 |
| **NGA72** | M | 177 | 170 | 173 | 91 | 142 | 124 | 112 | 104 | 126 | | 108 | | 522 | 513 | 292 | 371 | 126 | 130 | 115 | 111 | 114 | 95 | 30 | 30 |
| **NGA74** | M | 179 | 172 | 168 | 101 | 147 | 131 | 112 | 103 | 135 | | 117 | | 526 | 527 | 316 | 369 | 130 | 130 | 109 | 112 | 116 | 90 | 33 | 31 |
| **NGA103** | M | 182 | 175 | 177 | 101 | 140 | 127 | 113 | 107 | 137 | | 113 | | 525 | 513 | 299 | 369 | 121 | 127 | 121 | 108 | 114 | 103 | 36 | 30 |
| **NGA118** | M | 181 | 173 | 183 | 97 | 138 | 115 | 101 | 98 | 129 | | 110 | | 526 | 516 | 302 | 373 | 128 | 124 | 121 | 114 | 113 | 100 | 34 | 28 |
| **NGA143** | F | 187 | 175 | 181 | 107 | 132 | 115 | 106 | 92 | 127 | | 106 | | 520 | 514 | 287 | 360 | 121 | 121 | 118 | 110 | 108 | 97 | 34 | 27 |
| **NGA148** | M | 186 | 172 | 180 | 103 | 139 | 126 | 111 | 110 | 132 | | 110 | | 526 | 516 | 294 | 368 | 124 | 122 | 122 | 112 | 113 | 95 | 35 | |
| **NGA153** | M? | 184 | 165 | 177 | 100 | 137 | 118 | 110 | 104 | 125 | | 108 | | 520 | 513 | 290 | 358 | 120 | 122 | 116 | 107 | 108 | 93 | 38 | 31 |
| **NGA158** | M | 178 | 169 | 168 | 102 | 137 | 118 | 110 | 99 | 129 | | 108 | | 506 | 504 | 289 | 354 | 112 | 126 | 116 | 101 | 111 | 98 | 37 | 34 |
| **NGA170** | F | 186 | 169 | 177 | 98 | 151 | 125 | 106 | 97 | 133 | | 115 | | 542 | 542 | 325 | 375 | 130 | 121 | 124 | 114 | 108 | 100 | 33 | 28 |
| **NGA188** | M | 180 | 170 | 168 | 94 | 131 | 122 | 100 | 112 | 133 | 134 | 107 | 108 | 504 | 501 | 279 | 360 | 125 | 122 | 113 | 110 | 111 | 90 | 40 | 32 |
| **NGA227** | M | 174 | 158 | 170 | 92 | 155 | 141 | 125 | 122 | 132 | | 115 | | 530 | 524 | 312 | 365 | 123 | 131 | 111 | 112 | 115 | 91 | 37 | 35 |
| **NGA229** | F | 179 | 153 | 173 | 92 | 132 | 118 | 104 | 97 | 120 | 120 | 101 | 107 | 507 | 507 | 278 | 357 | 121 | 123 | 113 | 101 | 111 | 93 | 34 | 30 |
| **NGA248** | M | 187 | 175 | 182 | 93 | 147 | 123 | 111 | 101 | 134 | | | | 542 | 541 | 324 | 392 | 130 | 144 | 118 | 112 | 128 | 97 | 36 | 28 |
| **NGA263** | F | 185 | 175 | 76 | 99 | 144 | 123 | 111 | 99 | 131 | 132 | 109 | 115 | 530 | 529 | 302 | 369 | 123 | 126 | 120 | 106 | 113 | 98 | 36 | 28 |
| **NGA295** | M | 185 | 175 | 178 | 100 | 136 | 123 | 108 | 102 | 130 | | 110 | | 521 | 512 | 294 | 366 | 125 | 130 | 111 | 111 | 117 | 89 | 34 | 31 |
| **NGA311** | M | 199 | 187 | 194 | 106 | 146 | 131 | 123 | 114 | 150 | | 129 | | 567 | 560 | 335 | 417 | 150 | 137 | 130 | 131 | 124 | 105 | 35 | 32 |
| **NGA331** | M? | 182 | 164 | 173 | 98 | 139 | 118 | 106 | 94 | 124 | | 108 | | 523 | 522 | 295 | 357 | 128 | 107 | 122 | 112 | 100 | 100 | 32 | 26 |
| **NGA341** | M | 188 | 165 | 180 | 93 | 141 | 125 | 108 | 102 | 126 | | 107 | | 538 | 530 | 301 | 377 | 130 | 125 | 122 | 112 | 113 | 100 | 36 | 30 |
| **NGA409** | M | 181 | 173 | 174 | 100 | 134 | 109 | 104 | 103 | 128 | | 106 | | 500 | 493 | 287 | 356 | 124 | 112 | 120 | 112 | 101 | 102 | 38 | 32 |
| **NGA410** | F | 176 | 159 | 173 | 91 | 135 | 123 | 103 | 97 | 125 | | 104 | | 517 | 511 | 282 | 360 | 120 | 125 | 115 | 106 | 109 | 100 | 34 | 28 |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NGA411** | F? | 174 | 164 | 166 | | 141 | 128 | 105 | 102 | | | 102 | | 510 | 508 | 295 | 352 | 121 | 117 | 114 | 107 | 106 | 94 | | |
| **NGA429** | F | 163 | 157 | 161 | | 130 | 118 | 104 | 99 | | | 108 | | 484 | 477 | 287 | 341 | 121 | 117 | 104 | 106 | 104 | 92 | | |
| **NGA444** | M | 179 | 167 | 171 | 101 | 138 | 126 | 108 | 100 | 136 | 136 | 115 | 115 | 510 | 502 | 303 | 358 | 128 | 122 | 108 | 113 | 110 | 93 | 35 | 29 |
| **NGA467** | M | 175 | 163 | 171 | 97 | 151 | 133 | 117 | 113 | 138 | | 116 | | 529 | 520 | 311 | 373 | 122 | 133 | 118 | 109 | 115 | 101 | 34 | 30 |
| **NGA480** | M | 179 | 174 | 176 | 100 | 153 | 133 | 119 | 113 | 148 | 147 | 125 | 126 | 530 | 531 | 336 | 389 | 141 | 141 | 107 | 115 | 122 | 91 | 37 | 30 |
| **NGA486** | M | 167 | 163 | 161 | 100 | 141 | 120 | 110 | 100 | 129 | | 106 | | 493 | 494 | 293 | 335 | 120 | 105 | 110 | 104 | 97 | 95 | 36 | 31 |
| **NGA491** | M | 190 | 177 | 185 | 95 | 147 | 130 | 117 | 110 | 138 | | 116 | | 542 | 538 | 307 | 388 | 130 | 135 | 123 | 116 | 121 | 99 | 38 | 29 |
| **NGA539** | F | 172 | 165 | 164 | 93 | 133 | 118 | 105 | 101 | 127 | | 109 | | 496 | 489 | 291 | 360 | 121 | 120 | 119 | 105 | 107 | 96 | 34 | |
| **NGA542** | F | 182 | 175 | 172 | | 143 | | 108 | | | | | | | | | | | 122 | 119 | | 111 | 99 | | |
| **NGA563** | F | 188 | 167 | 182 | 100 | 139 | 118 | 109 | 96 | 125 | | 108 | | 532 | 520 | 287 | 373 | 126 | 125 | 122 | 114 | 111 | 100 | 35 | 30 |
| **NGA587** | M | 183 | 176 | 176 | | 147 | 129 | 120 | 102 | | | 110 | | 535 | 531 | 308 | 367 | 127 | 120 | 120 | 114 | 109 | 102 | | |
| **NGA593** | F | 176 | 152 | 167 | 92 | 144 | 126 | 115 | 100 | 126 | 126 | 109 | 114 | 513 | 510 | 300 | 364 | 125 | 119 | 120 | 109 | 105 | 96 | 34 | 29 |
| **NGA632** | F? | 177 | 172 | 172 | | 140 | 121 | 116 | 97 | | | | | 516 | 511 | 300 | 357 | 127 | 106 | 124 | 110 | 99 | 106 | | |
| **NGA660** | M | 183 | 175 | 179 | 93 | 154 | 131 | 120 | 111 | 134 | | 115 | | 541 | 538 | 317 | 384 | 133 | 127 | 124 | 114 | 115 | 102 | 33 | 29 |
| **NGA692** | F | 179 | 173 | 174 | 92 | 154 | 131 | 121 | 109 | 128 | 128 | 115 | 116 | 527 | 526 | 309 | 371 | 123 | 133 | 115 | 108 | 119 | 93 | 36 | 30 |
| **NGA742** | M | 179 | 172 | 175 | 102 | 141 | 131 | 112 | 111 | 139 | 140 | 117 | 123 | 525 | 510 | 312 | 371 | 121 | 124 | 126 | 107 | 110 | 109 | 36 | 31 |
| **NGA749** | M | 186 | 179 | 108 | 108 | 154 | 130 | 113 | 110 | 144 | 145 | 121 | 122 | 544 | 548 | 333 | 385 | 128 | 137 | 120 | 109 | 122 | 97 | 39 | 31 |
| **NGA750** | M | 178 | 170 | 170 | 97 | 139 | 121 | 105 | 102 | 128 | 128 | 113 | 115 | 516 | 504 | 302 | 365 | 128 | 107 | 130 | 110 | 98 | 105 | 29 | 27 |
| **NGA766** | F | 169 | 157 | 165 | 92 | 146 | 128 | 111 | 103 | 118 | 120 | 104 | 101 | 505 | 501 | 294 | 348 | 121 | 122 | 105 | 105 | 107 | 88 | 35 | 30 |
| **NGA752** | F | 169 | 165 | 164 | 89 | 139 | 113 | 106 | 98 | 127 | 126 | 111 | 110 | 490 | 490 | 307 | 363 | 127 | 120 | 116 | 111 | 117 | 92 | 31 | 26 |
| **NGA826** | M | 179 | 174 | 174 | 92 | 155 | 132 | 120 | 111 | 136 | | 120 | | 537 | 532 | 324 | 370 | 131 | 120 | 119 | 115 | 109 | 99 | 36 | 33 |
| **NGA830** | F | 170 | 161 | 167 | 94 | 146 | 119 | 111 | 99 | 127 | 129 | 109 | 115 | 512 | 501 | 307 | 351 | 122 | 113 | 116 | 107 | 104 | 96 | 34 | 26 |
| **NGA847** | M | 181 | 172 | 175 | 110 | 134 | 120 | 106 | 103 | 137 | | 114 | | 523 | 511 | 301 | 361 | 129 | 120 | 112 | 112 | 108 | 99 | 39 | 34 |
| **NGA897** | M | 182 | 175 | 177 | 102 | 148 | 126 | 114 | 108 | 136 | 135 | 116 | 122 | 526 | 530 | 315 | 385 | 130 | 131 | 124 | 113 | 115 | 102 | 36 | 35 |
| **NGA917** | M | 181 | 178 | 179 | 100 | 140 | 115 | 98 | 95 | 132 | 133 | 116 | 118 | 518 | 506 | 310 | 362 | 135 | 110 | 117 | 118 | 102 | 95 | 32 | 38 |
| **NGA919** | M | 195 | 186 | 188 | 106 | 145 | 121 | 115 | 111 | 137 | 140 | 124 | 128 | 553 | 554 | 335 | 398 | 137 | 136 | 125 | 118 | 122 | 102 | 36 | 28 |
| **NGA932** | M | 174 | 167 | 169 | 97 | 134 | 120 | 111 | 102 | 132 | 132 | 111 | 112 | 507 | 500 | 290 | 359 | 122 | 122 | 115 | 110 | 108 | 98 | 34 | 29 |
| **NGA969** | F? | 176 | 160 | 171 | 102 | 141 | 124 | 104 | 105 | 132 | | 113 | | 510 | 505 | 303 | 360 | 125 | 118 | 117 | 111 | 107 | 97 | 32 | 27 |
| **NGA1001** | F | 169 | 161 | 167 | 96 | 148 | 125 | 113 | 102 | 136 | 136 | 119 | 115 | 512 | 510 | 317 | 369 | 132 | 131 | 106 | 114 | 111 | 94 | 38 | 32 |
| **NGA1053** | F | 175 | 160 | 171 | 90 | 129 | 113 | 102 | 99 | 129 | 129 | 106 | 110 | 497 | 490 | 284 | 368 | 134 | 117 | 117 | 114 | 107 | 95 | 34 | 27 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NGA1067** | M | 178 | 173 | 173 | 98 | 140 | 117 | 113 | 107 | 133 | 132 | 114 | 118 | 519 | 508 | 303 | 370 | 133 | 129 | 108 | 115 | 113 | 90 | 34 | 30 |
| **NGA1130** | F | 175 | 164 | 172 | 95 | 150 | 122 | 117 | 102 | 137 | 138 | 126 | 122 | 526 | 525 | 326 | 382 | 131 | 121 | 130 | 115 | 108 | 109 | 34 | 30 |
| **NGA1136** | M | 177 | 158 | 172 | 98 | 142 | 124 | 107 | 97 | 133 | 133 | 113 | 116 | 516 | 508 | 309 | 363 | 129 | 116 | 118 | 112 | 103 | 98 | 34 | 28 |
| **NGA1146** | M | 166 | 163 | 156 | 103 | 141 | 132 | 107 | 109 | 139 | 141 | 115 | 116 | 502 | 492 | 303 | 342 | 116 | 117 | 109 | 104 | 103 | 91 | 36 | 27 |
| **NGA1156** | M | 171 | 163 | 165 | 94 | 134 | 112 | 105 | 95 | 124 | | 108 | | 502 | 490 | 290 | 352 | 120 | 121 | 111 | 106 | 107 | 90 | 33 | 27 |
| **NGA1212** | M | 185 | 171 | 178 | 105 | 140 | 121 | 109 | 105 | 140 | 142 | 114 | 120 | 531 | 526 | 305 | 381 | 122 | 126 | 133 | 107 | 114 | 110 | 35 | 32 |
| **NGA1218** | F | 188 | 167 | 179 | 95 | 137 | 118 | 105 | 96 | 124 | 125 | 107 | 102 | 520 | 517 | 293 | 374 | 127 | 125 | 122 | 108 | 114 | 98 | 34 | 24 |
| **NGB1 (1.1)** | M | 184 | 181 | 177 | 105 | 155 | 14 | 113 | 111 | 123 | 127 | 112 | 120 | 558 | 542 | 310 | 376 | 119 | 119 | 138 | 106 | 105 | 110 | 35 | 30 |
| **NGB9 (9.1)** | M | 181 | 169 | 174 | 97 | 143 | 128 | 115 | 110 | 133 | 134 | 113 | 118 | 528 | 523 | 310 | 370 | 124 | 126 | 120 | 109 | 111 | 99 | 38 | 30 |
| **NGB4 (4.1)** | M | 171 | 157 | 168 | 97 | 145 | 125 | 111 | 103 | 135 | 136 | 107 | 108 | 507 | 497 | 309 | 359 | 128 | 117 | 114 | 113 | 105 | 96 | 33 | 29 |
| **NGB6 (6.1)** | F | 177 | 169 | 171 | | 140 | 125 | 107 | 105 | | | 112 | 115 | 513 | 509 | 299 | 357 | 121 | 117 | 119 | 109 | 105 | 104 | | |
| **NGB7 (7.1)** | M | 182 | 172 | 171 | 102 | 139 | 128 | 109 | 104 | 133 | | 112 | | 518 | 513 | 288 | 364 | 124 | 125 | 115 | 108 | 111 | 95 | 37 | 35 |
| **NGB10 (10.1)** | F | 169 | 161 | 167 | 93 | 132 | 111 | 102 | 94 | 126 | | 109 | | 498 | 490 | 295 | 350 | 120 | 127 | 103 | 106 | 111 | 88 | 36 | 30 |
| **NGB16 (16.1)** | F | 175 | 159 | 171 | 95 | 147 | 120 | 108 | 98 | 124 | 126 | 111 | 115 | 518 | 514 | 305 | 354 | 118 | 127 | 109 | 108 | 102 | 97 | 35 | 29 |
| **NGB24 (24.1)** | M | 188 | 180 | 178 | 108 | 155 | 138 | 126 | 117 | 136 | 136 | 116 | 118 | 549 | 544 | 318 | 369 | 128 | 118 | 123 | 112 | 107 | 101 | 37 | 30 |
| **NGB33 (33.1)** | F? | 189 | 175 | 179 | 102 | 152 | 129 | 115 | 104 | 134 | | 118 | | 546 | 542 | 318 | 385 | 137 | 110 | 138 | 117 | 102 | 106 | 32 | 27 |
| **NGB36 (36.1)** | M | 189 | 178 | 185 | 105 | 145 | 132 | 113 | 111 | 142 | 142 | 120 | 124 | 547 | 546 | 320 | 395 | 146 | 134 | 115 | 121 | 118 | 99 | 38 | 29 |
| **NGB52 (52.1)** | F | 175 | 163 | 172 | 92 | 147 | 125 | 114 | 100 | 126 | 125 | 112 | 116 | 517 | 510 | 305 | 367 | 123 | 123 | 121 | 108 | 112 | 95 | 33 | 27 |
| **NGB71 (71.1)** | M? | 176 | 167 | 169 | 97 | 139 | 126 | 114 | 103 | 128 | | | | 511 | 500 | 292 | 350 | 119 | 122 | 109 | 102 | 111 | 94 | 35 | 32 |
| **NGB72 (72.1)** | M | 168 | 164 | 164 | 93 | 147 | 128 | 120 | 113 | 129 | | 111 | | 514 | 507 | 300 | 354 | 127 | 112 | 115 | 114 | 96 | 95 | 35 | 27 |
| **NGB73 (73.1)** | M | 183 | 174 | 176 | | 136 | 126 | 116 | 109 | | | 108 | | 526 | 517 | 293 | 370 | 123 | 124 | 123 | 109 | 110 | 104 | | |
| **NGB81 (81.1)** | M | 181 | 170 | 178 | 104 | 142 | 125 | 112 | 102 | 132 | 135 | 116 | 120 | 521 | 517 | 305 | 381 | 123 | 131 | 127 | 109 | 112 | 102 | 29 | 28 |

## 1.2 FACIAL SKULL, 1.3 ORBITAL SKELETON, 1.4 NASAL SKELETON AND 1.5 MAXILLARY SKELETON

| SKELETON | SEX | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.2.5 | 1.2.6 | 1.2.7 | 1.2.8 | 1.3.1 | 1.3.2 | 1.3.3 | 1.3.4 | 1.3.5 | 1.4.1 | 1.4.2 | 1.4.3 | 1.4.4 | 1.5.1 | 1.5.2 | 1.5.3 | 1.5.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NGA12** | M | | 87 | 113 | 96 | | | | | | | | 21 | | 22 | | | | | | | 38 |
| **NGA48** | M | | 94 | 122 | 97 | | | | | | | | | | | | | | | | | |
| **NGA72** | M | | 94 | 123 | 104 | 132 | | | | | | | | | | | | | | | | |
| **NGA74** | M | | 99 | 132 | 106 | | | | | | | 25 | | | | | | | | | | |
| **NGA103** | M | | 98 | 117 | 107 | | | | | | | | | | | | | | | | | |
| **NGA118** | M | | 88 | 112 | 101 | 127 | | | | | 21 | 20 | | | | | | | | | 43 | |
| **NGA143** | F | | 93 | 110 | 97 | | | | | | | | | | | | | | | | | |
| **NGA148** | M | | 96 | 117 | 100 | | | | | | | | | | | | | | | | | |
| **NGA153** | M? | | 92 | 116 | 101 | | | | | | | | 37 | 34 | | | | | | | | |
| **NGA158** | M | | 95 | 118 | 103 | | | | | | 26 | 24 | | | | | | | | | | |
| **NGA170** | F | | 100 | 135 | 103 | | | | | | 30 | 29 | | | | | | | | | 45 | |
| **NGA188** | M | 83 | 90 | 105 | 95 | | 93 | 107 | 62 | 92 | | 21 | 40 | 30 | 25 | 46 | 90 | 101 | | 62 | | 42 |
| **NGA227** | M | 94 | 93 | 125 | 106 | | 101 | 121 | 71 | | 26 | 26 | 42 | 33 | 24 | 53 | | | | | | |
| **NGA229** | F | 85 | 95 | 117 | 100 | | 85 | 109 | 70 | 93 | | 24 | 37 | 38 | 26 | 51 | 92 | 104 | 44 | 54 | | 37 |
| **NGA248** | M | | 104 | 130 | 105 | | | | | | | | | | | | | | | | | |
| **NGA263** | F | 93 | 103 | 129 | 105 | 128 | 89 | 112 | 66 | 97 | 22 | 21 | 39 | 32 | 23 | 49 | 97 | 107 | 49 | 59 | 39 | 39 |
| **NGA295** | M | | 98 | 117 | 106 | | | | | | | 19 | | | | | | | | | | |
| **NGA311** | M | | 104 | 126 | 118 | | | | | | | | | | | | | | | | | |
| **NGA331** | M? | | 95 | 118 | 98 | | | | | | | | | | | | | | | | | |
| **NGA341** | M | | 101 | 118 | 108 | | | | | | | | | | | | | | | | | |
| **NGA409** | M | | 86 | 108 | 97 | 126 | | | | | 23 | 22 | | | | | | | | | | |
| **NGA410** | F | | 100 | 120 | 105 | 126 | | | | | | | | | | | | | | | | 38 |
| **NGA411** | F? | | 96 | 121 | 102 | | | | | | | | | | | | | | | | | |
| **NGA429** | F | | 93 | | 94 | | | | | | | 22 | | | | | | | | | | |
| **NGA444** | M | 98 | 95 | 118 | | | 94 | 117 | 71 | | 23 | 21 | 39 | 33 | 24 | 51 | | | 53 | 62 | 45 | 36 |
| **NGA467** | M | 94 | 99 | 130 | 106 | | 95 | 107 | 64 | 97 | 23 | 21 | 39 | 31 | 23 | 47 | 97 | 104 | 55 | | 44 | |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NGA480** | M | 91 | 109 | 140 | 112 | 141 | 98 | 108 | 67 | 104 | 27 | 25 | 43 | 36 | 25 | 49 | 105 | 118 | | | 43 | |
| **NGA486** | M | | 97 | 118 | 100 | | | | | | | | | | | | | | 54 | 62 | 45 | 41 |
| **NGA491** | M | 89 | 95 | 116 | 103 | | 96 | 128 | 74 | 96 | 24 | 20 | 40 | 36 | 26 | 50 | 96 | 110 | | 65 | | 44 |
| **NGA539** | F | | 94 | 119 | 100 | | | | | | | | | | | | | | | | | |
| **NGA542** | F | | | 129 | | | | | | | | | | | | | | | | | | |
| **NGA563** | F | | 95 | 112 | 105 | | | | | | | | | | | | | | | | | |
| **NGA587** | M | | 103 | 134 | 108 | 137 | | | | | 24 | 23 | | | 20 | | | | | | | |
| **NGA593** | F | 81 | 99 | 121 | 103 | | | | 56 | | 21 | 19 | 41 | 38 | | 49 | | | | | | |
| **NGA632** | F? | | 96 | 114 | 101 | 124 | | | | | | 19 | | | | | | | | | | |
| **NGA660** | M | 92 | 99 | 127 | 109 | | 91 | | 72 | 103 | | 28 | 41 | 34 | 25 | 48 | 102 | | 53 | 62 | 39 | |
| **NGA692** | F | 88 | 100 | 123 | 104 | 128 | 89 | 107 | 62 | 98 | 23 | 22 | 41 | 36 | 24 | 48 | 98 | 108 | 50 | 57 | 41 | 38 |
| **NGA742** | M | 96 | 96 | 120 | 106 | | 87 | 111 | 67 | 96 | 20 | 16 | 41 | 35 | 25 | 51 | 97 | 110 | 51 | | 44 | |
| **NGA749** | M | 95 | 110 | 139 | 112 | | 99 | 112 | 63 | 102 | 24 | 21 | 42 | 35 | 25 | 53 | | | | | 42 | |
| **NGA750** | M | 96 | 93 | 118 | 102 | | 98 | 115 | 70 | 97 | 23 | 21 | 38 | 32 | 30 | 49 | 96 | 106 | | 60 | 43 | 36 |
| **NGA766** | F | 87 | 94 | 116 | 101 | | | | 63 | | | 22 | 40 | 33 | | 45 | | | | | | |
| **NGA752** | F | 84 | 88 | 115 | 95 | 117 | | | 64 | 91 | | 20 | 38 | 33 | | 46 | 91 | 104 | | | | |
| **NGA826** | M | | 98 | 129 | 108 | | | | | | | 25 | | | | | | | | | | |
| **NGA830** | F | 90 | 94 | 124 | 105 | 124 | | 106 | 65 | | 25 | 24 | 39 | 35 | 24 | 46 | | | | | | |
| **NGA847** | M | | 101 | 120 | 108 | | | | | | | 22 | 41 | | | | | | | | | |
| **NGA897** | M | 92 | 100 | 131 | 102 | 132 | 96 | 106 | 64 | 96 | 23 | 22 | 40 | 32 | 25 | 50 | 95 | 109 | | | 42 | |
| **NGA917** | M | 88 | 80 | 111 | 95 | | 93 | 115 | 74 | 90 | 18 | 16 | 39 | 36 | 22 | 53 | 90 | 104 | | 55 | 37 | 38 |
| **NGA919** | M | 101 | 100 | 134 | 107 | 132 | 88 | 118 | 69 | 99 | 23 | 22 | 42 | 35 | 25 | 52 | 99 | 112 | | 39 | 42 | |
| **NGA932** | M | 93 | 97 | 115 | 106 | | 103 | 107 | 63 | 96 | 22 | 22 | 41 | 34 | 23 | 45 | 97 | 107 | 49 | 64 | 39 | 43 |
| **NGA969** | F? | | 96 | 114 | 102 | | | | | | 23 | 21 | | | | | | | | 65 | | 44 |
| **NGA1001** | F | 89 | 96 | 133 | 101 | 131 | 94 | 116 | 65 | 93 | 22 | 19 | 38 | 34 | 25 | 45 | 93 | 104 | 49 | | 40 | |
| **NGA1053** | F | | 89 | 113 | 97 | 122 | 94 | 112 | | 94 | 25 | 24 | 38 | 36 | 22 | | 92 | 102 | | 60 | | 40 |
| **NGA1067** | M | 94 | 94 | 119 | 101 | 121 | 91 | 109 | 70 | 94 | 21 | 20 | 39 | 34 | 23 | 50 | 95 | 101 | | | | |
| **NGA1130** | F | 91 | 100 | 125 | 106 | 125 | 87 | 122 | 71 | 99 | 20 | 19 | 42 | 35 | 26 | 49 | 98 | 110 | | | 41 | |
| **NGA1136** | M | 90 | 96 | 120 | 106 | 134 | | 100 | 64 | 64 | 26 | 25 | 39 | 33 | 23 | 46 | 99 | 115 | 48 | 62 | 40 | 41 |
| **NGA1146** | M | | 91 | 117 | 104 | 144 | | | | | | 26 | 41 | 33 | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NGA1156** | M | 83 | 89 | 113 | 96 | 114 | 75 | | | | 19 | 18 | | | | 50 | | | 43 | 52 | 39 | 36 |
| **NGA1212** | M | 97 | 100 | 127 | 108 | 130 | 92 | 120 | 74 | 99 | 23 | 22 | 42 | 36 | 21 | 52 | 99 | 109 | 54 | 61 | 42 | 39 |
| **NGA1218** | F | 92 | 99 | 118 | 101 | 121 | 88 | 112 | 70 | 94 | 24 | 23 | 39 | 32 | 23 | 49 | 94 | 108 | 52 | 62 | 41 | 41 |
| **NGB1 (1.1)** | M | 113 | 102 | 128 | 115 | 141 | 106 | 123 | 71 | 108 | 29 | 25 | 44 | 30 | 30 | 54 | 107 | 122 | 64 | 66 | 56 | 44 |
| **NGB9 (9.1)** | M | | 106 | 129 | 111 | | 84 | | | 99 | 25 | 26 | 40 | 35 | | | 100 | 114 | | | | |
| **NGB4 (4.1)** | M | 95 | 90 | 116 | 100 | 132 | 92 | 110 | 66 | 92 | 20 | 18 | 39 | 32 | 27 | 58 | 93 | 105 | 52 | | 44 | |
| **NGB6 (6.1)** | F | | 94 | 120 | 101 | 130 | 99 | | 74 | 91 | 22 | 22 | 40 | 36 | 24 | 53 | 96 | 109 | | | 39 | 41 |
| **NGB7 (7.1)** | M | | 90 | 115 | 101 | 134 | | | | | | | | | | | | | | | | |
| **NGB10 (10.1)** | F | 85 | 95 | 118 | 103 | | 96 | | 70 | | | 19 | 42 | 38 | 28 | 51 | | | 44 | 60 | | 42 |
| **NGB16 (16.1)** | F | 93 | 95 | 120 | 99 | | 87 | | 70 | 94 | 22 | 21 | 38 | 34 | 23 | 54 | 94 | 103 | 48 | | 40 | |
| **NGB24 (24.1)** | M | 96 | 102 | 134 | 108 | | 90 | 114 | 71 | 102 | 25 | 26 | 42 | 35 | 29 | 52 | 102 | 117 | 53 | 60 | | 39 |
| **NGB33 (33.1)** | F? | | 106 | 132 | 109 | | | | | | | | | | | | | | | | | |
| **NGB36 (36.1)** | M | 92 | 105 | 132 | 112 | 137 | 98 | | 71 | 105 | 23 | 22 | 44 | 35 | 26 | 56 | 103 | 121 | | | 41 | |
| **NGB52 (52.1)** | F | 93 | 100 | 120 | 104 | 129 | 88 | 109 | 70 | 97 | 24 | 23 | 39 | 34 | 23 | 48 | 97 | 110 | 53 | 63 | 46 | 40 |
| **NGB71 (71.1)** | M? | | 94 | 115 | 103 | | | | | | | | | | | | | | | | | |
| **NGB72 (72.1)** | M | | 95 | 123 | 104 | | | | | | | | | | | | | | | | | |
| **NGB73 (73.1)** | M | | 98 | 117 | 108 | | 91 | | | | | | 40 | | 23 | | | | | | 41 | |
| **NGB81 (81.1)** | M | 94 | 94 | 119 | 101 | 131 | 91 | 115 | 69 | 93 | 24 | 21 | 38 | 31 | 22 | 50 | 93 | 106 | 51 | 65 | 44 | 40 |

# Ballumbie

### 1.1 NEUROCRANIUM

| SKELETON | SEX | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.1.6 | 1.1.7 | 1.1.8 | 1.1.9 | 1.1.10 | 1.1.11 | 1.1.12 | 1.1.13 | 1.1.14 | 1.1.15 | 1.1.16 | 1.1.17 | 1.1.18 | 1.1.19 | 1.1.20 | 1.1.21 | 1.1.22 | 1.1.23 | 1.1.24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **314 A** | M | 185 | 177 | 180 | 97 | 135 | 117 | 112 | 100 | 122 | | 107 | | 530 | 522 | 297 | 368 | 131 | 123 | 114 | 112 | 107 | 91 | 34 | 29 |
| **314 E** | M? | 174 | 165 | 166 | | 140 | | 105 | | | | | | 508 | 504 | | 364 | 125 | 120 | 119 | 107 | 108 | 96 | | |
| **314 F** | F | 171 | 155 | 163 | 90 | 141 | 121 | 112 | 98 | 122 | 124 | 105 | 109 | 506 | 499 | 288 | 348 | 121 | 108 | 119 | 106 | 97 | 97 | 32 | 29 |
| **341** | M | 190 | 178 | 186 | 100 | 148 | 126 | 116 | 110 | 136 | 137 | 116 | 124 | 543 | 541 | 307 | 399 | 132 | 143 | 124 | 114 | 123 | 102 | 35 | 28 |
| **417** | F | 173 | 165 | 170 | | 141 | 125 | 111 | 107 | | | | 115 | 512 | 500 | 290 | | 123 | 115 | | 110 | 103 | | | |
| **419** | M | 186 | 170 | 181 | 97 | 151 | 129 | 113 | 104 | 124 | | 110 | | | 541 | 308 | 377 | 126 | 137 | 114 | 107 | 120 | 98 | 37 | 32 |
| **425 B** | F | 165 | 144 | 159 | 89 | 145 | 117 | 110 | 97 | 117 | | | | 503 | 502 | 297 | 346 | 118 | 123 | 105 | 97 | 106 | 88 | 33 | 30 |
| **432** | F? | 172 | 163 | 163 | 89 | 139 | 121 | 110 | 104 | 121 | | | | 504 | 495 | 284 | 350 | 116 | 116 | 118 | 103 | 102 | 98 | 34 | |
| **435** | F? | 171 | 165 | 170 | 86 | 141 | 124 | 114 | 101 | 122 | 121 | 112 | 107 | 509 | 505 | 293 | 356 | 121 | 123 | 112 | 108 | 109 | 91 | 35 | 32 |
| **447 A** | M | 191 | 183 | 184 | 106 | 145 | 128 | 111 | 107 | 136 | 140 | 113 | 122 | 549 | 536 | 311 | 380 | 125 | 135 | 120 | 111 | 118 | 100 | 39 | 31 |
| **467** | F | | 161 | 167 | | 140 | 124 | 105 | 96 | | | 106 | 114 | | | 292 | 353 | 122 | 113 | 118 | 108 | 100 | 91 | | |
| **512** | F | 171 | 164 | 167 | 85 | 143 | 118 | 113 | 96 | 114 | | | | 510 | 508 | 295 | 345 | 118 | 115 | 112 | 104 | 103 | 88 | 38 | 30 |
| **521** | M | 185 | 173 | 179 | 101 | 156 | 134 | 117 | 110 | 136 | 136 | 119 | 122 | 543 | 538 | 318 | 383 | 130 | 125 | 128 | 116 | 112 | 105 | 36 | 31 |
| **525** | M? | 175 | 161 | 166 | 90 | 139 | 115 | 108 | 92 | 127 | | | | 505 | 500 | 297 | 369 | 128 | 121 | 120 | 110 | 107 | 94 | 34 | 29 |
| **527** | M | 180 | 175 | 176 | 102 | 144 | 123 | 113 | 100 | 126 | 128 | 110 | 115 | 529 | 524 | 303 | 358 | 119 | 126 | 113 | 104 | 113 | 97 | 35 | 30 |
| **552** | M | 169 | 160 | 168 | 81 | 141 | | | | 120 | | | | 503 | 496 | | 357 | 127 | 121 | 109 | 111 | 106 | 89 | 35 | 28 |
| **554** | M | 165 | 162 | 160 | 91 | 145 | 127 | 111 | 109 | 131 | 133 | 110 | 112 | 503 | 497 | 303 | 356 | 122 | 124 | 110 | 106 | 107 | 89 | 33 | 30 |
| **566 A** | M | 197 | 190 | 187 | 107 | 151 | 129 | 124 | 103 | 136 | 138 | 118 | 124 | 566 | 556 | 322 | 392 | 126 | 130 | 136 | 112 | 120 | 112 | 37 | 30 |
| **566 B** | M | 197 | 190 | 189 | 107 | 149 | 130 | 113 | 106 | 139 | 139 | 118 | 121 | 559 | 553 | 321 | 392 | 139 | 127 | 126 | 120 | 115 | 101 | 38 | 31 |
| **566 C** | M | 176 | 173 | 172 | 109 | 145 | 122 | 109 | 101 | 132 | 132 | 113 | 116 | 519 | 510 | 307 | 355 | 126 | 114 | 115 | 110 | 104 | 96 | 35 | 28 |
| **567** | M | 176 | 168 | 169 | 97 | 149 | 128 | 114 | 109 | 132 | 134 | 111 | 115 | 524 | 521 | 310 | 364 | 127 | 117 | 120 | 111 | 104 | 99 | 36 | |
| **599** | M? | 181 | 171 | 177 | 93 | 142 | 119 | 110 | 98 | 120 | 120 | 108 | 113 | 522 | 519 | 300 | 367 | 128 | 128 | 111 | 112 | 115 | 90 | 34 | 27 |
| **606** | M | 176 | 170 | 171 | 95 | 143 | 124 | 116 | 100 | 128 | | 113 | 116 | 517 | 510 | 306 | 362 | 125 | 125 | 112 | 109 | 111 | 94 | 39 | 28 |

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **622** | F | | 157 | 172 | 89 | 148 | 128 | 112 | 1003 | 125 | 126 | 111 | 113 | | | 298 | 359 | 125 | 124 | 110 | 111 | 111 | 93 | 37 | 30 |
| **623** | M | 188 | 177 | 185 | 95 | 138 | 118 | 99 | 102 | 130 | 131 | 112 | 111 | 531 | 524 | 296 | 387 | 136 | 135 | 116 | 118 | 119 | 98 | 33 | 30 |
| **630** | M | 181 | 174 | 176 | 105 | 150 | 130 | 114 | 108 | 133 | 133 | 115 | 119 | 531 | 526 | 317 | 373 | 131 | 129 | 113 | 113 | 111 | 91 | 38 | 33 |
| **653** | M | 171 | 157 | 170 | 95 | 139 | 113 | 109 | 101 | 130 | 132 | 108 | 116 | 504 | 497 | 294 | 353 | 115 | 130 | 108 | 104 | 113 | 97 | 37 | 32 |
| **701** | M | 186 | 178 | 180 | 99 | 144 | 131 | 111 | 106 | 132 | 133 | 116 | 120 | 527 | 525 | 310 | 381 | 133 | 121 | 127 | 115 | 110 | 99 | 33 | 28 |
| **717** | F | 169 | 160 | 164 | 95 | 144 | 125 | 113 | 102 | 125 | 124 | 111 | 113 | 510 | 504 | 302 | 349 | 121 | 122 | 106 | 107 | 109 | 89 | 35 | 28 |
| **721** | F | 170 | 156 | 164 | 92 | 141 | 120 | 102 | 103 | 125 | 125 | 107 | 110 | 501 | 498 | 300 | 351 | 128 | 113 | 110 | 110 | 101 | 92 | 34 | |
| **725** | M | 183 | 179 | 174 | 104 | 152 | 133 | 115 | 113 | 135 | 137 | 113 | 116 | 541 | 529 | 303 | 362 | 126 | 126 | 110 | 113 | 112 | 93 | 38 | 31 |
| **760** | M | 177 | 169 | 172 | 98 | 144 | 121 | 116 | 100 | 120 | | 107 | | 522 | 515 | 300 | 349 | 125 | 111 | 113 | 110 | 103 | 92 | 35 | 32 |
| **763** | M? | 189 | 176 | 183 | 96 | 144 | 121 | 112 | 102 | 135 | 134 | 117 | 117 | 533 | 527 | 312 | 385 | 135 | 132 | 118 | 118 | 118 | 96 | 40 | |
| **790** | M | | 160 | 172 | | 152 | 131 | 121 | 108 | | | 118 | 120 | | | 325 | 389 | 139 | 120 | 130 | 118 | 106 | 105 | | |
| **793** | F | 175 | 165 | 173 | 95 | 149 | 123 | 122 | 97 | 119 | 120 | 108 | 116 | 527 | 519 | 311 | 359 | 128 | 119 | 112 | 112 | 103 | 94 | 36 | 28 |
| **832** | M | 179 | 168 | 175 | | 151 | 127 | 114 | 103 | | | 113 | | 531 | 522 | 315 | 355 | 127 | 118 | 110 | 114 | 106 | 91 | | |
| **844** | M | 179 | 178 | 175 | 104 | 139 | 126 | 106 | 106 | 131 | | 109 | | 519 | 522 | 302 | 361 | 120 | 126 | 115 | 104 | 111 | 93 | 34 | 30 |

## 1.2 FACIAL SKULL, 1.3 ORBITAL SKELETON, 1.4 NASAL SKELETON AND 1.5 MAXILLARY SKELETON

| SKELETON | SEX | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.2.5 | 1.2.6 | 1.2.7 | 1.2.8 | 1.3.1 | 1.3.2 | 1.3.3 | 1.3.4 | 1.3.5 | 1.4.1 | 1.4.2 | 1.4.3 | 1.4.4 | 1.5.1 | 1.5.2 | 1.5.3 | 1.5.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **314 A** | M | | 99 | 127 | 108 | | | | | | | | | | | | | | | | | |
| **314 E** | M? | | 98 | 120 | 102 | | | | | | | | | | | | | | | | | |
| **314 F** | F | 92 | 95 | | 103 | | 93 | | 64 | | 22 | 20 | 38 | 32 | 25 | 47 | | | 54 | 62 | 45 | 40 |
| **341** | M | 88 | 96 | 125 | 100 | | 89 | | 67 | | 22 | 21 | 37 | 33 | 24 | 50 | | | | | 40 | |
| **417** | F | | 97 | 108 | 108 | | 95 | 110 | | | 22 | 22 | 40 | 37 | 26 | 51 | | | | 60 | 38 | 40 |
| **419** | M | | 107 | 132 | | | | | | | | | | | | | | | | | | |
| **425 B** | F | 95 | 100 | 121 | 105 | | 93 | | 67 | 99 | 26 | 25 | 41 | 34 | 25 | 51 | | | | | 47 | |
| **432** | F? | | 96 | 112 | 102 | | | | | | 23 | 22 | 38 | 36 | | | | | | | | |
| **435** | F? | 84 | 94 | 115 | 103 | 126 | 85 | 116 | 72 | 95 | 19 | 18 | 39 | 34 | 22 | 53 | 94 | 102 | 47 | 60 | 41 | 40 |
| **447 A** | M | 102 | 96 | 126 | 106 | 140 | 92 | 117 | 72 | 101 | 26 | 24 | 40 | 35 | | 48 | 100 | 112 | | 65 | 46 | 43 |
| **467** | F | | 96 | 114 | 100 | 126 | 86 | 106 | 65 | 93 | 20 | 20 | 37 | 36 | 22 | 50 | 92 | 101 | 47 | 55 | 38 | 34 |
| **512** | F | | 94 | 119 | 100 | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **521** | M | 92 | 98 | 125 | 105 | | 93 | 113 | 70 | 100 | 25 | 23 | 42 | 35 | 23 | 52 | 100 | 113 | 49 | 62 | 42 | 42 |
| **525** | M? | 89 | 95 | 114 | 100 | | 88 | | 64 | 92 | 20 | 20 | 37 | 31 | 23 | 44 | 91 | 100 | | | 40 | |
| **527** | M | 97 | 101 | 123 | 104 | | 96 | 115 | 71 | 94 | 22 | 21 | 39 | 35 | 25 | 51 | 95 | 108 | 53 | 63 | 46 | 38 |
| **552** | M | 77 | 88 | 111 | 100 | | 91 | 108 | 62 | 97 | 22 | 20 | 40 | 37 | | 46 | 97 | | 44 | 56 | | 38 |
| **554** | M | 81 | 97 | 122 | 101 | | 90 | | 60 | 96 | 22 | 21 | 39 | 32 | 22 | 46 | 96 | 102 | | | 39 | |
| **566 A** | M | 106 | 104 | 130 | 109 | | 105 | | 73 | 102 | 26 | 23 | 41 | 34 | 26 | 50 | 103 | 113 | 56 | | 47 | 47 |
| **566 B** | M | 102 | 97 | 128 | 108 | 141 | 97 | | 69 | 102 | 24 | 20 | 43 | 37 | 24 | 51 | 102 | 113 | 56 | 61 | 49 | 40 |
| **566 C** | M | 97 | 101 | 121 | 104 | 130 | 92 | | 70 | 95 | 22 | 21 | 40 | 28 | 23 | 49 | 94 | 105 | | | 44 | |
| **567** | M | 90 | 98 | 128 | 104 | | | 118 | 69 | | 22 | 21 | 40 | 34 | 25 | 51 | | | 51 | | 40 | |
| **599** | M? | 86 | 100 | 130 | 105 | | | | 62 | | 25 | 22 | 39 | 37 | | 46 | | | | | | |
| **606** | M | 87 | 92 | 114 | 103 | 136 | 88 | 121 | 69 | 100 | 23 | 22 | 42 | 35 | 25 | 49 | 99 | 116 | 49 | 62 | 40 | 41 |
| **622** | F | 77 | 96 | 114 | 105 | | 84 | | 63 | 95 | 20 | 19 | 40 | 35 | 21 | 46 | 95 | 106 | 42 | 58 | 36 | 36 |
| **623** | M | 81 | 93 | 118 | 103 | | 88 | 103 | 61 | 94 | 24 | 23 | 38 | 33 | 24 | 49 | 94 | 108 | 45 | 60 | 43 | 40 |
| **630** | M | 89 | 98 | 131 | 102 | 139 | 93 | | 77 | 97 | 21 | 21 | 42 | 40 | 26 | 55 | 96 | 117 | | | 42 | |
| **653** | M | 95 | 95 | 121 | 99 | | 88 | | 65 | 92 | 21 | 21 | 37 | 33 | 24 | 44 | 93 | 103 | 50 | 59 | 43 | 38 |
| **701** | M | 100 | 104 | 120 | 165 | | 95 | 127 | 76 | 97 | 22 | 21 | 41 | 37 | 23 | 53 | 96 | 110 | 55 | 65 | 46 | 43 |
| **717** | F | 97 | 95 | 122 | 105 | 130 | 93 | | 70 | 99 | 23 | 22 | 40 | 35 | 25 | 52 | 100 | 111 | 56 | 63 | 47 | 41 |
| **721** | F | 82 | 92 | 125 | 97 | | 83 | 106 | 64 | 92 | 21 | 20 | 38 | 37 | 28 | 46 | 94 | 105 | 43 | 55 | 38 | 32 |
| **725** | M | 90 | 91 | 126 | 109 | 140 | 92 | 108 | 70 | 100 | 21 | 21 | 41 | 35 | 27 | 55 | 100 | 113 | | | 44 | |
| **760** | M | | 97 | 126 | 105 | | | | | | 24 | 23 | | | | | | | | | | |
| **763** | M? | 82 | 99 | 121 | 106 | | | | 65 | 102 | 23 | 23 | 41 | 35 | 27 | 48 | 101 | 120 | 48 | | 39 | |
| **790** | M | | 109 | 130 | 112 | | 103 | 131 | 76 | 105 | 29 | 28 | 41 | 34 | 31 | 56 | 105 | 119 | | | 43 | |
| **793** | F | 90 | 97 | 131 | 104 | | 85 | 111 | 71 | 97 | 20 | 20 | 40 | 39 | 26 | 52 | 97 | 107 | | | 44 | |
| **832** | M | | 105 | 127 | 106 | | 97 | | 68 | 99 | 23 | 22 | 40 | 37 | 25 | 50 | 98 | 110 | | | | |
| **844** | M | | 100 | | | | | | | | | 20 | | | | | | | 48 | 58 | 40 | 39 |

# Appendix 7. Inter-observer error

## Correlation for parametric data

**Correlations**

| | | observer_1 | Author |
|---|---|---|---|
| observer_1 | Pearson Correlation | 1 | .992** |
| | Sig. (2-tailed) | | .000 |
| | N | 270 | 270 |
| Author | Pearson Correlation | .992** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 270 | 270 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Correlations**

| | | Author | observer_2 |
|---|---|---|---|
| Author | Pearson Correlation | 1 | .993** |
| | Sig. (2-tailed) | | .000 |
| | N | 270 | 270 |
| observer_2 | Pearson Correlation | .993** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 270 | 270 |

**. Correlation is significant at the 0.01 level (2-tailed).

## Correlation for non-parametric data

### Correlations

| | | | observer_1 | Author |
|---|---|---|---|---|
| Spearman's rho | observer_1 | Correlation Coefficient | 1.000 | .963** |
| | | Sig. (2-tailed) | . | .000 |
| | | N | 60 | 60 |
| | Author | Correlation Coefficient | .963** | 1.000 |
| | | Sig. (2-tailed) | .000 | . |
| | | N | 60 | 60 |

**. Correlation is significant at the 0.01 level (2-tailed).

### Correlations

| | | | Author | observer_2 |
|---|---|---|---|---|
| Spearman's rho | Author | Correlation Coefficient | 1.000 | .969** |
| | | Sig. (2-tailed) | . | .000 |
| | | N | 60 | 60 |
| | observer_2 | Correlation Coefficient | .969** | 1.000 |
| | | Sig. (2-tailed) | .000 | . |
| | | N | 60 | 60 |

**. Correlation is significant at the 0.01 level (2-tailed).

# Appendix 8. Intra-observer error

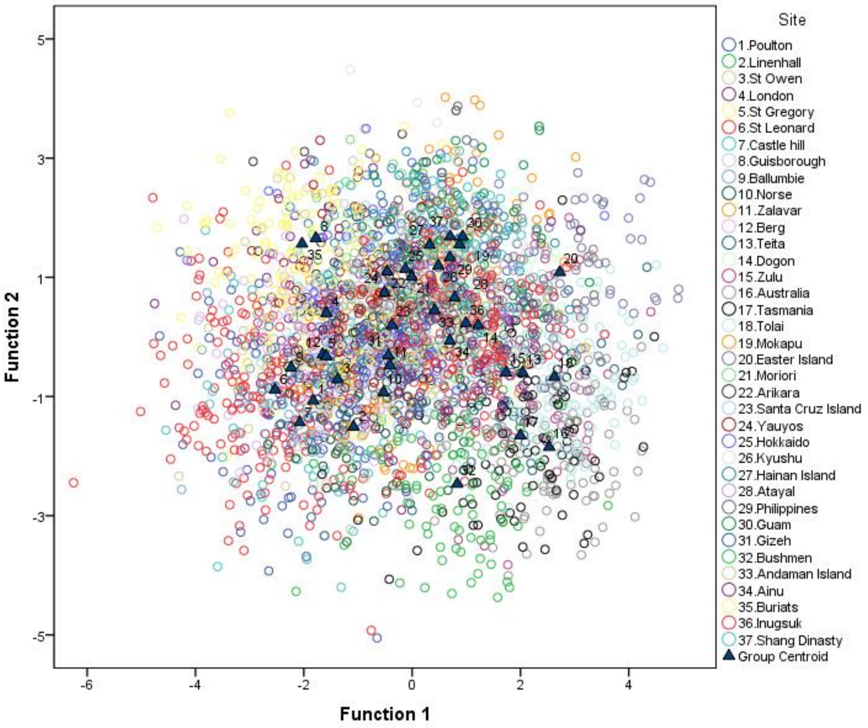
**Correlations**

| | | Author_1 | Author_2 |
|---|---|---|---|
| Author_1 | Pearson Correlation | 1 | .964** |
| | Sig. (2-tailed) | | .000 |
| | N | 33 | 33 |
| Author_2 | Pearson Correlation | .964** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 33 | 33 |

**. Correlation is significant at the 0.01 level (2-tailed).

# Appendix 9. Comparison among British samples and complete Howells' data set

## Non-pooled samples




### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 2.303[a] | 34.2 | 34.2 | .835 |
| 2 | 1.163[a] | 17.3 | 51.5 | .733 |
| 3 | .782[a] | 11.6 | 63.1 | .662 |
| 4 | .537[a] | 8.0 | 71.0 | .591 |
| 5 | .500[a] | 7.4 | 78.5 | .577 |
| 6 | .453[a] | 6.7 | 85.2 | .558 |
| 7 | .234[a] | 3.5 | 88.7 | .436 |
| 8 | .213[a] | 3.2 | 91.8 | .419 |
| 9 | .189[a] | 2.8 | 94.6 | .399 |
| 10 | .093[a] | 1.4 | 96.0 | .291 |
| 11 | .085[a] | 1.3 | 97.3 | .280 |
| 12 | .068[a] | 1.0 | 98.3 | .252 |
| 13 | .051[a] | .7 | 99.0 | .219 |
| 14 | .043[a] | .6 | 99.7 | .204 |
| 15 | .022[a] | .3 | 100.0 | .147 |

a. First 15 canonical discriminant functions were used in the analysis.

**Standardized Canonical Discriminant Function Coefficients**

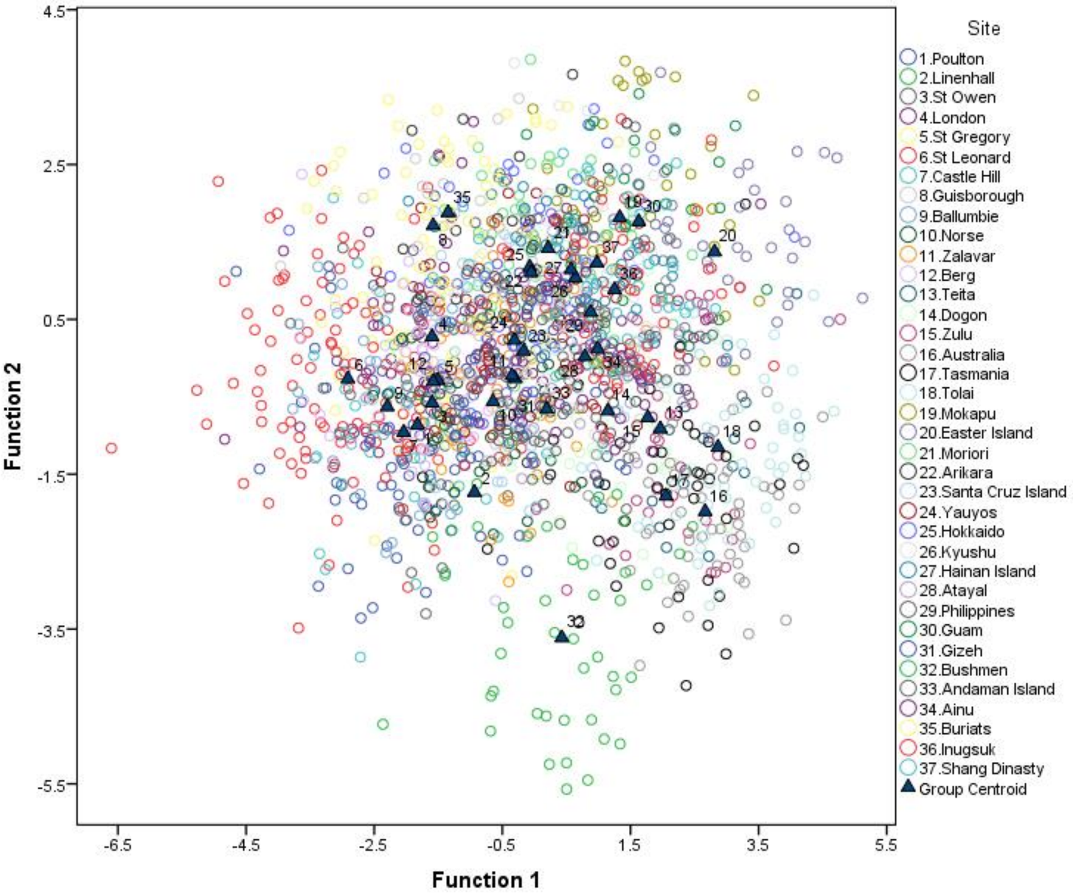
| | Function | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| B1.1.1 | .372 | -.621 | .444 | -.525 | -.954 | .211 | -.516 | -.419 | .237 | .073 | .578 | -1.029 | -.224 | -.780 | -.606 |
| B1.1.4 | -.516 | -.070 | .249 | .154 | .117 | -.841 | .642 | .728 | .648 | -.488 | -.868 | .358 | .297 | -.259 | .349 |
| B1.1.5 | -.734 | .100 | -.264 | .424 | -.421 | .084 | -.467 | -.102 | -.013 | -.189 | .173 | .094 | .211 | -.287 | .242 |
| B1.1.9 | .533 | .618 | .273 | .154 | .174 | -.149 | -.719 | -.215 | -.483 | .329 | .578 | -.369 | .050 | -.588 | -.796 |
| B1.1.20 | -.101 | -.055 | -.066 | .046 | .090 | -.260 | .164 | .557 | .344 | .329 | -.076 | .221 | .305 | 1.273 | .120 |
| B1.1.21 | -.009 | -.123 | -.072 | .029 | .263 | -.436 | .511 | -.336 | -.242 | .270 | -.252 | .683 | .185 | .172 | .940 |
| B1.1.22 | -.200 | .115 | .109 | .100 | .608 | -.067 | .186 | -.007 | .164 | -.196 | -.073 | -.069 | -.642 | .391 | .753 |
| B1.1.23 | -.020 | -.055 | -.172 | -.060 | .064 | .053 | .510 | .571 | -.396 | -.259 | .573 | .126 | -.079 | .073 | .257 |
| B1.2.1 | .721 | .218 | .137 | .254 | -.053 | .733 | -.526 | -.271 | -.204 | -.443 | .338 | .374 | .235 | .467 | .208 |
| B1.2.6 | -.009 | .303 | -.303 | -.476 | .198 | .384 | .166 | .219 | -.034 | .262 | -.335 | -.689 | .423 | -.172 | .380 |
| B1.2.8 | -.680 | -.027 | -.090 | -.152 | .664 | -.096 | .813 | -.648 | .533 | -.271 | .468 | .025 | .399 | -.024 | -.580 |
| B1.3.4 | -.106 | -.601 | .356 | .597 | .292 | .390 | .082 | .062 | -.391 | .367 | -.250 | -.056 | -.093 | .026 | -.240 |
| B1.3.5 | .147 | .362 | .179 | -.186 | -.048 | .381 | -.117 | .236 | .517 | .459 | .214 | .476 | -.112 | -.325 | .233 |
| B1.4.1 | .317 | .046 | -.578 | .572 | -.110 | -.230 | .327 | -.139 | .415 | .134 | .132 | -.012 | -.290 | -.136 | -.164 |
| B1.4.2 | .334 | .515 | .215 | .037 | -.881 | .088 | -.175 | -.127 | -.908 | -.006 | -.618 | .011 | -.621 | .469 | .113 |

## Classification Results[a]

| | | Site | Predicted Group Membership | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | |
| Original | Count | 1 | 33 | 9 | 13 | 4 | 5 | 5 | 15 | 1 | 11 | 1 | 5 | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 4 | 0 | 0 | 3 | 4 | 1 | 0 | 132 |
| | | 2 | 0 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| | | 3 | 4 | 9 | 18 | 3 | 5 | 1 | 1 | 0 | 3 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 58 |
| | | 4 | 1 | 0 | 5 | 41 | 2 | 3 | 2 | 7 | 3 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 3 | 4 | 3 | 5 | 3 | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 1 | 0 | 0 | 96 |
| | | 5 | 5 | 3 | 8 | 5 | 14 | 3 | 4 | 1 | 6 | 5 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 0 | 0 | 70 |
| | | 6 | 2 | 6 | 8 | 2 | 8 | 128 | 14 | 0 | 7 | 1 | 2 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 3 | 0 | 1 | 199 |
| | | 7 | 5 | 5 | 1 | 0 | 2 | 3 | 27 | 2 | 1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 54 |
| | | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| | | 9 | 2 | 0 | 2 | 5 | 2 | 1 | 2 | 0 | 13 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 36 |
| | | 10 | 5 | 4 | 10 | 4 | 6 | 0 | 5 | 0 | 4 | 34 | 6 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 9 | 2 | 0 | 8 | 0 | 2 | 0 | 110 |
| | | 11 | 1 | 3 | 1 | 2 | 7 | 2 | 1 | 2 | 0 | 7 | 22 | 9 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 3 | 2 | 0 | 5 | 0 | 0 | 11 | 0 | 2 | 4 | 1 | 1 | 2 | 98 |
| | | 12 | 5 | 0 | 0 | 6 | 3 | 3 | 2 | 1 | 7 | 5 | 4 | 44 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 10 | 0 | 0 | 109 |
| | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 1 | 7 | 6 | 0 | 4 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 5 | 0 | 1 | 0 | 0 | 1 | 83 |
| | | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 46 | 6 | 0 | 2 | 3 | 0 | 0 | 1 | 3 | 3 | 3 | 0 | 0 | 3 | 4 | 4 | 1 | 0 | 1 | 5 | 5 | 0 | 0 | 1 | 99 |
| | | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 3 | 1 | 0 | 7 | 3 | 39 | 6 | 3 | 9 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 4 | 2 | 0 | 1 | 4 | 0 | 6 | 0 | 1 | 1 | 101 |
| | | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 3 | 0 | 3 | 70 | 10 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 101 |
| | | 17 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 4 | 57 | 11 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 87 |
| | | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 | 2 | 1 | 3 | 4 | 78 | 2 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 110 |
| | | 19 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 66 | 6 | 4 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 7 | 0 | 0 | 3 | 2 | 2 | 0 | 1 | 100 |
| | | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 74 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 86 |
| | | 21 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 1 | 8 | 0 | 64 | 3 | 1 | 1 | 4 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 7 | 2 | 0 | 0 | 108 |
| | | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 32 | 5 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 4 | 0 | 1 | 69 |
| | | 23 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 70 | 13 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 102 |
| | | 24 | 0 | 0 | 2 | 6 | 1 | 0 | 0 | 3 | 3 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 57 | 2 | 3 | 4 | 3 | 1 | 2 | 0 | 1 | 6 | 1 | 0 | 1 | 1 | 110 |
| | | 25 | 0 | 0 | 0 | 2 | 2 | 1 | 0 | 1 | 2 | 2 | 5 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 4 | 1 | 4 | 8 | 1 | 7 | 9 | 10 | 2 | 4 | 2 | 5 | 1 | 0 | 2 | 4 | 0 | 1 | 2 | 87 |
| | | 26 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 4 | 5 | 0 | 0 | 1 | 4 | 2 | 1 | 2 | 0 | 9 | 4 | 20 | 6 | 5 | 1 | 4 | 4 | 0 | 3 | 0 | 0 | 3 | 5 | 91 |
| | | 27 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 6 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 6 | 2 | 2 | 6 | 4 | 21 | 3 | 5 | 0 | 3 | 0 | 3 | 0 | 1 | 0 | 13 | 83 |
| | | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 1 | 3 | 20 | 1 | 0 | 2 | 0 | 4 | 0 | 0 | 1 | 3 | 47 |
| | | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 2 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 2 | 0 | 2 | 0 | 5 | 2 | 14 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 50 |
| | | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 | 2 | 1 | 2 | 0 | 1 | 4 | 2 | 2 | 1 | 0 | 26 | 0 | 0 | 0 | 3 | 0 | 1 | 3 | 57 |
| | | 31 | 4 | 4 | 3 | 10 | 7 | 0 | 3 | 0 | 0 | 8 | 10 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 1 | 3 | 0 | 0 | 2 | 1 | 0 | 2 | 38 | 0 | 2 | 1 | 0 | 0 | 1 | 111 |
| | | 32 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 3 | 1 | 1 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 66 | 2 | 0 | 0 | 0 | 0 | 90 |
| | | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 4 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 53 | 0 | 0 | 1 | 0 | 70 |
| | | 34 | 0 | 2 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 2 | 2 | 0 | 1 | 4 | 1 | 1 | 1 | 0 | 5 | 0 | 5 | 1 | 0 | 1 | 2 | 1 | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 44 | 0 | 1 | 0 | 86 |
| | | 35 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 90 | 0 | 0 | 109 |
| | | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 5 | 0 | 2 | 4 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 83 | 0 | 108 |
| | | 37 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 2 | 1 | 7 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 22 | 42 |
| | % | 1 | 25.0 | 6.8 | 9.8 | 3.0 | 3.8 | 3.8 | 11.4 | .8 | 8.3 | .8 | 3.8 | 9.1 | .0 | .0 | .0 | .0 | .8 | .0 | .0 | .0 | .0 | .0 | 1.5 | .8 | .0 | .0 | .0 | .8 | .0 | .8 | 3.0 | .0 | .0 | 2.3 | 3.0 | .8 | .0 | 100.0 |
| | | 2 | .0 | 71.4 | 14.3 | .0 | .0 | 14.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 3 | 6.9 | 15.5 | 31.0 | 5.2 | 8.6 | 1.7 | 1.7 | .0 | 5.2 | 8.6 | 1.7 | .0 | .0 | .0 | .0 | .0 | 1.7 | .0 | .0 | .0 | 1.7 | .0 | 3.4 | 1.7 | 1.7 | .0 | .0 | .0 | .0 | .0 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 4 | 1.0 | .0 | 5.2 | 42.7 | 2.1 | 3.1 | 2.1 | 7.3 | 3.1 | 4.2 | .0 | 2.1 | .0 | .0 | .0 | .0 | .0 | .0 | 1.0 | .0 | 1.0 | .0 | 3.1 | 4.2 | 3.1 | 5.2 | 3.1 | .0 | .0 | .0 | 4.2 | .0 | 1.0 | .0 | 1.0 | .0 | .0 | 100.0 |
| | | 5 | 7.1 | 4.3 | 11.4 | 7.1 | 20.0 | 4.3 | 5.7 | 1.4 | 8.6 | 7.1 | .0 | 2.9 | .0 | 1.4 | .0 | .0 | .0 | .0 | .0 | .0 | 1.4 | 1.4 | 1.4 | 5.7 | .0 | .0 | .0 | .0 | 1.4 | .0 | .0 | 1.4 | .0 | 1.4 | 4.3 | .0 | .0 | 100.0 |
| | | 6 | 1.0 | 3.0 | 4.0 | 1.0 | 4.0 | 64.3 | 7.0 | .0 | 3.5 | .5 | 1.0 | 4.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.0 | .5 | .0 | .0 | .0 | .0 | .5 | .0 | .0 | .5 | .0 | .5 | 1.0 | .0 | 1.5 | .0 | .5 | 100.0 |
| | | 7 | 9.3 | 9.3 | 1.9 | .0 | 3.7 | 5.6 | 50.0 | 3.7 | 1.9 | 5.6 | .0 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | 100.0 |
| | | 8 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | 83.3 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 9 | 5.6 | .0 | 5.6 | 13.9 | 5.6 | 2.8 | 5.6 | .0 | 36.1 | 2.8 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.8 | 2.8 | .0 | .0 | .0 | .0 | .0 | .0 | 2.8 | .0 | .0 | .0 | 8.3 | .0 | .0 | 100.0 |
| | | 10 | 4.5 | 3.6 | 9.1 | 3.6 | 5.5 | .0 | 4.5 | .0 | 3.6 | 30.9 | 5.5 | 1.8 | .9 | .0 | .0 | 1.8 | .0 | .0 | .9 | .0 | 1.8 | .0 | .0 | .9 | .0 | .9 | .0 | .9 | .0 | .0 | 8.2 | 1.8 | .0 | 7.3 | .0 | 1.8 | .0 | 100.0 |
| | | 11 | 1.0 | 3.1 | 1.0 | 2.0 | 7.1 | 2.0 | 1.0 | 2.0 | .0 | 7.1 | 22.4 | 9.2 | .0 | 1.0 | 1.0 | .0 | 3.1 | .0 | .0 | 2.0 | 1.0 | .0 | .0 | 2.0 | 3.1 | 2.0 | .0 | 5.1 | .0 | .0 | 11.2 | .0 | 2.0 | 4.1 | 1.0 | 1.0 | 2.0 | 100.0 |
| | | 12 | 4.6 | .0 | .0 | 5.5 | 2.8 | 2.8 | 1.8 | .9 | 6.4 | 4.6 | 3.7 | 40.4 | .0 | 1.8 | .0 | .0 | .9 | .0 | .9 | .0 | .0 | 2.8 | 1.8 | 1.8 | .9 | .0 | .9 | .0 | .0 | .0 | .0 | .9 | 4.6 | .0 | 9.2 | .0 | .0 | 100.0 |
| | | 13 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 59.0 | 1.2 | 8.4 | 7.2 | .0 | 4.8 | .0 | 2.4 | 1.2 | .0 | 2.4 | .0 | .0 | .0 | 1.2 | 2.4 | 1.2 | .0 | .0 | 6.0 | .0 | 1.2 | .0 | .0 | 1.2 | 100.0 |
| | | 14 | .0 | .0 | 1.0 | .0 | .0 | .0 | 1.0 | .0 | .0 | .0 | .0 | .0 | 6.1 | 46.5 | 6.1 | .0 | 2.0 | 3.0 | .0 | .0 | 1.0 | 3.0 | 3.0 | 3.0 | .0 | .0 | 3.0 | 4.0 | 4.0 | 1.0 | .0 | 1.0 | 5.1 | 5.1 | .0 | .0 | 1.0 | 100.0 |
| | | 15 | .0 | 1.0 | .0 | .0 | .0 | .0 | 2.0 | .0 | 1.0 | 3.0 | 1.0 | .0 | 6.9 | 3.0 | 38.6 | 5.9 | 3.0 | 8.9 | .0 | 3.0 | .0 | 1.0 | .0 | .0 | .0 | 3.0 | .0 | 4.0 | 2.0 | .0 | 1.0 | 4.0 | .0 | 5.9 | .0 | 1.0 | 1.0 | 100.0 |
| | | 16 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.0 | .0 | .0 | 3.0 | .0 | 3.0 | 69.3 | 9.9 | 5.0 | .0 | .0 | 1.0 | .0 | 1.0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.0 | .0 | 1.0 | .0 | .0 | .0 | 2.0 | .0 | 100.0 |
| | | 17 | 1.1 | 1.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.1 | .0 | .0 | .0 | .0 | 4.6 | 4.6 | 65.5 | 12.6 | 1.1 | 1.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.1 | .0 | 4.6 | .0 | 1.1 | .0 | .0 | .0 | 100.0 |
| | | 18 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | 4.5 | 1.8 | .9 | 2.7 | 3.6 | 70.9 | 1.8 | 4.5 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .9 | .0 | .9 | .0 | .0 | .9 | .9 | .0 | 1.8 | .0 | 100.0 |
| | | 19 | .0 | .0 | .0 | 1.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.0 | 1.0 | .0 | .0 | .0 | 66.0 | 6.0 | 4.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | .0 | .0 | 1.0 | 7.0 | .0 | .0 | 3.0 | 2.0 | 2.0 | .0 | 1.0 | 100.0 |
| | | 20 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.2 | 2.3 | 86.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.3 | 1.2 | 3.5 | 1.2 | .0 | .0 | 1.2 | .0 | .0 | 1.2 | 100.0 |
| | | 21 | .0 | .9 | 2.8 | .0 | .9 | .0 | .0 | 2.8 | .0 | .9 | .0 | .0 | .9 | .9 | 2.8 | .0 | .0 | .9 | 7.4 | .0 | 59.3 | 2.8 | .9 | .9 | 3.7 | .9 | .0 | .0 | .9 | .9 | .0 | .0 | .0 | 6.5 | 1.9 | .0 | .0 | 100.0 |
| | | 22 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.4 | .0 | 4.3 | 1.4 | 2.9 | 1.4 | 1.4 | .0 | .0 | .0 | .0 | 1.4 | .0 | 2.9 | 46.4 | 7.2 | 4.3 | 4.3 | 1.4 | 2.9 | 2.9 | 1.4 | 1.4 | .0 | 1.4 | .0 | 1.4 | 5.8 | .0 | 1.4 | 100.0 |
| | | 23 | 1.0 | .0 | 2.0 | 1.0 | .0 | .0 | .0 | .0 | 1.0 | .0 | .0 | 1.0 | .0 | 1.0 | 1.0 | 1.0 | .0 | .0 | .0 | .0 | 2.0 | 2.0 | 68.6 | 12.7 | 1.0 | .0 | 1.0 | .0 | .0 | 1.0 | .0 | .0 | 2.0 | .0 | .0 | 1.0 | .0 | 100.0 |
| | | 24 | .0 | .0 | 1.8 | 5.5 | .9 | .0 | .0 | 2.7 | 2.7 | .0 | .9 | .9 | 1.8 | .9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .9 | 6.4 | 51.8 | 1.8 | 2.7 | 3.6 | 2.7 | .9 | 1.8 | .0 | .9 | 5.5 | .9 | .0 | .9 | .9 | 100.0 |
| | | 25 | .0 | .0 | .0 | 2.3 | 2.3 | 1.1 | .0 | 1.1 | 2.3 | 2.3 | 5.7 | 2.3 | .0 | 1.1 | 1.1 | 1.1 | .0 | .0 | 4.6 | 1.1 | 4.6 | 9.2 | 1.1 | 8.0 | 10.3 | 11.5 | 2.3 | 4.6 | 2.3 | 5.7 | 1.1 | .0 | 2.3 | 4.6 | .0 | 1.1 | 2.3 | 100.0 |
| | | 26 | .0 | 1.1 | .0 | 2.2 | 1.1 | .0 | .0 | 1.1 | .0 | .0 | 2.2 | .0 | 1.1 | 4.4 | 5.5 | .0 | .0 | 1.1 | 4.4 | 2.2 | 1.1 | 2.2 | .0 | 9.9 | 4.4 | 22.0 | 6.6 | 5.5 | 1.1 | 4.4 | 4.4 | .0 | 3.3 | .0 | .0 | 3.3 | 5.5 | 100.0 |
| | | 27 | .0 | .0 | .0 | 1.2 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | 1.2 | 1.2 | 7.2 | 1.2 | .0 | .0 | .0 | 1.2 | .0 | 1.2 | 7.2 | 2.4 | 2.4 | 7.2 | 4.8 | 25.3 | 3.6 | 6.0 | .0 | 3.6 | .0 | 3.6 | .0 | 1.2 | .0 | 15.7 | 100.0 |
| | | 28 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.1 | 2.1 | 2.1 | 6.4 | 2.1 | .0 | 2.1 | .0 | .0 | .0 | .0 | 6.4 | .0 | .0 | 2.1 | 2.1 | 6.4 | 42.6 | 2.1 | .0 | 4.3 | .0 | 8.5 | .0 | .0 | 2.1 | 6.4 | 100.0 |
| | | 29 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.0 | 4.0 | 4.0 | 4.0 | .0 | .0 | 2.0 | 6.0 | 2.0 | 2.0 | 2.0 | 4.0 | .0 | 4.0 | .0 | 10.0 | 4.0 | 28.0 | 10.0 | .0 | .0 | .0 | .0 | .0 | .0 | 12.0 | 100.0 |
| | | 30 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | .0 | 1.8 | .0 | .0 | .0 | .0 | 12.3 | 3.5 | 1.8 | 3.5 | .0 | 1.8 | 7.0 | 3.5 | 3.5 | 1.8 | .0 | 45.6 | .0 | .0 | .0 | 5.3 | .0 | 1.8 | 5.3 | 100.0 |
| | | 31 | 3.6 | 3.6 | 2.7 | 9.0 | 6.3 | .0 | 2.7 | .0 | .0 | 7.2 | 9.0 | .0 | 3.6 | .9 | .0 | .0 | .0 | .0 | .0 | .9 | 1.8 | 2.7 | .9 | 2.7 | .0 | .0 | 1.8 | .9 | .0 | 1.8 | 34.2 | .0 | 1.8 | .9 | .0 | .0 | .9 | 100.0 |
| | | 32 | 1.1 | 1.1 | 1.1 | .0 | .0 | .0 | 1.1 | .0 | 3.3 | .0 | .0 | .0 | 3.3 | 1.1 | 1.1 | 3.3 | 4.4 | .0 | .0 | .0 | .0 | .0 | 1.1 | .0 | 1.1 | .0 | .0 | 1.1 | .0 | .0 | .0 | 73.3 | 2.2 | .0 | .0 | .0 | .0 | 100.0 |
| | | 33 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.9 | .0 | .0 | .0 | 1.4 | .0 | .0 | .0 | .0 | 2.9 | .0 | .0 | .0 | 1.4 | 5.7 | .0 | 2.9 | .0 | 5.7 | .0 | .0 | .0 | .0 | 75.7 | .0 | .0 | 1.4 | .0 | 100.0 |
| | | 34 | .0 | 2.3 | .0 | .0 | 1.2 | .0 | 4.7 | .0 | .0 | 2.3 | 2.3 | .0 | 1.2 | 4.7 | 1.2 | 1.2 | 1.2 | .0 | 5.8 | .0 | 5.8 | 1.2 | .0 | 1.2 | 2.3 | 1.2 | .0 | 3.5 | 1.2 | .0 | .0 | 1.2 | 2.3 | 51.2 | .0 | 1.2 | .0 | 100.0 |
| | | 35 | .9 | .0 | .0 | .0 | 1.8 | 1.8 | .0 | .0 | .9 | .0 | .0 | 2.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .9 | 7.3 | .9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 82.6 | .0 | .0 | 100.0 |
| | | 36 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .9 | .0 | .9 | .0 | .0 | .9 | .9 | .9 | 1.9 | .0 | 4.6 | .0 | 1.9 | 3.7 | .0 | .9 | .0 | 2.8 | .0 | .0 | .0 | .9 | .0 | 76.9 | .0 | 100.0 |
| | | 37 | .0 | .0 | .0 | 4.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | 2.4 | .0 | 7.1 | .0 | .0 | .0 | 2.4 | 4.8 | 2.4 | 16.7 | .0 | 2.4 | .0 | .0 | .0 | 2.4 | .0 | 52.4 | 100.0 |

a. 50.5% of original grouped cases correctly classified.

## Male samples




### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 2.548[a] | 33.2 | 33.2 | .847 |
| 2 | 1.317[a] | 17.1 | 50.3 | .754 |
| 3 | .938[a] | 12.2 | 62.5 | .696 |
| 4 | .711[a] | 9.3 | 71.8 | .645 |
| 5 | .601[a] | 7.8 | 79.6 | .613 |
| 6 | .478[a] | 6.2 | 85.8 | .569 |
| 7 | .255[a] | 3.3 | 89.2 | .451 |
| 8 | .221[a] | 2.9 | 92.0 | .425 |
| 9 | .203[a] | 2.6 | 94.7 | .411 |
| 10 | .105[a] | 1.4 | 96.0 | .308 |
| 11 | .095[a] | 1.2 | 97.3 | .295 |
| 12 | .072[a] | .9 | 98.2 | .259 |
| 13 | .064[a] | .8 | 99.0 | .244 |
| 14 | .043[a] | .6 | 99.6 | .204 |
| 15 | .030[a] | .4 | 100.0 | .171 |

a. First 15 canonical discriminant functions were used in the analysis.

## Standardized Canonical Discriminant Function Coefficients

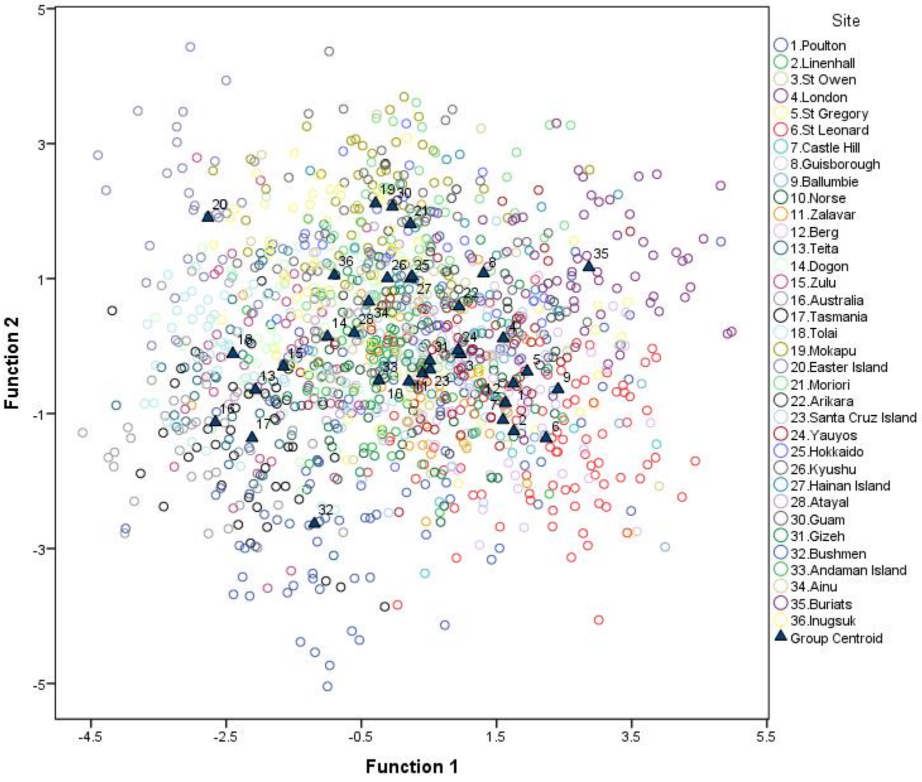
| | Function | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| B1.1.1 | .310 | -.314 | .783 | -.613 | -.625 | .015 | -.530 | .165 | -.211 | -.302 | .006 | .861 | .000 | .639 | -.590 |
| B1.1.4 | -.550 | .106 | .107 | .355 | .111 | .661 | .755 | .347 | .615 | .045 | -.355 | -.594 | -.705 | -.117 | -.049 |
| B1.1.5 | -.611 | .188 | .029 | -.575 | .328 | .142 | -.396 | -.109 | .016 | -.290 | .150 | -.072 | -.265 | .089 | .136 |
| B1.1.9 | .614 | .497 | .062 | .112 | -.108 | .135 | -.693 | -.522 | -.298 | .119 | .544 | .523 | -.020 | .262 | -.583 |
| B1.1.20 | -.086 | -.071 | -.113 | .206 | .111 | .190 | .147 | .185 | .575 | .391 | -.252 | .057 | .381 | -.939 | .468 |
| B1.1.21 | -.079 | -.097 | -.183 | .253 | .133 | .298 | .500 | .062 | -.359 | .280 | .025 | -.517 | -.204 | -.014 | 1.030 |
| B1.1.22 | -.338 | .158 | -.202 | .710 | .345 | -.075 | .197 | .139 | .088 | -.260 | -.458 | -.133 | .375 | .267 | .505 |
| B1.1.23 | .009 | -.050 | -.067 | -.029 | .084 | -.016 | .682 | -.313 | .349 | -.363 | .394 | .105 | .293 | -.018 | .258 |
| B1.2.1 | .735 | .110 | .142 | -.076 | .240 | -.468 | -.603 | -.096 | -.102 | -.542 | .289 | -.340 | .264 | -.414 | .318 |
| B1.2.6 | .061 | .251 | -.191 | -.064 | -.180 | -.523 | .281 | -.121 | .090 | .069 | -.382 | .506 | -.589 | .009 | .203 |
| B1.2.8 | -.561 | .090 | -.195 | .358 | -.052 | -.094 | .407 | .830 | -.469 | -.061 | .663 | .366 | -.090 | -.338 | -.324 |
| B1.3.4 | -.066 | -.440 | .547 | .156 | .553 | -.326 | .065 | -.329 | -.185 | .418 | .021 | .029 | .076 | -.043 | -.214 |
| B1.3.5 | .150 | .296 | -.006 | -.033 | -.168 | -.343 | -.280 | .298 | .562 | .323 | .345 | -.260 | .014 | .475 | .306 |
| B1.4.1 | .297 | -.053 | -.469 | -.253 | .556 | .339 | .110 | .476 | -.007 | .179 | .047 | .103 | .151 | .268 | -.183 |
| B1.4.2 | .379 | .482 | .276 | -.503 | -.095 | .070 | -.016 | -.651 | -.382 | .038 | -.729 | -.498 | .565 | .015 | .096 |

**Classification Results[a]**

| | | | Predicted Group Membership | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Site | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | Total |
| Original | Count | 1 | 28 | 6 | 7 | 1 | 0 | 2 | 10 | 1 | 8 | 3 | 1 | 8 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 2 | 2 | 0 | 0 | 92 |
| | | 2 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| | | 3 | 6 | 2 | 14 | 3 | 3 | 1 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 39 |
| | | 4 | 1 | 0 | 1 | 32 | 2 | 3 | 0 | 4 | 7 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 2 | 1 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 71 |
| | | 5 | 2 | 1 | 6 | 4 | 18 | 0 | 2 | 0 | 4 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 48 |
| | | 6 | 0 | 1 | 1 | 0 | 13 | 72 | 6 | 0 | 8 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 112 |
| | | 7 | 5 | 2 | 1 | 0 | 2 | 1 | 18 | 2 | 2 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 41 |
| | | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 12 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 16 |
| | | 9 | 1 | 0 | 3 | 3 | 2 | 1 | 2 | 0 | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 25 |
| | | 10 | 4 | 1 | 5 | 1 | 2 | 0 | 4 | 0 | 1 | 15 | 4 | 2 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 6 | 0 | 0 | 4 | 0 | 0 | 0 | 55 |
| | | 11 | 0 | 2 | 0 | 1 | 6 | 0 | 1 | 2 | 0 | 7 | 12 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 3 | 2 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 1 | 53 |
| | | 12 | 3 | 1 | 0 | 1 | 3 | 0 | 1 | 1 | 1 | 4 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 0 | 0 | 56 |
| | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 4 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 33 |
| | | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 24 | 2 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 2 | 4 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 47 |
| | | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 3 | 18 | 5 | 1 | 6 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 2 | 2 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 55 |
| | | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 40 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 52 |
| | | 17 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 32 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 45 |
| | | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 3 | 45 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 56 |
| | | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 33 | 2 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 51 |
| | | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 41 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 49 |
| | | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 3 | 0 | 41 | 0 | 3 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 57 |
| | | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 25 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 1 | 42 |
| | | 23 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 51 |
| | | 24 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 26 | 1 | 0 | 3 | 4 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 55 |
| | | 25 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 2 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 1 | 6 | 0 | 5 | 8 | 4 | 2 | 2 | 0 | 3 | 3 | 0 | 0 | 1 | 1 | 0 | 1 | 55 |
| | | 26 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 0 | 2 | 3 | 19 | 5 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 50 |
| | | 27 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 3 | 20 | 1 | 3 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 6 | 45 |
| | | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 2 | 12 | 1 | 0 | 2 | 0 | 4 | 1 | 0 | 0 | 1 | 29 |
| | | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 2 | 0 | 1 | 0 | 3 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 6 | 4 | 17 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 50 |
| | | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 30 |
| | | 31 | 4 | 1 | 1 | 2 | 4 | 0 | 2 | 0 | 0 | 3 | 7 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 2 | 1 | 2 | 0 | 2 | 18 | 1 | 0 | 1 | 0 | 0 | 0 | 58 |
| | | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 41 |
| | | 33 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 35 |
| | | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 48 |
| | | 35 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 55 |
| | | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 43 | 0 | 53 |
| | | 37 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 0 | 1 | 3 | 2 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 23 | 42 |
| | % | 1 | 30.4 | 6.5 | 7.6 | 1.1 | .0 | 2.2 | 10.9 | 1.1 | 8.7 | 3.3 | 1.1 | 8.7 | .0 | .0 | .0 | .0 | 1.1 | .0 | .0 | .0 | 1.1 | .0 | 4.3 | 1.1 | .0 | 1.1 | .0 | .0 | .0 | 1.1 | 3.3 | 1.1 | .0 | 2.2 | 2.2 | .0 | .0 | 100.0 |
| | | 2 | .0 | 80.0 | .0 | .0 | .0 | 20.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 3 | 15.4 | 5.1 | 35.9 | 7.7 | 7.7 | 2.6 | .0 | .0 | 7.7 | 5.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.1 | .0 | .0 | 5.1 | .0 | .0 | .0 | .0 | .0 | .0 | 2.6 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 4 | 1.4 | .0 | 1.4 | 45.1 | 2.8 | 4.2 | .0 | 5.6 | 9.9 | 1.4 | 1.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.8 | 9.9 | 2.8 | 1.4 | 1.4 | 1.4 | .0 | .0 | 4.2 | .0 | .0 | .0 | 2.8 | .0 | .0 | 100.0 |
| | | 5 | 4.2 | 2.1 | 12.5 | 8.3 | 37.5 | .0 | 4.2 | .0 | 8.3 | 2.1 | 2.1 | 2.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.1 | 2.1 | .0 | .0 | .0 | .0 | 2.1 | .0 | 2.1 | 2.1 | .0 | 2.1 | 4.2 | .0 | .0 | 100.0 |
| | | 6 | .0 | .9 | .9 | .0 | 11.6 | 64.3 | 5.4 | .0 | 7.1 | .0 | .9 | 3.6 | .0 | .0 | .0 | .0 | .0 | .0 | .9 | .0 | .9 | .0 | .9 | .0 | .0 | .0 | .9 | .9 | .0 | .0 | .0 | .0 | .0 | .0 | .9 | .0 | .0 | 100.0 |
| | | 7 | 12.2 | 4.9 | 2.4 | .0 | 4.9 | 2.4 | 43.9 | 4.9 | 4.9 | 2.4 | .0 | 9.8 | .0 | .0 | .0 | .0 | 2.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | .0 | .0 | 2.4 | .0 | .0 | 100.0 |
| | | 8 | .0 | .0 | .0 | 6.3 | .0 | .0 | .0 | 75.0 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.3 | .0 | .0 | 100.0 |
| | | 9 | 4.0 | .0 | 12.0 | 12.0 | 8.0 | 4.0 | 8.0 | .0 | 36.0 | .0 | .0 | 4.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.0 | .0 | .0 | 4.0 | 4.0 | .0 | .0 | 100.0 |
| | | 10 | 7.3 | 1.8 | 9.1 | 1.8 | 3.6 | .0 | 7.3 | .0 | 1.8 | 27.3 | 7.3 | 3.6 | 3.6 | .0 | .0 | 1.8 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.6 | .0 | .0 | 10.9 | .0 | .0 | 7.3 | .0 | .0 | .0 | 100.0 |
| | | 11 | .0 | 3.8 | .0 | 1.9 | 11.3 | .0 | 1.9 | 3.8 | .0 | 13.2 | 22.6 | 7.5 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | 3.8 | .0 | .0 | .0 | 3.8 | 5.7 | 3.8 | .0 | 1.9 | .0 | .0 | 9.4 | .0 | .0 | 1.9 | .0 | .0 | 1.9 | 100.0 |
| | | 12 | 5.4 | 1.8 | .0 | 1.8 | 5.4 | .0 | 1.8 | 1.8 | 1.8 | 7.1 | .0 | 58.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.6 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | .0 | 1.8 | .0 | 1.8 | 5.4 | .0 | .0 | 100.0 |
| | | 13 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 54.5 | .0 | 12.1 | 9.1 | .0 | 6.1 | .0 | 3.0 | .0 | .0 | 3.0 | 3.0 | .0 | .0 | .0 | 6.1 | .0 | .0 | .0 | 3.0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 14 | .0 | .0 | .0 | .0 | .0 | .0 | 2.1 | .0 | .0 | .0 | .0 | .0 | 4.3 | 51.1 | 4.3 | .0 | 6.4 | 4.3 | .0 | .0 | .0 | .0 | 2.1 | 4.3 | .0 | .0 | 2.1 | 4.3 | 8.5 | .0 | .0 | .0 | 2.1 | 2.1 | .0 | .0 | 2.1 | 100.0 |
| | | 15 | .0 | 1.8 | .0 | .0 | .0 | .0 | 1.8 | .0 | .0 | 1.8 | .0 | .0 | 5.5 | 5.5 | 32.7 | 9.1 | 1.8 | 10.9 | 1.8 | 3.6 | .0 | .0 | .0 | 1.8 | .0 | 3.6 | 3.6 | 3.6 | 3.6 | .0 | .0 | 1.8 | .0 | 3.6 | .0 | .0 | 1.8 | 100.0 |
| | | 16 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.8 | .0 | 3.8 | 76.9 | 9.6 | 3.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 17 | 2.2 | 2.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | 2.2 | 4.4 | 71.1 | 11.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | 100.0 |
| | | 18 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | 3.6 | 3.6 | 5.4 | 80.4 | 1.8 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | 100.0 |
| | | 19 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.0 | .0 | .0 | .0 | 64.7 | 3.9 | 3.9 | 3.9 | .0 | .0 | 3.9 | 3.9 | .0 | .0 | 2.0 | 7.8 | .0 | .0 | .0 | .0 | 2.0 | .0 | 2.0 | 100.0 |
| | | 20 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.1 | 83.7 | .0 | .0 | .0 | .0 | .0 | 2.0 | .0 | .0 | .0 | 4.1 | .0 | .0 | .0 | 2.0 | .0 | .0 | 2.0 | 100.0 |
| | | 21 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | 1.8 | .0 | .0 | .0 | 1.8 | 1.8 | .0 | .0 | .0 | 5.3 | .0 | 71.9 | .0 | 5.3 | .0 | 3.5 | 1.8 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | 3.5 | .0 | .0 | .0 | 100.0 |
| | | 22 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | 2.4 | .0 | .0 | 2.4 | .0 | .0 | .0 | .0 | 2.4 | .0 | 4.8 | 59.5 | 4.8 | .0 | 2.4 | .0 | .0 | 2.4 | .0 | 2.4 | .0 | .0 | .0 | 2.4 | 7.1 | 2.4 | 2.4 | 100.0 |
| | | 23 | 2.0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 78.4 | 7.8 | 2.0 | .0 | .0 | .0 | .0 | 2.0 | .0 | .0 | 2.0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 24 | .0 | .0 | .0 | 7.3 | 5.5 | .0 | .0 | 1.8 | 1.8 | .0 | .0 | 1.8 | .0 | 3.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 7.3 | 47.3 | 1.8 | .0 | 5.5 | 7.3 | 1.8 | 1.8 | .0 | .0 | 3.6 | .0 | .0 | .0 | 1.8 | 100.0 |
| | | 25 | .0 | .0 | .0 | 1.8 | 3.6 | .0 | .0 | .0 | 1.8 | 3.6 | 9.1 | 3.6 | .0 | .0 | .0 | .0 | .0 | 1.8 | 7.3 | .0 | 1.8 | 10.9 | .0 | 9.1 | 14.5 | 7.3 | 3.6 | 3.6 | .0 | 5.5 | 5.5 | .0 | .0 | 1.8 | 1.8 | .0 | 1.8 | 100.0 |
| | | 26 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.0 | 2.0 | 6.0 | .0 | .0 | .0 | 4.0 | 2.0 | 4.0 | 2.0 | .0 | 4.0 | 6.0 | 38.0 | 10.0 | 8.0 | .0 | 2.0 | 2.0 | .0 | .0 | .0 | .0 | 2.0 | 4.0 | 100.0 |
| | | 27 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | 2.2 | .0 | 2.2 | 4.4 | .0 | 2.2 | 2.2 | 6.7 | 44.4 | 2.2 | 6.7 | .0 | 2.2 | .0 | 4.4 | .0 | .0 | .0 | 13.3 | 100.0 |
| | | 28 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.4 | 3.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 6.9 | 3.4 | .0 | 3.4 | 6.9 | 41.4 | 3.4 | .0 | 6.9 | .0 | 13.8 | 3.4 | .0 | .0 | 3.4 | 100.0 |
| | | 29 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.0 | 6.0 | 4.0 | .0 | 2.0 | .0 | 6.0 | .0 | 2.0 | .0 | 2.0 | 4.0 | 2.0 | .0 | 12.0 | 8.0 | 34.0 | 4.0 | .0 | .0 | 2.0 | .0 | .0 | .0 | 8.0 | 100.0 |
| | | 30 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 13.3 | 13.3 | 3.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 56.7 | 3.3 | .0 | .0 | .0 | .0 | .0 | 10.0 | 100.0 |
| | | 31 | 6.9 | 1.7 | 1.7 | 3.4 | 6.9 | .0 | 3.4 | .0 | .0 | 5.2 | 12.1 | .0 | 5.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.4 | 1.7 | 1.7 | .0 | .0 | 3.4 | 1.7 | 3.4 | .0 | 3.4 | 31.0 | 1.7 | .0 | 1.7 | .0 | .0 | .0 | 100.0 |
| | | 32 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | .0 | 4.9 | .0 | .0 | .0 | 2.4 | .0 | 2.4 | 4.9 | 4.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 78.0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 33 | .0 | 2.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.9 | .0 | .0 | 2.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.9 | .0 | 2.9 | .0 | 5.7 | .0 | .0 | .0 | .0 | 80.0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 34 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.2 | 4.2 | .0 | 2.1 | 2.1 | .0 | .0 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | .0 | 2.1 | .0 | 2.1 | 2.1 | .0 | .0 | 2.1 | .0 | .0 | .0 | .0 | 68.8 | .0 | .0 | .0 | 100.0 |
| | | 35 | 1.8 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.1 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 85.5 | .0 | .0 | 100.0 |
| | | 36 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | 1.9 | .0 | .0 | 1.9 | 1.9 | .0 | 1.9 | .0 | 3.8 | .0 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | 81.1 | .0 | 100.0 |
| | | 37 | .0 | .0 | .0 | 2.4 | 2.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | .0 | .0 | .0 | .0 | 2.4 | 2.4 | .0 | 4.8 | 2.4 | .0 | .0 | 2.4 | 7.1 | 4.8 | 9.5 | .0 | 2.4 | .0 | .0 | .0 | .0 | .0 | 54.8 | 100.0 |

a. 53.8% of original grouped cases correctly classified.

# Female samples




## Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 2.370[a] | 32.0 | 32.0 | .839 |
| 2 | 1.266[a] | 17.1 | 49.0 | .747 |
| 3 | 1.026[a] | 13.8 | 62.9 | .712 |
| 4 | .624[a] | 8.4 | 71.3 | .620 |
| 5 | .481[a] | 6.5 | 77.8 | .570 |
| 6 | .434[a] | 5.9 | 83.6 | .550 |
| 7 | .282[a] | 3.8 | 87.4 | .469 |
| 8 | .257[a] | 3.5 | 90.9 | .452 |
| 9 | .197[a] | 2.7 | 93.5 | .406 |
| 10 | .136[a] | 1.8 | 95.4 | .346 |
| 11 | .098[a] | 1.3 | 96.7 | .299 |
| 12 | .089[a] | 1.2 | 97.9 | .286 |
| 13 | .086[a] | 1.2 | 99.1 | .281 |
| 14 | .042[a] | .6 | 99.6 | .200 |
| 15 | .027[a] | .4 | 100.0 | .162 |

a. First 15 canonical discriminant functions were used in the analysis.

## Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| B1.1.1 | -.473 | -.384 | .547 | -.343 | -.206 | .573 | -.468 | -.227 | .201 | -.410 | -1.176 | .215 | .595 | -.191 | -.062 |
| B1.1.4 | .297 | .068 | .301 | .153 | -.567 | -.559 | .145 | .575 | .422 | -.585 | .638 | .066 | -.564 | .093 | .427 |
| B1.1.5 | .715 | -.011 | .000 | .452 | -.005 | .234 | -.346 | -.312 | .024 | .045 | -.056 | .172 | .040 | -.244 | .400 |
| B1.1.9 | -.275 | .547 | .004 | .138 | .365 | -.427 | -.403 | -.266 | -.349 | -.080 | -.980 | -.035 | .489 | -.389 | -.195 |
| B1.1.20 | .130 | -.040 | -.047 | .044 | -.323 | -.151 | .051 | .531 | .243 | .680 | .845 | .121 | .001 | -.023 | -.613 |
| B1.1.21 | -.042 | -.014 | .040 | .006 | -.280 | -.330 | .778 | -.253 | -.110 | .437 | .751 | -.224 | -.132 | -.015 | .544 |
| B1.1.22 | .089 | .224 | -.025 | -.123 | .068 | -.199 | .356 | -.097 | .231 | .448 | .353 | .185 | -.362 | .944 | .213 |
| B1.1.23 | .069 | -.065 | -.043 | .017 | .033 | .133 | .192 | .579 | -.605 | .365 | -.089 | .264 | -.274 | .111 | .301 |
| B1.2.1 | -.543 | .361 | -.030 | .051 | .568 | .557 | -.322 | -.419 | -.281 | .349 | .434 | .297 | -.128 | -.212 | -.053 |
| B1.2.6 | .102 | .131 | -.362 | -.333 | .138 | .124 | .073 | .387 | .029 | -.240 | .193 | .027 | .783 | .228 | .329 |
| B1.2.8 | .605 | -.246 | .016 | -.119 | .369 | -.310 | .966 | .003 | .308 | -.340 | -.206 | .702 | -.271 | -.300 | -.291 |
| B1.3.4 | .070 | -.263 | .621 | .330 | .520 | -.113 | .049 | .045 | -.139 | .032 | .081 | -.514 | .152 | .261 | -.177 |
| B1.3.5 | -.106 | .327 | -.123 | -.412 | .200 | .173 | -.100 | .253 | .565 | .321 | -.146 | -.392 | -.191 | -.425 | .315 |
| B1.4.1 | -.263 | -.037 | -.281 | .750 | -.129 | .099 | .391 | .100 | .358 | -.001 | -.375 | -.030 | -.175 | .004 | -.063 |
| B1.4.2 | -.182 | .631 | .008 | .044 | -.575 | .614 | -.275 | -.389 | -.712 | .007 | .186 | -.637 | .107 | .405 | -.311 |

**Classification Results[a]**

| | | | Predicted Group Membership | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Site | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | Total |
| Original | Count | 1 | 13 | 3 | 3 | 4 | 3 | 1 | 3 | 0 | 1 | 0 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 40 |
| | | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | | 3 | 2 | 2 | 10 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 |
| | | 4 | 0 | 0 | 3 | 7 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 25 |
| | | 5 | 3 | 1 | 2 | 0 | 4 | 3 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 |
| | | 6 | 1 | 5 | 4 | 2 | 3 | 60 | 1 | 0 | 2 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 87 |
| | | 7 | 1 | 2 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| | | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 10 |
| | | 10 | 3 | 2 | 5 | 1 | 0 | 1 | 1 | 0 | 1 | 18 | 5 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 4 | 0 | 1 | 55 |
| | | 11 | 4 | 0 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 3 | 8 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 1 | 9 | 0 | 0 | 1 | 0 | 1 | 45 |
| | | 12 | 2 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 4 | 4 | 4 | 21 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 53 |
| | | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 2 | 3 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 50 |
| | | 14 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 21 | 3 | 0 | 1 | 3 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 3 | 4 | 0 | 0 | 1 | 3 | 3 | 0 | 0 | 52 |
| | | 15 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 4 | 0 | 24 | 2 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 46 |
| | | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 33 | 3 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 49 |
| | | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 28 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 42 |
| | | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 1 | 0 | 42 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 54 |
| | | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 4 | 3 | 0 | 1 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 49 |
| | | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 |
| | | 21 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 1 | 3 | 0 | 31 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 3 | 2 | 1 | 51 |
| | | 22 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 27 |
| | | 23 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 36 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 51 |
| | | 24 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 33 | 1 | 4 | 1 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 55 |
| | | 25 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 2 | 9 | 3 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 32 |
| | | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 3 | 0 | 2 | 4 | 12 | 2 | 3 | 1 | 3 | 0 | 2 | 2 | 0 | 1 | 41 |
| | | 27 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 2 | 2 | 16 | 2 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 38 |
| | | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 11 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 18 |
| | | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 2 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 27 |
| | | 31 | 1 | 0 | 2 | 6 | 2 | 0 | 1 | 0 | 0 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 4 | 2 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 53 |
| | | 32 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 2 | 2 | 0 | 0 | 49 |
| | | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 29 | 0 | 0 | 0 | 35 |
| | | 34 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 18 | 0 | 0 | 38 |
| | | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 0 | 54 |
| | | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 46 | 55 |
| | % | 1 | 32.5 | 7.5 | 7.5 | 10.0 | 7.5 | 2.5 | 7.5 | .0 | 2.5 | .0 | 7.5 | 2.5 | .0 | .0 | 2.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.5 | .0 | .0 | .0 | .0 | .0 | 2.5 | .0 | .0 | .0 | .0 | 5.0 | .0 | 100.0 |
| | | 2 | .0 | 50.0 | 50.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 3 | 10.5 | 10.5 | 52.6 | .0 | 5.3 | .0 | 5.3 | .0 | .0 | 5.3 | .0 | .0 | .0 | .0 | .0 | .0 | 5.3 | .0 | .0 | .0 | .0 | .0 | 5.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 4 | .0 | .0 | 12.0 | 28.0 | .0 | 4.0 | 8.0 | .0 | .0 | 4.0 | .0 | 16.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.0 | .0 | 4.0 | .0 | 4.0 | .0 | .0 | .0 | 16.0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 5 | 13.6 | 4.5 | 9.1 | .0 | 18.2 | 13.6 | 4.5 | 4.5 | 9.1 | 4.5 | 4.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.5 | .0 | 4.5 | 4.5 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 6 | 1.1 | 5.7 | 4.6 | 2.3 | 3.4 | 69.0 | 1.1 | .0 | 2.3 | .0 | 1.1 | 5.7 | .0 | .0 | .0 | .0 | .0 | .0 | 1.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.1 | .0 | .0 | .0 | .0 | 1.1 | .0 | .0 | .0 | 100.0 |
| | | 7 | 7.7 | 15.4 | .0 | .0 | .0 | .0 | 69.2 | .0 | .0 | 7.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 9 | 10.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 50.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.0 | 10.0 | 10.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 10.0 | .0 | 100.0 |
| | | 10 | 5.5 | 3.6 | 9.1 | 1.8 | .0 | 1.8 | 1.8 | .0 | 1.8 | 32.7 | 9.1 | .0 | 3.6 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | 1.8 | 1.8 | .0 | 1.8 | 1.8 | .0 | .0 | .0 | .0 | 10.9 | .0 | .0 | 7.3 | .0 | 1.8 | 100.0 |
| | | 11 | 8.9 | .0 | 4.4 | 2.2 | 2.2 | 4.4 | .0 | .0 | .0 | 6.7 | 17.8 | 11.1 | .0 | .0 | 2.2 | .0 | 2.2 | .0 | .0 | .0 | 2.2 | .0 | .0 | .0 | 2.2 | .0 | .0 | 6.7 | 2.2 | 20.0 | .0 | .0 | 2.2 | .0 | 2.2 | 100.0 |
| | | 12 | 3.8 | .0 | .0 | 3.8 | 1.9 | 1.9 | .0 | .0 | 7.5 | 7.5 | 7.5 | 39.6 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.7 | 3.8 | 1.9 | 3.8 | .0 | 1.9 | .0 | .0 | .0 | .0 | 1.9 | .0 | 5.7 | .0 | 100.0 |
| | | 13 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 64.0 | 4.0 | 6.0 | 2.0 | 2.0 | 2.0 | .0 | 2.0 | .0 | .0 | 4.0 | .0 | .0 | .0 | 2.0 | .0 | .0 | 2.0 | 10.0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 14 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | 5.8 | 40.4 | 5.8 | .0 | 1.9 | 5.8 | 1.9 | .0 | 1.9 | 1.9 | .0 | 3.8 | 1.9 | .0 | 5.8 | 7.7 | .0 | .0 | 1.9 | 5.8 | 5.8 | .0 | .0 | 100.0 |
| | | 15 | 4.3 | .0 | .0 | .0 | .0 | .0 | .0 | 2.2 | .0 | .0 | 2.2 | .0 | 8.7 | .0 | 52.2 | 4.3 | 4.3 | 6.5 | .0 | 4.3 | .0 | .0 | .0 | .0 | 4.3 | .0 | .0 | .0 | .0 | .0 | 4.3 | .0 | 2.2 | .0 | .0 | 100.0 |
| | | 16 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.1 | .0 | .0 | 2.0 | .0 | 4.1 | 67.3 | 6.1 | 6.1 | .0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.0 | .0 | 6.1 | 100.0 |
| | | 17 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.8 | 9.5 | 66.7 | 4.8 | 2.4 | 2.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 9.5 | .0 | .0 | .0 | .0 | 100.0 |
| | | 18 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | 1.9 | 3.7 | 3.7 | 1.9 | .0 | 77.8 | .0 | 1.9 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | 100.0 |
| | | 19 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 71.4 | 8.2 | 6.1 | .0 | 2.0 | .0 | 2.0 | .0 | 2.0 | 4.1 | .0 | .0 | .0 | .0 | .0 | 4.1 | .0 | 100.0 |
| | | 20 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 94.6 | .0 | .0 | .0 | .0 | 2.7 | .0 | .0 | 2.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 21 | .0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.9 | 2.0 | .0 | 2.0 | 5.9 | .0 | 60.8 | 3.9 | 2.0 | .0 | .0 | .0 | .0 | .0 | 3.9 | .0 | .0 | .0 | 5.9 | 3.9 | 2.0 | 100.0 |
| | | 22 | .0 | .0 | 3.7 | .0 | .0 | .0 | .0 | 3.7 | .0 | 7.4 | .0 | 3.7 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 48.1 | 3.7 | 7.4 | 3.7 | 3.7 | 7.4 | .0 | .0 | .0 | .0 | .0 | .0 | 3.7 | .0 | 100.0 |
| | | 23 | .0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | 3.9 | .0 | .0 | .0 | .0 | 2.0 | 2.0 | .0 | .0 | .0 | .0 | .0 | 2.0 | 3.9 | 70.6 | 9.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.0 | .0 | .0 | 2.0 | 100.0 |
| | | 24 | .0 | .0 | .0 | 3.6 | 1.8 | .0 | .0 | 1.8 | .0 | .0 | 3.6 | .0 | .0 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.6 | 3.6 | 60.0 | 1.8 | 7.3 | 1.8 | .0 | .0 | 1.8 | 1.8 | 5.5 | .0 | .0 | .0 | 100.0 |
| | | 25 | .0 | .0 | .0 | .0 | 3.1 | 3.1 | .0 | .0 | 3.1 | .0 | .0 | .0 | .0 | 6.3 | 3.1 | .0 | .0 | .0 | 3.1 | .0 | .0 | 6.3 | 3.1 | 6.3 | 28.1 | 9.4 | 3.1 | 9.4 | 6.3 | 3.1 | .0 | .0 | .0 | .0 | 3.1 | 100.0 |
| | | 26 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | .0 | .0 | .0 | .0 | .0 | .0 | 2.4 | .0 | .0 | 2.4 | 4.9 | 2.4 | .0 | 7.3 | .0 | 4.9 | 9.8 | 29.3 | 4.9 | 7.3 | 2.4 | 7.3 | .0 | 4.9 | 4.9 | .0 | 2.4 | 100.0 |
| | | 27 | .0 | .0 | .0 | 2.6 | .0 | .0 | .0 | .0 | .0 | .0 | 2.6 | .0 | 2.6 | 13.2 | .0 | .0 | .0 | .0 | .0 | .0 | 2.6 | 5.3 | .0 | .0 | 5.3 | 5.3 | 42.1 | 5.3 | 2.6 | 2.6 | .0 | 2.6 | .0 | 5.3 | .0 | 100.0 |
| | | 28 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 5.6 | 5.6 | 11.1 | 61.1 | 5.6 | .0 | .0 | 5.6 | .0 | .0 | .0 | 100.0 |
| | | 30 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 14.8 | .0 | 7.4 | 3.7 | .0 | .0 | 3.7 | 3.7 | 7.4 | 3.7 | 51.9 | .0 | .0 | .0 | 3.7 | .0 | .0 | 100.0 |
| | | 31 | 1.9 | .0 | 3.8 | 11.3 | 3.8 | .0 | 1.9 | .0 | .0 | 13.2 | 7.5 | .0 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | .0 | .0 | 1.9 | 1.9 | 7.5 | 3.8 | .0 | 37.7 | .0 | .0 | .0 | .0 | .0 | 100.0 |
| | | 32 | .0 | .0 | 2.0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 4.1 | 2.0 | 4.1 | 2.0 | 2.0 | .0 | .0 | .0 | .0 | 4.1 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 71.4 | 4.1 | 4.1 | .0 | .0 | 100.0 |
| | | 33 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.9 | .0 | 2.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 2.9 | 5.7 | .0 | .0 | 2.9 | 82.9 | .0 | .0 | .0 | 100.0 |
| | | 34 | .0 | .0 | 2.6 | .0 | 2.6 | .0 | .0 | .0 | 2.6 | 5.3 | .0 | 2.6 | .0 | 2.6 | 5.3 | .0 | .0 | .0 | 5.3 | .0 | 5.3 | 5.3 | .0 | .0 | 2.6 | .0 | 2.6 | 5.3 | 2.6 | .0 | .0 | .0 | 47.4 | .0 | .0 | 100.0 |
| | | 35 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.9 | 3.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 3.7 | 5.6 | 1.9 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 83.3 | .0 | 100.0 |
| | | 36 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.8 | .0 | 1.8 | .0 | 5.5 | .0 | .0 | .0 | 5.5 | .0 | .0 | .0 | .0 | .0 | 83.6 | 100.0 |

a. 56.4% of original grouped cases correctly classified.

# Appendix 10. Eigenvalues and Standardized Canonical Discriminant Function Coefficients for British medieval samples

## Non-pooled samples

### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 1.533[a] | 56.3 | 56.3 | .778 |
| 2 | .656[a] | 24.1 | 80.5 | .630 |
| 3 | .218[a] | 8.0 | 88.5 | .423 |
| 4 | .141[a] | 5.2 | 93.6 | .351 |
| 5 | .084[a] | 3.1 | 96.7 | .278 |
| 6 | .058[a] | 2.1 | 98.8 | .234 |
| 7 | .022[a] | .8 | 99.6 | .148 |
| 8 | .010[a] | .4 | 100.0 | .098 |

a. First 8 canonical discriminant functions were used in the analysis.

### Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| B1.1.1 | .212 | .352 | -.404 | .504 | -.445 | -.363 | .102 | -.810 |
| B1.1.4 | -.015 | -.117 | .309 | -.153 | .255 | .287 | -.378 | .725 |
| B1.1.5 | .124 | .015 | .005 | -.085 | -.431 | .557 | -.158 | -.128 |
| B1.1.9 | .075 | -.136 | -.210 | -.084 | .313 | -.527 | 1.025 | -.313 |
| B1.1.17 | -.224 | -.329 | -.521 | -.261 | -.264 | .803 | .370 | .366 |
| B1.1.18 | .058 | -.409 | .060 | .796 | -.625 | .024 | -.224 | .724 |
| B1.1.19 | .512 | .356 | -.009 | -.283 | .339 | -.033 | -.440 | .990 |
| B1.1.20 | .286 | .321 | .805 | .008 | .662 | -.281 | -.436 | -.335 |
| B1.1.21 | .197 | .578 | .058 | -1.019 | .698 | .290 | .194 | -.468 |
| B1.1.22 | -.789 | -.536 | -.099 | .092 | -.181 | -.104 | -.072 | -.446 |
| B1.1.23 | -.094 | -.021 | .430 | -.472 | .030 | .134 | -.332 | .232 |
| B1.2.1 | .175 | -.022 | -.250 | .520 | .337 | .233 | -.060 | -.450 |
| B1.2.6 | .019 | -.289 | -.114 | -.078 | .043 | -.335 | -.239 | .384 |
| B1.2.8 | -.216 | -.527 | .710 | .311 | .202 | .230 | -.049 | .024 |
| B1.3.4 | -.759 | .774 | -.005 | .214 | .115 | -.020 | .113 | .207 |
| B1.3.5 | .259 | -.045 | .296 | .067 | -.342 | -.530 | -.019 | -.315 |
| B1.4.1 | .115 | .007 | .348 | -.006 | -.324 | .006 | .379 | -.011 |
| B1.4.2 | .509 | .408 | -.389 | .121 | -.034 | .036 | .337 | .353 |

## Males

### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 1.648[a] | 51.6 | 51.6 | .789 |
| 2 | .955[a] | 29.9 | 81.4 | .699 |
| 3 | .250[a] | 7.8 | 89.2 | .447 |
| 4 | .139[a] | 4.4 | 93.6 | .350 |
| 5 | .095[a] | 3.0 | 96.6 | .294 |
| 6 | .056[a] | 1.8 | 98.3 | .231 |
| 7 | .032[a] | 1.0 | 99.3 | .176 |
| 8 | .022[a] | .7 | 100.0 | .146 |

a. First 8 canonical discriminant functions were used in the analysis.

### Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| B1.1.1 | .248 | -.380 | -.150 | .587 | -.326 | -.551 | -.027 | -.836 |
| B1.1.4 | -.040 | .157 | .274 | -.136 | .629 | .244 | -.541 | .625 |
| B1.1.5 | .040 | .056 | .106 | .144 | .521 | .237 | .105 | -.286 |
| B1.1.9 | .064 | .110 | -.125 | -.188 | -1.004 | -.194 | .362 | -.033 |
| B1.1.17 | -.077 | .287 | -.550 | -.250 | .725 | .565 | .485 | .598 |
| B1.1.18 | .197 | .597 | -.077 | .858 | .778 | -.579 | -.106 | .429 |
| B1.1.19 | .701 | -.288 | -.116 | -.186 | .161 | .543 | -.550 | .527 |
| B1.1.20 | .087 | -.140 | .771 | .062 | -.624 | -.002 | -.391 | -.521 |
| B1.1.21 | -.027 | -.642 | .160 | -1.075 | -.198 | .844 | .305 | -.113 |
| B1.1.22 | -.970 | .550 | -.175 | .115 | .199 | -.137 | .079 | -.270 |
| B1.1.23 | -.026 | .038 | .255 | -.562 | .161 | .195 | -.056 | -.043 |
| B1.2.1 | .101 | .090 | -.125 | .526 | -.542 | .138 | .479 | -.391 |
| B1.2.6 | .001 | .203 | -.148 | -.031 | .045 | -.011 | -.603 | .286 |
| B1.2.8 | -.223 | .472 | .615 | .138 | .042 | .325 | -.220 | -.031 |
| B1.3.4 | -.542 | -.903 | .059 | .124 | -.150 | .024 | -.014 | .210 |
| B1.3.5 | .165 | .195 | .207 | -.071 | .085 | -.614 | -.125 | -.190 |
| B1.4.1 | -.010 | .057 | .346 | -.079 | .126 | -.306 | .325 | .009 |
| B1.4.2 | .402 | -.333 | -.205 | .218 | -.193 | .059 | .540 | .559 |

## Females

### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 1.943[a] | 55.0 | 55.0 | .813 |
| 2 | .596[a] | 16.9 | 71.9 | .611 |
| 3 | .310[a] | 8.8 | 80.7 | .486 |
| 4 | .273[a] | 7.7 | 88.4 | .463 |
| 5 | .203[a] | 5.7 | 94.2 | .411 |
| 6 | .101[a] | 2.9 | 97.0 | .303 |
| 7 | .094[a] | 2.7 | 99.7 | .293 |
| 8 | .011[a] | .3 | 100.0 | .104 |

a. First 8 canonical discriminant functions were used in the analysis.

### Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| B1.1.1 | .078 | -.225 | .125 | .570 | -.774 | -.237 | .465 | -1.103 |
| B1.1.4 | -.045 | .153 | -.410 | -.223 | .547 | .037 | .164 | .350 |
| B1.1.5 | .110 | -.199 | -.052 | -.233 | -.699 | .180 | .126 | -.127 |
| B1.1.9 | -.023 | -.220 | -.294 | .226 | -.374 | -.074 | .407 | -.654 |
| B1.1.17 | -.295 | -.330 | -.343 | .422 | -.528 | -.328 | -.025 | .654 |
| B1.1.18 | -.167 | -.026 | .466 | .376 | .739 | .349 | .164 | .241 |
| B1.1.19 | .328 | .769 | -.023 | -.621 | .775 | .119 | -.553 | .542 |
| B1.1.20 | .494 | .686 | .012 | -.751 | .600 | .567 | -.061 | .017 |
| B1.1.21 | .500 | .418 | -.641 | -.421 | -.122 | -.292 | -.129 | .540 |
| B1.1.22 | -.422 | -.388 | .073 | .530 | .107 | -.487 | .443 | -.358 |
| B1.1.23 | -.230 | .162 | .253 | -.488 | .260 | .436 | .039 | -.195 |
| B1.2.1 | .285 | -.045 | -.106 | .462 | .153 | .500 | -.480 | -.170 |
| B1.2.6 | -.099 | -.354 | .001 | -.152 | .185 | -.476 | .282 | .067 |
| B1.2.8 | -.212 | -.253 | .367 | .019 | .364 | .187 | .741 | .346 |
| B1.3.4 | -.813 | .612 | -.082 | .441 | -.117 | .000 | -.183 | .148 |
| B1.3.5 | .470 | .238 | .443 | .057 | .059 | -.312 | .083 | -.227 |
| B1.4.1 | .229 | .031 | .336 | -.090 | -.120 | .146 | .343 | .147 |
| B1.4.2 | .601 | -.005 | -.118 | .268 | -.316 | .226 | -.695 | .058 |

# Appendix 11. Eigenvalues and Standardized Canonical Discriminant Function Coefficients for British and Howells' European samples

## Non-pooled samples

**Eigenvalues**

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 1.282[a] | 47.2 | 47.2 | .749 |
| 2 | .499[a] | 18.4 | 65.6 | .577 |
| 3 | .410[a] | 15.1 | 80.7 | .539 |
| 4 | .253[a] | 9.3 | 90.1 | .450 |
| 5 | .101[a] | 3.7 | 93.8 | .302 |
| 6 | .084[a] | 3.1 | 96.9 | .278 |
| 7 | .040[a] | 1.5 | 98.4 | .197 |
| 8 | .031[a] | 1.1 | 99.5 | .172 |
| 9 | .008[a] | .3 | 99.8 | .091 |
| 10 | .003[a] | .1 | 99.9 | .058 |
| 11 | .002[a] | .1 | 100.0 | .047 |

a. First 11 canonical discriminant functions were used in the analysis.

**Standardized Canonical Discriminant Function Coefficients**

| | Function | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| B1.1.1 | .573 | .603 | .489 | .075 | -.579 | -.278 | -.231 | .046 | -.271 | -.305 | .257 |
| B1.1.4 | -.251 | -.223 | .157 | -.002 | .511 | .050 | -.093 | -.619 | -.368 | -.809 | .176 |
| B1.1.5 | -.007 | -.342 | -.065 | .658 | -.583 | .034 | .502 | -.095 | -.084 | -.144 | .153 |
| B1.1.9 | .209 | -.045 | .130 | -.381 | -.172 | .522 | -.111 | .939 | .398 | .199 | .336 |
| B1.1.20 | -.033 | -.104 | .091 | .185 | .533 | .369 | .139 | -.582 | .448 | .271 | .090 |
| B1.1.21 | .068 | .143 | -.021 | .027 | .292 | .475 | .126 | -.110 | -.430 | .268 | -.536 |
| B1.1.22 | -.509 | -.157 | -.034 | -.331 | .022 | -.181 | -.264 | -.354 | -.097 | .128 | .297 |
| B1.1.23 | -.063 | -.055 | -.767 | .071 | .435 | .069 | -.109 | -.393 | .133 | .088 | -.158 |
| B1.2.1 | .312 | .146 | -.092 | -.342 | .036 | -.426 | .602 | .047 | .476 | .870 | -.058 |
| B1.2.6 | .014 | -.240 | .053 | -.234 | -.095 | -.022 | -.325 | -.006 | .174 | -.566 | -.808 |
| B1.2.8 | -.621 | -.808 | .496 | .116 | .475 | -.071 | .320 | .084 | -.524 | .079 | -.261 |
| B1.3.4 | -.786 | .800 | -.019 | .102 | .077 | -.025 | .111 | .221 | .195 | -.037 | -.086 |
| B1.3.5 | .215 | -.154 | .234 | .373 | .169 | -.263 | -.663 | .150 | .186 | .402 | -.060 |
| B1.4.1 | .177 | -.009 | -.297 | .146 | .378 | -.052 | -.059 | .425 | -.639 | .081 | .392 |
| B1.4.2 | .749 | .530 | -.307 | -.076 | -.227 | -.144 | .286 | .316 | .663 | -.358 | .265 |

## Males

### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 1.437[a] | 46.3 | 46.3 | .768 |
| 2 | .698[a] | 22.5 | 68.7 | .641 |
| 3 | .362[a] | 11.7 | 80.4 | .516 |
| 4 | .267[a] | 8.6 | 89.0 | .459 |
| 5 | .162[a] | 5.2 | 94.2 | .374 |
| 6 | .080[a] | 2.6 | 96.8 | .272 |
| 7 | .038[a] | 1.2 | 98.0 | .192 |
| 8 | .032[a] | 1.0 | 99.0 | .176 |
| 9 | .014[a] | .4 | 99.5 | .117 |
| 10 | .011[a] | .4 | 99.8 | .107 |
| 11 | .005[a] | .2 | 100.0 | .073 |

a. First 11 canonical discriminant functions were used in the analysis.

### Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| B1.1.1 | -.638 | .448 | -.731 | -.072 | -.202 | .224 | -.106 | .067 | .529 | -.013 | -.174 |
| B1.1.4 | .291 | -.166 | .081 | -.192 | .460 | -.022 | -.471 | .585 | -.237 | -.572 | -.319 |
| B1.1.5 | .052 | -.102 | .124 | -.712 | -.133 | .405 | .491 | .121 | -.111 | -.068 | -.081 |
| B1.1.9 | -.252 | -.142 | -.154 | .462 | -.244 | -.548 | .328 | -.678 | .115 | .105 | -.126 |
| B1.1.20 | .068 | -.158 | .089 | .012 | .425 | -.270 | .238 | .213 | .410 | .140 | -.140 |
| B1.1.21 | -.002 | .115 | .162 | .082 | .178 | -.204 | .117 | .581 | -.764 | .130 | .261 |
| B1.1.22 | .704 | -.293 | .140 | .234 | -.076 | .309 | -.273 | .327 | -.026 | .275 | -.308 |
| B1.1.23 | -.015 | .092 | .847 | .040 | .076 | -.215 | -.105 | .254 | .409 | .101 | .152 |
| B1.2.1 | -.292 | -.003 | .148 | .498 | .020 | .520 | .440 | -.544 | .257 | .574 | .507 |
| B1.2.6 | .010 | -.165 | -.040 | .123 | -.097 | -.013 | -.207 | .153 | .131 | -.858 | .414 |
| B1.2.8 | .475 | -.585 | -.236 | -.138 | .694 | -.229 | .313 | .150 | -.058 | .053 | .305 |
| B1.3.4 | .569 | .881 | -.119 | .059 | .136 | -.112 | .097 | -.286 | .067 | -.057 | .089 |
| B1.3.5 | -.145 | -.226 | -.071 | -.388 | .114 | -.079 | -.548 | -.370 | .089 | .324 | .282 |
| B1.4.1 | -.123 | -.017 | .301 | .035 | .303 | -.050 | -.338 | .082 | -.534 | .385 | -.096 |
| B1.4.2 | -.600 | .410 | .256 | .248 | -.212 | .448 | .195 | -.425 | -.238 | -.251 | -.727 |

## Females

### Eigenvalues

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 1.367[a] | 42.1 | 42.1 | .760 |
| 2 | .712[a] | 21.9 | 64.1 | .645 |
| 3 | .441[a] | 13.6 | 77.6 | .553 |
| 4 | .271[a] | 8.3 | 86.0 | .461 |
| 5 | .183[a] | 5.7 | 91.6 | .394 |
| 6 | .128[a] | 3.9 | 95.6 | .336 |
| 7 | .061[a] | 1.9 | 97.5 | .240 |
| 8 | .052[a] | 1.6 | 99.1 | .221 |
| 9 | .023[a] | .7 | 99.8 | .151 |
| 10 | .005[a] | .2 | 99.9 | .073 |
| 11 | .002[a] | .1 | 100.0 | .044 |

a. First 11 canonical discriminant functions were used in the analysis.

### Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| B1.1.1 | .321 | .240 | -.297 | .077 | -.449 | -.665 | .275 | -.275 | .957 | -.152 | -.255 |
| B1.1.4 | -.139 | .252 | .045 | -.317 | .463 | .466 | -.101 | .034 | .252 | .044 | -.582 |
| B1.1.5 | -.058 | -.325 | .545 | .021 | .223 | -.430 | -.247 | -.316 | .349 | .015 | .153 |
| B1.1.9 | .016 | -.035 | -.130 | -.225 | .145 | -.761 | .362 | .213 | -.079 | -.726 | .099 |
| B1.1.20 | .081 | .214 | .265 | .334 | .566 | .402 | -.438 | .049 | -.199 | .185 | .128 |
| B1.1.21 | .204 | .278 | .056 | .047 | .481 | .332 | .092 | .267 | -.580 | .496 | .044 |
| B1.1.22 | -.061 | .281 | -.044 | -.089 | -.041 | .618 | .260 | .046 | -.100 | -.044 | .587 |
| B1.1.23 | -.178 | -.428 | -.249 | .343 | .090 | .413 | -.155 | .425 | .315 | -.057 | .336 |
| B1.2.1 | .390 | .074 | -.246 | .003 | -.318 | -.024 | -.732 | .194 | -.256 | -.158 | .470 |
| B1.2.6 | -.029 | -.105 | .090 | -.454 | -.069 | .298 | .395 | -.134 | .356 | .497 | .311 |
| B1.2.8 | -.692 | .067 | .727 | -.549 | -.075 | .124 | -.020 | .641 | .113 | .137 | -.312 |
| B1.3.4 | -.731 | .448 | -.463 | .339 | -.112 | -.267 | -.053 | -.032 | -.238 | .206 | .223 |
| B1.3.5 | .291 | .295 | .435 | .345 | -.352 | .362 | .256 | .021 | -.007 | -.410 | -.186 |
| B1.4.1 | .177 | -.248 | .056 | .355 | -.014 | -.236 | .413 | .527 | .051 | .141 | -.259 |
| B1.4.2 | .824 | -.140 | -.315 | .170 | -.149 | -.439 | -.295 | -.174 | -.541 | .082 | .509 |

# Appendix 12. Eigenvalues and Standardized Canonical Discriminant Function Coefficients for British and Howells' samples

## Non-pooled samples

**Eigenvalues**

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 2.642[a] | 39.5 | 39.5 | .852 |
| 2 | 1.404[a] | 21.0 | 60.5 | .764 |
| 3 | .695[a] | 10.4 | 70.9 | .640 |
| 4 | .623[a] | 9.3 | 80.3 | .620 |
| 5 | .504[a] | 7.5 | 87.8 | .579 |
| 6 | .273[a] | 4.1 | 91.9 | .463 |
| 7 | .162[a] | 2.4 | 94.3 | .374 |
| 8 | .124[a] | 1.9 | 96.2 | .332 |
| 9 | .106[a] | 1.6 | 97.8 | .309 |
| 10 | .070[a] | 1.1 | 98.8 | .256 |
| 11 | .029[a] | .4 | 99.2 | .167 |
| 12 | .026[a] | .4 | 99.6 | .158 |
| 13 | .014[a] | .2 | 99.8 | .119 |
| 14 | .008[a] | .1 | 100.0 | .091 |
| 15 | .002[a] | .0 | 100.0 | .048 |

a. First 15 canonical discriminant functions were used in the analysis.

**Standardized Canonical Discriminant Function Coefficients**

| | Function | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| B1.1.1 | .348 | -.452 | -.151 | -1.090 | -.337 | -.324 | -.167 | .051 | .110 | -.272 | -.224 | -.268 | .028 | -1.412 | -.127 |
| B1.1.4 | -.376 | -.130 | .435 | .049 | -.035 | .837 | .418 | -.670 | .200 | -.312 | .616 | -.247 | -.477 | .555 | .673 |
| B1.1.5 | -.723 | .270 | -.315 | -.321 | .233 | .247 | .006 | -.174 | -.039 | -.086 | -.538 | .175 | .244 | -.150 | .283 |
| B1.1.9 | .507 | .524 | .565 | .015 | -.083 | -.045 | -.565 | .264 | .243 | .173 | -.691 | .329 | -.147 | -.824 | -.277 |
| B1.1.20 | .001 | -.080 | .006 | .182 | .048 | .294 | .429 | .077 | .401 | -.240 | .454 | .362 | .426 | .798 | -.683 |
| B1.1.21 | -.007 | -.072 | .106 | .143 | -.012 | .162 | .147 | .637 | -.271 | .153 | .109 | .024 | .133 | .928 | .726 |
| B1.1.22 | -.219 | -.042 | .300 | .512 | -.063 | -.180 | .114 | -.166 | -.216 | .207 | .208 | -.582 | .690 | .372 | .150 |
| B1.1.23 | .011 | -.092 | -.330 | .351 | .066 | .403 | -.012 | .020 | -.214 | .578 | .541 | .230 | .263 | -.189 | .078 |
| B1.2.1 | .606 | .122 | -.044 | -.117 | .400 | -.466 | .043 | -.306 | -.604 | .272 | -.474 | .606 | .399 | .222 | -.284 |
| B1.2.6 | .028 | .328 | -.241 | .289 | -.158 | -.525 | -.321 | -.053 | .226 | -.523 | .585 | .234 | .068 | -.170 | .442 |
| B1.2.8 | -.717 | .041 | .322 | .496 | -.348 | -.104 | 1.008 | .411 | -.494 | -.173 | .213 | .112 | -.523 | -.426 | -.177 |
| B1.3.4 | -.215 | -.731 | .265 | .187 | .716 | -.202 | -.364 | .199 | .128 | .028 | .024 | -.022 | -.175 | .013 | -.172 |
| B1.3.5 | .204 | .251 | .004 | -.159 | .027 | -.413 | .401 | -.183 | .644 | .574 | -.104 | .115 | .065 | .041 | .359 |
| B1.4.1 | .360 | .097 | -.286 | .354 | .275 | .350 | .503 | .255 | .173 | -.141 | -.339 | -.506 | -.062 | -.168 | .022 |
| B1.4.2 | .377 | .550 | -.222 | -.696 | .445 | .008 | -.950 | .040 | -.279 | .190 | .116 | -.516 | .101 | .567 | -.358 |

# Males

**Eigenvalues**

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 2.974[a] | 39.2 | 39.2 | .865 |
| 2 | 1.520[a] | 20.1 | 59.3 | .777 |
| 3 | .901[a] | 11.9 | 71.1 | .688 |
| 4 | .694[a] | 9.2 | 80.3 | .640 |
| 5 | .631[a] | 8.3 | 88.6 | .622 |
| 6 | .285[a] | 3.8 | 92.4 | .471 |
| 7 | .183[a] | 2.4 | 94.8 | .393 |
| 8 | .114[a] | 1.5 | 96.3 | .319 |
| 9 | .108[a] | 1.4 | 97.7 | .312 |
| 10 | .078[a] | 1.0 | 98.7 | .269 |
| 11 | .037[a] | .5 | 99.2 | .189 |
| 12 | .030[a] | .4 | 99.6 | .170 |
| 13 | .019[a] | .3 | 99.9 | .137 |
| 14 | .008[a] | .1 | 100.0 | .087 |
| 15 | .002[a] | .0 | 100.0 | .047 |

a. First 15 canonical discriminant functions were used in the analysis.

## Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| B1.1.1 | .227 | -.360 | -.825 | -.100 | -.683 | -.361 | -.153 | -.072 | -.116 | -.208 | -.131 | .138 | .350 | -.125 | -1.185 |
| B1.1.4 | -.396 | .027 | .228 | .275 | -.161 | .790 | .543 | -.196 | -.313 | -.333 | -.201 | .575 | -.651 | .474 | .462 |
| B1.1.5 | -.606 | .328 | -.497 | .032 | .174 | .199 | .076 | -.239 | -.056 | -.093 | -.199 | -.460 | .218 | .220 | -.115 |
| B1.1.9 | .548 | .460 | .106 | .141 | -.392 | -.140 | -.641 | .119 | -.247 | .289 | -.059 | -.592 | .029 | -.161 | -.753 |
| B1.1.20 | .025 | -.118 | .208 | .038 | .054 | .285 | .318 | .000 | -.348 | -.111 | .736 | -.033 | .165 | -.462 | .797 |
| B1.1.21 | .003 | -.020 | .160 | .109 | .128 | .198 | .009 | .538 | .282 | -.080 | -.060 | .049 | .143 | .739 | .892 |
| B1.1.22 | -.338 | .074 | .758 | .200 | .156 | -.058 | .126 | -.270 | .282 | .020 | -.129 | .400 | .553 | .098 | .342 |
| B1.1.23 | .053 | -.100 | .069 | -.127 | .363 | .580 | -.050 | -.091 | .373 | .380 | .490 | .246 | .107 | .168 | -.096 |
| B1.2.1 | .613 | .043 | -.074 | .188 | .066 | -.392 | .201 | -.418 | .615 | .292 | .176 | -.821 | .144 | -.203 | .138 |
| B1.2.6 | .092 | .268 | .026 | -.143 | .281 | -.493 | -.203 | -.206 | -.254 | -.339 | .455 | .369 | -.195 | .496 | -.130 |
| B1.2.8 | -.568 | .202 | .418 | -.144 | -.106 | -.025 | .657 | .879 | .298 | -.212 | .380 | -.002 | -.309 | -.110 | -.498 |
| B1.3.4 | -.174 | -.609 | -.062 | .736 | .298 | -.191 | -.305 | .208 | -.074 | .116 | .042 | -.009 | -.189 | -.188 | -.067 |
| B1.3.5 | .190 | .215 | -.046 | -.072 | -.021 | -.289 | .399 | -.130 | -.412 | .837 | -.131 | .021 | .185 | .355 | .096 |
| B1.4.1 | .385 | .017 | .149 | -.088 | .500 | .308 | .348 | .392 | -.288 | -.161 | -.457 | .004 | .303 | -.152 | -.149 |
| B1.4.2 | .404 | .441 | -.615 | .244 | .007 | -.058 | -.713 | -.332 | .400 | -.002 | -.363 | .311 | .137 | -.424 | .604 |

# Females

**Eigenvalues**

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 2.766[a] | 37.4 | 37.4 | .857 |
| 2 | 1.535[a] | 20.7 | 58.1 | .778 |
| 3 | .916[a] | 12.4 | 70.5 | .692 |
| 4 | .581[a] | 7.9 | 78.4 | .606 |
| 5 | .569[a] | 7.7 | 86.1 | .602 |
| 6 | .343[a] | 4.6 | 90.7 | .505 |
| 7 | .241[a] | 3.3 | 93.9 | .441 |
| 8 | .150[a] | 2.0 | 96.0 | .361 |
| 9 | .091[a] | 1.2 | 97.2 | .289 |
| 10 | .085[a] | 1.2 | 98.4 | .280 |
| 11 | .060[a] | .8 | 99.2 | .239 |
| 12 | .029[a] | .4 | 99.6 | .168 |
| 13 | .014[a] | .2 | 99.8 | .119 |
| 14 | .013[a] | .2 | 99.9 | .114 |
| 15 | .004[a] | .1 | 100.0 | .061 |

a. First 15 canonical discriminant functions were used in the analysis.

## Standardized Canonical Discriminant Function Coefficients

| | Function | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| B1.1.1 | -.536 | -.358 | .033 | .082 | -.720 | -.005 | -.528 | -.165 | .154 | -.768 | -.650 | .320 | .629 | -.136 | -.534 |
| B1.1.4 | .216 | -.092 | .455 | -.177 | .091 | -.630 | .271 | -.310 | -.524 | .812 | -.027 | .274 | .057 | -.432 | .471 |
| B1.1.5 | .711 | .123 | .003 | .344 | -.196 | -.291 | -.116 | -.044 | -.078 | -.268 | -.188 | -.140 | .351 | .378 | .236 |
| B1.1.9 | -.283 | .433 | .316 | -.397 | .441 | -.043 | -.474 | -.156 | .363 | -.928 | -.194 | -.159 | .194 | .119 | -.247 |
| B1.1.20 | .058 | .033 | .011 | .104 | .084 | -.079 | .793 | -.215 | .107 | .690 | .028 | -.497 | -.438 | .084 | -.465 |
| B1.1.21 | .005 | .018 | .157 | -.106 | -.046 | -.002 | .703 | .645 | .191 | .367 | .406 | -.145 | -.049 | -.014 | .752 |
| B1.1.22 | .119 | .071 | .091 | -.169 | .034 | .296 | .467 | .305 | -.266 | .509 | .543 | .583 | -.077 | .519 | .010 |
| B1.1.23 | .078 | -.108 | -.235 | .321 | .320 | -.100 | .139 | .154 | -.104 | .030 | .716 | -.042 | .439 | -.242 | -.234 |
| B1.2.1 | -.482 | .300 | .049 | .424 | -.091 | .392 | -.336 | .310 | -.266 | -.028 | .254 | -.670 | -.139 | .586 | .008 |
| B1.2.6 | .090 | .276 | -.342 | -.174 | .123 | .322 | -.271 | .053 | .360 | .602 | -.239 | .062 | .538 | -.161 | -.049 |
| B1.2.8 | .698 | -.231 | .135 | -.329 | .389 | .400 | .437 | .493 | -.772 | -.169 | -.446 | .092 | .033 | -.540 | -.208 |
| B1.3.4 | .118 | -.624 | .535 | .281 | .326 | .258 | -.189 | -.050 | .438 | .069 | .169 | .125 | -.281 | .077 | .012 |
| B1.3.5 | -.210 | .224 | -.040 | -.159 | -.296 | .556 | .229 | -.740 | -.111 | -.144 | .143 | -.235 | .255 | -.072 | .359 |
| B1.4.1 | -.203 | .194 | -.119 | .469 | .357 | -.064 | .477 | -.087 | -.114 | -.362 | -.365 | .452 | -.072 | -.061 | .149 |
| B1.4.2 | -.222 | .696 | .046 | .438 | -.568 | -.317 | -.504 | .184 | .648 | .052 | .500 | .135 | -.655 | .032 | -.059 |

# Appendix 13. Eigenvalues for British medieval samples

## Non-pooled samples

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 8.741 | 48.561 | 48.561 | 8.741 | 48.561 | 48.561 |
| 2 | 4.052 | 22.509 | 71.071 | 4.052 | 22.509 | 71.071 |
| 3 | 1.916 | 10.646 | 81.717 | 1.916 | 10.646 | 81.717 |
| 4 | 1.678 | 9.323 | 91.039 | 1.678 | 9.323 | 91.039 |
| 5 | .757 | 4.206 | 95.246 | | | |
| 6 | .430 | 2.390 | 97.635 | | | |
| 7 | .359 | 1.992 | 99.627 | | | |
| 8 | .067 | .373 | 100.000 | | | |
| 9 | 6.383E-16 | 3.546E-15 | 100.000 | | | |
| 10 | 5.438E-16 | 3.021E-15 | 100.000 | | | |
| 11 | 2.010E-16 | 1.116E-15 | 100.000 | | | |
| 12 | 1.342E-16 | 7.456E-16 | 100.000 | | | |
| 13 | 9.197E-17 | 5.110E-16 | 100.000 | | | |
| 14 | 4.687E-17 | 2.604E-16 | 100.000 | | | |
| 15 | -4.135E-18 | -2.297E-17 | 100.000 | | | |
| 16 | -1.951E-16 | -1.084E-15 | 100.000 | | | |
| 17 | -3.020E-16 | -1.678E-15 | 100.000 | | | |
| 18 | -1.303E-15 | -7.241E-15 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

## Males

### Total Variance Explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.964 | 44.242 | 44.242 | 7.964 | 44.242 | 44.242 |
| 2 | 4.062 | 22.566 | 66.807 | 4.062 | 22.566 | 66.807 |
| 3 | 2.233 | 12.408 | 79.216 | 2.233 | 12.408 | 79.216 |
| 4 | 1.602 | 8.902 | 88.118 | 1.602 | 8.902 | 88.118 |
| 5 | .997 | 5.541 | 93.659 | | | |
| 6 | .700 | 3.891 | 97.550 | | | |
| 7 | .309 | 1.715 | 99.265 | | | |
| 8 | .132 | .735 | 100.000 | | | |
| 9 | 2.333E-15 | 1.296E-14 | 100.000 | | | |
| 10 | 6.476E-16 | 3.598E-15 | 100.000 | | | |
| 11 | 3.573E-16 | 1.985E-15 | 100.000 | | | |
| 12 | 2.495E-16 | 1.386E-15 | 100.000 | | | |
| 13 | 1.071E-16 | 5.948E-16 | 100.000 | | | |
| 14 | 3.108E-17 | 1.727E-16 | 100.000 | | | |
| 15 | -1.420E-16 | -7.889E-16 | 100.000 | | | |
| 16 | -2.922E-16 | -1.623E-15 | 100.000 | | | |
| 17 | -3.309E-16 | -1.838E-15 | 100.000 | | | |
| 18 | -6.834E-16 | -3.796E-15 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

## Females

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 6.810 | 37.835 | 37.835 | 6.810 | 37.835 | 37.835 |
| 2 | 3.630 | 20.164 | 57.999 | 3.630 | 20.164 | 57.999 |
| 3 | 2.733 | 15.184 | 73.183 | 2.733 | 15.184 | 73.183 |
| 4 | 1.699 | 9.440 | 82.623 | 1.699 | 9.440 | 82.623 |
| 5 | 1.520 | 8.445 | 91.068 | 1.520 | 8.445 | 91.068 |
| 6 | .996 | 5.531 | 96.599 | | | |
| 7 | .612 | 3.401 | 100.000 | | | |
| 8 | 7.432E-16 | 4.129E-15 | 100.000 | | | |
| 9 | 4.353E-16 | 2.419E-15 | 100.000 | | | |
| 10 | 3.209E-16 | 1.783E-15 | 100.000 | | | |
| 11 | 1.262E-16 | 7.008E-16 | 100.000 | | | |
| 12 | 7.258E-17 | 4.032E-16 | 100.000 | | | |
| 13 | -1.401E-16 | -7.783E-16 | 100.000 | | | |
| 14 | -1.683E-16 | -9.349E-16 | 100.000 | | | |
| 15 | -2.213E-16 | -1.230E-15 | 100.000 | | | |
| 16 | -3.530E-16 | -1.961E-15 | 100.000 | | | |
| 17 | -6.674E-16 | -3.708E-15 | 100.000 | | | |
| 18 | -1.620E-15 | -9.000E-15 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

# Appendix 14. Eigenvalues for British and Howells' European samples

## Non-pooled samples

**Total Variance Explained**

| Component | Initial Eigenvalues Total | % of Variance | Cumulative % | Extraction Sums of Squared Loadings Total | % of Variance | Cumulative % |
|---|---|---|---|---|---|---|
| 1 | 6.463 | 43.087 | 43.087 | 6.463 | 43.087 | 43.087 |
| 2 | 2.721 | 18.138 | 61.225 | 2.721 | 18.138 | 61.225 |
| 3 | 1.909 | 12.724 | 73.948 | 1.909 | 12.724 | 73.948 |
| 4 | 1.710 | 11.398 | 85.346 | 1.710 | 11.398 | 85.346 |
| 5 | 1.078 | 7.189 | 92.536 | 1.078 | 7.189 | 92.536 |
| 6 | .677 | 4.514 | 97.050 | | | |
| 7 | .224 | 1.493 | 98.543 | | | |
| 8 | .129 | .862 | 99.406 | | | |
| 9 | .048 | .319 | 99.724 | | | |
| 10 | .032 | .215 | 99.939 | | | |
| 11 | .009 | .061 | 100.000 | | | |
| 12 | 6.398E-16 | 4.265E-15 | 100.000 | | | |
| 13 | 1.020E-16 | 6.800E-16 | 100.000 | | | |
| 14 | 8.045E-17 | 5.364E-16 | 100.000 | | | |
| 15 | -4.825E-16 | -3.216E-15 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

## Males

### Total Variance Explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.918 | 39.451 | 39.451 | 5.918 | 39.451 | 39.451 |
| 2 | 2.754 | 18.360 | 57.810 | 2.754 | 18.360 | 57.810 |
| 3 | 2.098 | 13.985 | 71.796 | 2.098 | 13.985 | 71.796 |
| 4 | 1.622 | 10.814 | 82.610 | 1.622 | 10.814 | 82.610 |
| 5 | 1.227 | 8.181 | 90.791 | 1.227 | 8.181 | 90.791 |
| 6 | .580 | 3.864 | 94.656 | | | |
| 7 | .469 | 3.129 | 97.785 | | | |
| 8 | .150 | .999 | 98.784 | | | |
| 9 | .111 | .739 | 99.523 | | | |
| 10 | .050 | .337 | 99.860 | | | |
| 11 | .021 | .140 | 100.000 | | | |
| 12 | 2.563E-16 | 1.708E-15 | 100.000 | | | |
| 13 | 1.991E-16 | 1.327E-15 | 100.000 | | | |
| 14 | -8.090E-17 | -5.394E-16 | 100.000 | | | |
| 15 | -3.488E-16 | -2.325E-15 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

## Females

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.822 | 32.144 | 32.144 | 4.822 | 32.144 | 32.144 |
| 2 | 3.693 | 24.618 | 56.762 | 3.693 | 24.618 | 56.762 |
| 3 | 2.048 | 13.651 | 70.414 | 2.048 | 13.651 | 70.414 |
| 4 | 1.517 | 10.110 | 80.524 | 1.517 | 10.110 | 80.524 |
| 5 | .976 | 6.509 | 87.033 | | | |
| 6 | .807 | 5.379 | 92.412 | | | |
| 7 | .684 | 4.559 | 96.971 | | | |
| 8 | .349 | 2.329 | 99.299 | | | |
| 9 | .101 | .674 | 99.974 | | | |
| 10 | .004 | .026 | 100.000 | | | |
| 11 | 5.311E-16 | 3.541E-15 | 100.000 | | | |
| 12 | 2.533E-16 | 1.689E-15 | 100.000 | | | |
| 13 | 2.002E-16 | 1.335E-15 | 100.000 | | | |
| 14 | -5.265E-17 | -3.510E-16 | 100.000 | | | |
| 15 | -5.170E-16 | -3.447E-15 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

# Appendix 15. Eigenvalues for British and Howells' samples

## Non-pooled samples

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.963 | 39.751 | 39.751 | 5.963 | 39.751 | 39.751 |
| 2 | 3.188 | 21.255 | 61.006 | 3.188 | 21.255 | 61.006 |
| 3 | 2.165 | 14.434 | 75.440 | 2.165 | 14.434 | 75.440 |
| 4 | 1.174 | 7.824 | 83.264 | 1.174 | 7.824 | 83.264 |
| 5 | .880 | 5.868 | 89.131 | | | |
| 6 | .615 | 4.102 | 93.233 | | | |
| 7 | .349 | 2.327 | 95.560 | | | |
| 8 | .220 | 1.464 | 97.023 | | | |
| 9 | .167 | 1.111 | 98.135 | | | |
| 10 | .131 | .872 | 99.007 | | | |
| 11 | .070 | .467 | 99.474 | | | |
| 12 | .048 | .323 | 99.796 | | | |
| 13 | .020 | .130 | 99.927 | | | |
| 14 | .007 | .047 | 99.974 | | | |
| 15 | .004 | .026 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

## Males

### Total Variance Explained

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 5.880 | 39.197 | 39.197 | 5.880 | 39.197 | 39.197 |
| 2 | 3.308 | 22.052 | 61.249 | 3.308 | 22.052 | 61.249 |
| 3 | 1.826 | 12.173 | 73.422 | 1.826 | 12.173 | 73.422 |
| 4 | 1.292 | 8.612 | 82.034 | 1.292 | 8.612 | 82.034 |
| 5 | .956 | 6.371 | 88.405 | | | |
| 6 | .636 | 4.243 | 92.649 | | | |
| 7 | .303 | 2.023 | 94.672 | | | |
| 8 | .289 | 1.926 | 96.598 | | | |
| 9 | .190 | 1.265 | 97.863 | | | |
| 10 | .123 | .823 | 98.686 | | | |
| 11 | .084 | .561 | 99.246 | | | |
| 12 | .057 | .378 | 99.625 | | | |
| 13 | .039 | .257 | 99.882 | | | |
| 14 | .016 | .106 | 99.987 | | | |
| 15 | .002 | .013 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

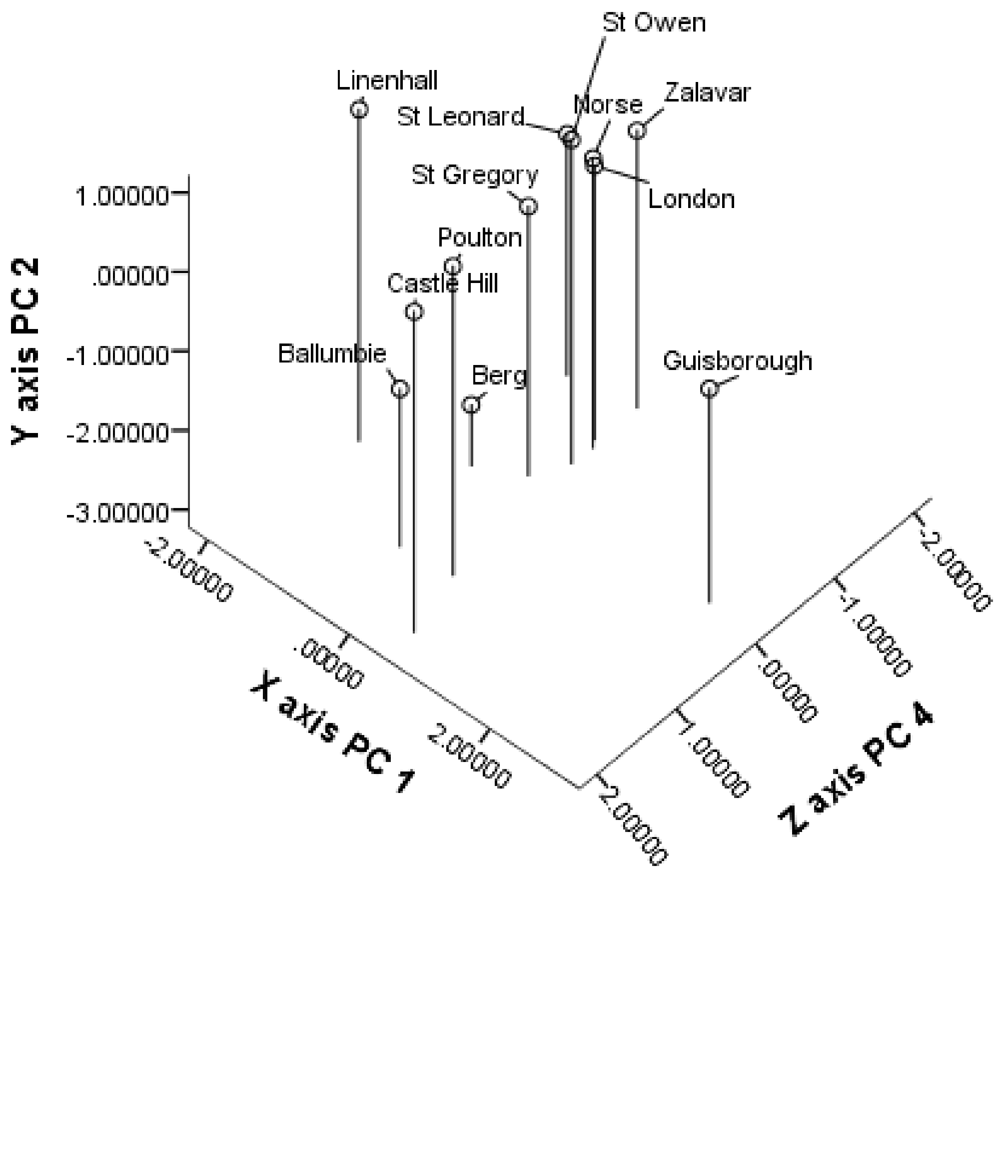
## Females

### Total Variance Explained

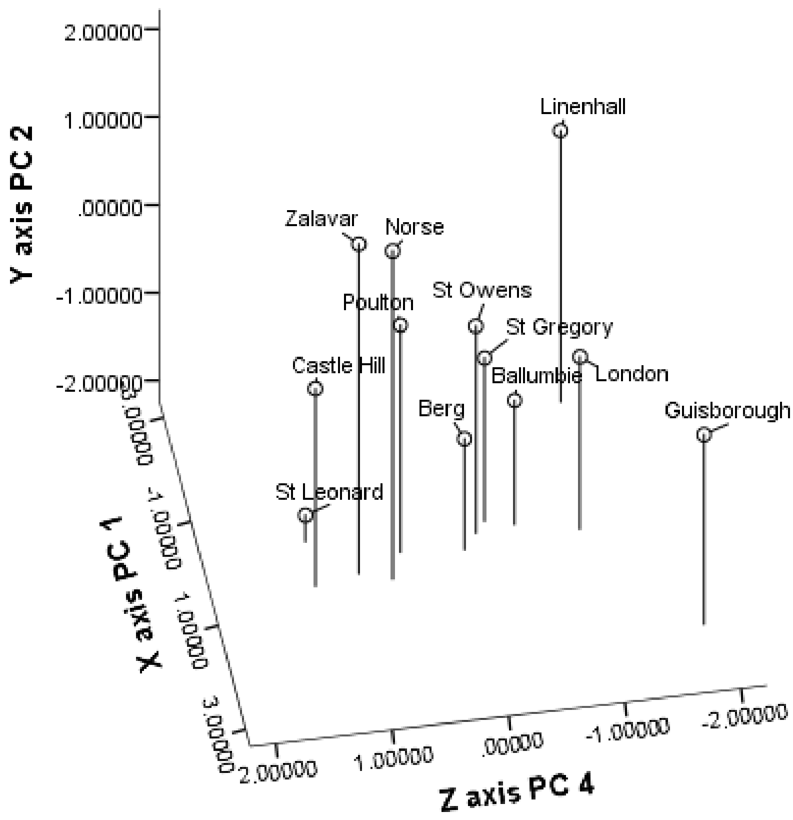
| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 4.871 | 32.475 | 32.475 | 4.871 | 32.475 | 32.475 |
| 2 | 3.727 | 24.849 | 57.324 | 3.727 | 24.849 | 57.324 |
| 3 | 2.586 | 17.239 | 74.563 | 2.586 | 17.239 | 74.563 |
| 4 | 1.215 | 8.102 | 82.665 | 1.215 | 8.102 | 82.665 |
| 5 | .730 | 4.864 | 87.528 | | | |
| 6 | .506 | 3.376 | 90.904 | | | |
| 7 | .473 | 3.154 | 94.058 | | | |
| 8 | .362 | 2.416 | 96.474 | | | |
| 9 | .205 | 1.366 | 97.840 | | | |
| 10 | .115 | .767 | 98.606 | | | |
| 11 | .098 | .652 | 99.259 | | | |
| 12 | .065 | .433 | 99.692 | | | |
| 13 | .029 | .195 | 99.887 | | | |
| 14 | .012 | .082 | 99.968 | | | |
| 15 | .005 | .032 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

Appendix 16. Three-dimensional scatterplot for PC1, PC2 and PC4 for the non-pooled British and Howells' European samples



Appendix 17. Three-dimensional scatterplot for PC1, PC2 and PC4 for the male British and Howells' European samples



Appendix 18. Three-dimensional scatterplot for PC1, PC2 and PC4 for the female British and Howells' European samples