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The Effects of Feudalism on Medieval English Mobility: A Biological Distance Study Using Nonmetric Cranial Traits.

Jonathan H. Barkmeier
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The Effects of Feudalism on Medieval English Mobility:
A Biological Distance Study Using Nonmetric Cranial Traits.

by

Jonathan H. Barkmeier

A thesis submitted in partial fulfillment
of the requirement for the degree of
Master of Arts in Applied Anthropology
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Abstract

Social and environmental factors play a key role in determining biocultural phenomena that can be observed on skeletal populations. Genetic markers in the form of nonmetric traits can help understand underlying questions about population movement and subsequent gene flow. During the medieval period in England, feudalism may have limited migration and created sedentary lifestyles for the peasant class who lived and worked on land owned by the nobility. By using a biological distance model, questions about the interactions between rural and urban populations, as well as the restrictive economic system that was in place during the Middle Ages, can be addressed by comparing the homogeneity (or lack thereof) among different English skeletal populations. This research sought to accomplish two primary goals: 1) Use embodiment theory to help understand how socio-cultural factors impact populations physically and, 2) Compare rural populations against urban populations to examine if migration was restricted in medieval England under feudalism, studies of which are currently lacking in the bioarchaeological literature. Results from the biological distance model show a significant genetic variation between sites at longer distances in medieval England. Socio-cultural factors as well as the networks of cities and their surrounding villages and towns may have played a part in migration during the Middle Ages.
Chapter 1: Introduction

1.1 Introduction

During the medieval period in England (circa 500 AD-1500AD), the rise of feudalism at the beginning of the 11th century played an important role in the class system and social control among the population. This era of English history is known to have changes in the political climate, economic growth, and geographic expansion resulting in rising population in both the urban and rural areas (Mortimer 2010). The introduction of the feudal system, however, may have restricted movement from those working in the rural area, as control based on a class system and land ownership was a defining aspect of feudal society. As the vast majority of the population were subject to a particular lord or baron, a restriction of movement would have been beneficial to landowners as a source of labor. This restriction of movement in turn could have limited migration between the populations, either within their own village or community, or nearby neighbors.

A recent study by Cesaretti et al. (2016) has countered this notion of restricted movement and highlighted the interconnections many towns and cities in medieval Europe had with one another. In particular, this work has emphasized trade routes and suggested widespread migrations to urban areas (Cesaretti et al. 2016). The expansion of cities and increasing populations made migration to larger urban hubs a more attractive offer than rural life. Through their models, Cesaretti et al. (2016) hypothesized that smaller communities may be more interconnected with each other or larger urban areas than previously thought. However, rural-rural movement was much more circumscribed than rural-urban migration although movement
into small towns involved no greater movements than migration within the countryside (Postles 2000).

This study examines phenotypic variation in the form of nonmetric cranial traits in order to understand genetic relationships between medieval English populations. Using a biological distance (biodistance) framework, genetic affinity can be tested between populations to answer questions of sociocultural interactions and movement at the inter- and intragroup levels (Buikstra et al. 1990). The close proximity between the three London populations used for this study could show a greater amount of genetic diversity in comparison to the two rural communities examined here. As London was a major European urban center during the medieval period, as well as the largest in England, intermixing between people from different areas may have been common. In the case of the rural sites, the smaller populations may have been more limited in their movements, as well as outside genetic influence, and therefore be more genetically homogenous. Analyzing nonmetric cranial traits from the rural areas and comparing the data from the London cemeteries could show if there are differences or patterns of nonmetric traits, supporting the idea of spatially separate populations outside major, urban centers. A lack of homogeneity within the rural population could provide evidence to strengthen Cesaretti et al.’s (2016) claim that populations in rural areas migrated to larger, urban areas more frequently.

This study starts with a broad overview of English history in the Middle Ages. Chapter two examines the time period in medieval England in which the feudal system dominated the economy. It also looks at lives of those within the system and how individuals were affected by it through previous historical scholarship. Chapter three outlines the history of nonmetric trait research and biodistance analysis. As a genetic basis for population kinship is assumed for these studies, literature regarding nonmetric trait and the link with genetics is included as well. The methods and
materials are discussed in chapter four with a brief history of the sites/ populations included in this study as well as definitions and descriptions of the nonmetric traits used. The statistical process is defined and how it will be used in conjunction with nonmetric trait data. Finally, chapters four and five (the results and discussion respectively), present the results of the biodistance analysis and places the findings in their historical context to help test the hypothesis about population movement in England.
Chapter 2: England and Feudalism in the Middle Ages

2.1 Introduction

The medieval period in England represents an era in which major sociopolitical changes occurred that had major effects on every social class within the country and would mark a period of growth, development, and innovation on not only the landscape and its people, but also on the political-economic climate in which it was set. Often history focuses on those who write it, in this case the kings, clergy, nobles, and artists who made up the minority of the population. This gives little attention to the vast majority of the population whose labor allowed society to function (Kowaleski 2014). As the majority were illiterate, we rely on documentation and interpretation by the minority of society (i.e. nobility, merchants, and clergy) to help understand their lives (Dyer 1994). By examining historical writing, in addition to using biological and archaeological sciences, the experiences of those who were most affected by feudal rule can be brought to light in a time where the social structure in England had control of the autonomy of those within it.

2.2 The Middle Ages

The period in history commonly referred to as the Middle Ages spans a large time frame and represents an era of political, social, and cultural change in European history. The notion of a single ‘Middle Ages’ has been used by many scholars to describe the time period of around 500-1500 AD within most of Europe (Grauer 2003; Nicholas 2014). However, as more specialized fields of historical study began to emerge, there became an issue of overgeneralization within
Europe (Power 2012). Later subdivisions within this larger time frame allowed historians to examine change in Europe while differentiating periods in the context of important events. German and English historians tended to divide the Middle Ages in ‘early’ (~500 AD-1000 AD), ‘high’ (~1000 AD-1350 AD), and ‘late’ (~1350 AD-1500 AD), while many Romance-speaking scholars preferred the distinction of ‘high’ and ‘low’ Middle Ages (Power 2012). Though the social and political climate developmentally changed throughout the Middle Ages in Europe, the high Middle Ages (~1000-1350 AD) can be seen as a period of stark change throughout the continent.

Within English history the start of the high Middle Ages commonly coincides with the Norman invasion of Britain \(^1\) in 1066 AD and the subsequent conquest as a result of William the Conqueror’s victory at the Battle of Hastings (Hollister 1994; Power 2012). Prior to the introduction of Norman culture in England, the political system of the early Middle Ages in Britain was slow to change, resulting in a gradual rate of growth economically and socially. During the high Middle, agricultural advances, such as the heavy plow and increased use of horses in farming, allowed an increased rate of food production as well as an introduction of a larger variety of food. While much of society resolved around agriculture, and would for the next few centuries, the economy was beginning to develop and diversify, with cities starting to flourish and become a crucial factor in the social and economic structure of England (Hollister 1994).

The English landscape was also altered to a large degree in the Middle Ages to match the growing economy which transformed not only the land, but the lives of those in it (Fleming

\(^1\) Britain refers to the main landmass that incorporates the modern-day countries of England, Wales, and Scotland. For the purposes of this study, the terms England/English are used to place the sample sites/populations in their geographic context within Britain.
2012). The resulting change with increased agriculture and expansion of the economic sector, in both rural and urban areas, allowed for the population to increase and sustain itself at a much higher rate than before. Villages and similar smaller communities at the beginning of the high Middle Ages comprised over 90 percent of the total population, consisting mostly of the peasant class (Gies & Gies 1990a; Carpenter 1992). In the twelfth and thirteenth century the increased population was a result of an ever-growing peasant class from the countryside. The total number of towns founded in England began to rise dramatically from 100 to 830 and those living in the towns increased from 10 percent of the population to almost 20 percent (Weir 1992). Previously uninhabited areas in Scotland and Wales also saw a small, but noticeable, population shift as well (Dyer 1994). The resulting shifts in population and the economy within the British Isles are some of the key factors that mark the high Middle Ages as an important time period for medieval England in terms of social, cultural, and political growth.

2.3 Feudalism in England

Conceptualizing the political and economic system of Europe in the Middle Ages is paramount to understanding what life was like for those residing within it. A single, definitive structure was not imposed on the entirety of the continent and differences occur, both temporally and in its application, among different societies. Feudalism became the overall political-economic system that dominated much of Europe during the Middle Ages in one form or another. Feudalism is more of a modern-day term used by medieval historians to describe the social structure and as such, is complicated to narrow down an exact definition (Sayles 1961; Jupp 2003). A classic definition used by many scholars as an overarching description comes from Francois-Louis Granshof (1944, p.xvi) in which feudalism is described as, “a set of reciprocal legal and military obligations among the warrior nobility, revolving around the three
key concepts of lords, vassals, and fiefs. This definition helps establish a baseline for the system in place though must be left open to interpretation. Sayles (1961, p.199) argues that:

…feudalism must remain in its meaning somewhat vague, indeterminate, and elastic, if it is to cover the activities of many peoples of diverse origins and traditions over a period of half a thousand years: it will mean something different in different places something different in the same place at different times. It is only a rough and ready summation of medieval society, a useful generalization to which exception are legion.

Under this assumption the feudal system can be understood at its base level and framed through cultural and social differences surrounding English society to contextualize how feudalism affected those that lived under its influence.

---

2 The terms lord, vassal, and fief are general descriptors used in the context of feudalism for individuals and the land in which they lived or worked. Lords generally owned the land (fief) and were in a superior role while vassals typically worked and lived in servitude to a local lord. These terms are expanded on in this study though Sayles (1961), Becket (1984), and Mortimer (2010) offer a more in-depth look into medieval terminology.
Though the application of Feudalism has its differences depending on the region of Europe in question, the base idea of the lord, vassal, and fief connection is an appropriate framework to help understand the application of the feudal system. Some scholars stress that the early intention of feudalism was militarily based (Hollister 1963; Bloch 2014) and that the necessity of heavily armed cavalry in early European warfare played a large role in the development of the feudal concept (Bloch 2014). As land-owning nobles (or the males in their families) were often the core of the cavalry-based armies, the buildup of feudal lands was a direct result of an effort to maintain internal order and the introduction of the vassal “land for military service” idea. In Anglo-Norman England however, this idea is often contradicted as internal, baronial revolts occurred occasionally in the eleventh and twelfth centuries (Hollister 1963), as well as the initiation and subsequent rise of “fiscal feudalism” that changed the implications of land ownership and military service (Carpenter 2000).

Diverting from the traditional aspect of military service for landownership in the feudal era, “fiscal feudalism” or “the money fief” became an ever-increasing concept through the Middle Ages in Europe. Classical feudal service sank into insignificance as noble landowners were able to use their economic gains from their lands to hire mercenary replacements for any military interests (Hollister 1963). With the alteration of the traditional viewpoint of the military-based feudal society to one that ran on economic incentive, lords did not retain the loyalty from their subjects who held their land and the close community of the court did not embrace the vassal-lord relationship that some historians may view as the inherent binding of the social system. Feudalism had, in essence, only become about self-sufficiency and the means to make money (Carpenter 2000). In either case, the lord, vassal, and fief still continued to be the basis of the social and economic system in Europe, though how feudal society ultimately ran varied from region to region.
In England, society was heavily influenced by the Norman Conquest at the beginning of high Middle Ages. Arriving from Normandy (located in northwestern France), the ethnic group known as the Normans comprised of previous Danish and Scandinavian peoples that had

Figure 2.2: Matthew Paris’ map of Great Britain (13th Century)

Source: The British Library; Public Domain

known as the Normans comprised of previous Danish and Scandinavian peoples that had
assimilated centuries before in France (Hadley 2012). Though the Normans altered some of the existing social and economic structures upon arrival, a similar land-based system was already place from prior centuries. The early Middle Ages (~5th century AD) saw ethnic groups from modern day Denmark and Germany (e.g. Angles, Saxons, and Jutes) establish themselves on the British Isles and structure a tenure of land, which had similar characteristics of Norman feudalism (Jupp 2003) The continental structure of feudalism was established by the Normans throughout English society, bridging the previously established concepts already in place in other areas in Europe. It can be argued that the Normans introduced the concept of the feudal fief on the previous system and since it did not arise gradually within England, Norman imposed feudalism is seen as a more “perfect” form of feudalism by historical scholars (Hollister 1963). It is this introduction where “fiscal feudalism” is seen as the dominant system that has replaced the previous socio-economic structure and become a defining feature of English society (Carpenter 2000). As this was put into place via conquest, the traditional, military-style feudalism has little semblance within Norman England society.

One aspect of Norman-introduced feudalism that differed from some regions in continental Europe is that under the common law the Monarchy owned and controlled all land within England. Those subjects under them had freehold tenure from the Crown and in essence were allowed the opportunity to live and work on the land (Jupp 2003). The previous structure of the English manor consisting of a large manor house (in which the lord may have resided in), the surrounding smaller village dwellings, and varying land acreage (typically in the hundreds) remained relatively unchanged following the Norman conquest (Nicholas 2014). However, large areas of previously uninhabited country were transformed (Hollister 1961). Previous centuries saw more loosely joined communities, though these slowly began to shape into dense, nucleated
villages surrounding an estate or manor (Fleming 2012). The gradual change in social and economic conditions had spurred the development of new lands for agricultural products. Swamps and marshes were drained to make room for more arable farmland in which the ruling class could profit from. This led to an increased surplus that allowed for increased financial growth within the country based on land use, but also a higher population growth in order to facilitate the labor (Hollister 1994; Jupp 2003). In this way, the imposed feudalism of the Normans had a direct effect in English society and the evolution of the landscape itself.

At its core, England functioned day-to-day by those who labored in the urban and rural sectors. The majority of the population consisted of mostly lower-class people with varying social statuses. The term “peasant” is often used as a catch-all term to describe most of the laborers and agriculturalists that represented those who were subjugated by the knights, barons and lords, and above all, the monarchy (Beckett 1984; Carpenter 1992). There has been some contention about terminology addressing the wide range of social groups among the vast majority of the population. Beckett (1984) offers a thorough study in which the varying terms for the common populace are compared based on financial and social status. Terms such as serfs, freeman, yeomen, villein, franklin, and sokemen all carry different connotations among the broad term of “peasant”. This is a more modern demonym for those in the countryside that was created by historical scholars to categorize individuals, though it does not incorporate the subtleties of the bonds of freedom and landownership that may be associated with a particular group. In truth, historical documents often dismiss specific terminology between social groups as all those in the peasantry were subject to their respective lords as tenants to which social or financial status rarely mattered (Mortimer 2010).

It is important to note, however, two distinctions that should be expanded on in terms of the peasantry. Regardless of financial status, the biggest division within the peasant population
was that of freedom and autonomy (Mortimer 2010). Two major groups can be examined under this lens, exposing the differences in the structure of their lives. The freeman (or yeomen) had the ability to own land, in a loose sense, and work as they saw fit within the confines of their Lords oversight. Often, some sort of fee was paid as rent to continue to live on the local lord’s land and work on the freeman’s personal farm, granting some level of rights and autonomy (Sayles 1961). In contrast, the serf (or villein) was generally a landless laborer who often worked on the lord’s personal manor or within fields owned directly by the lord (Hollister 1994). A set number of workdays were often allotted to serfs in which the produce of their labor contributed directly to the agricultural capital of the lord’s manor. Their lives were often that of a subsistence agriculturalist, as they did not have any control over the land on which they lived or the products in which they produced (Hollister 1994; Mortimer 2010). Compared to the freeman, a serf essentially had little rights and was often considered to have little freedom. A lord generally had complete power over the legal, financial, and some personal aspects of the serf’s life (Mortimer 2010).

Serfdom is often characterized by a lack of autonomy. Often tied to the soil in which they were born on, migration was controlled by the lord’s will in addition to marriage rights and apprenticeship of children (Sayles 1961). Even in the context of freemen, choice and action were controlled to a degree in ways that would align with the lord’s interests. As the peasantry were seen as an economic investment, birth, death, and marriage all had influence on property and financial security for the lord and thus were regulated in varying ways (Schofield 2009). Overall, while divisions within social groups can be made, the majority of the population of England in the
Middle Ages can be classified as the peasant class, laboring in some way or another in service to those of higher status.

Opportunity and land-use available to the peasant class varied among the different areas and depended on the size and capacity of the lord’s estate. In the medieval era, peasants could be expected to have access to lands as much as 30 acres in size, though some families had less than half that acreage (Carpenter 1992; Schofield 2009). As previously mentioned, the terms in which the peasantry lived on the land were directly related to the economic relationship with their lord (i.e. rent in the form of money or labor) (Schofield 2009). Land holdings could be divided any way the presiding lord saw fit and within their own interests. Typically, this meant creating smaller land holdings for an increased number of laborers, or for the rising populations to gain some form of “inheritance”, which benefited both lord and subject (Dryer 1994). Areas divided in such a way were often very small (some being less than 10 acres) and often barely allowed more than subsistence and a basic surplus in the form of rent (Carpenter 1992).

In some areas, in which populations may have not risen as dramatically or were affected by external factors (e.g. violence or disease), labor shortages caused slight increases in peasant autonomy and allowed them to produce in excess from their traditional labor or monetary bond.
Contractual evidence from a small village in Oakington, Cambridgeshire shows a great degree of autonomy in relation to how the population managed their fields and livestock in order to not only meet subsistence needs, but also develop surplus for markets. However, the waxing and waning of the local economic system prevented them from fully benefiting from their labor (Sapoznik 2013). Even including populations such as these, the peasantry never developed a fully capable market mentality as the power structures in place prevented them from being entirely integrated in the market economy. Their labor and product were still under direction from those who owned the land and rent often kept individuals from developing an independent agricultural trade; essentially allowing them to be only “partially integrated” in the market (Dyer 1994, p.168).

The peasant class was still able to survive and grow within the confines of the economic and political system in place, as their well-being affected their lord’s overall livelihood and it was in their best interest to create a self-sustaining system of labor under which the lord could control.

The few larger towns and cities offered no real change when it came to lifestyle for the peasantry. The main areas of cities and their internal suburbs were generally only inhabited by the nobility and their families, middle-class merchants and burghers, and the clergy; all of whom made up only a small fraction of the population (Gies & Gies 1990b). In comparison to those in continental Europe, English cities had relatively fewer walls surrounding the cities during the Norman period. The urban sprawl allowed those who worked as agriculturalists to be near the markets and urban centers though their residences were often in the farther district or boroughs (Nicholas 2014). The living conditions for the peasantry within these urban areas were often no better than their rural counterparts, who were still faced with the pressures of rent through labor or money as well as urban-based problems such as the threat of disease and increased violence (Gies & Gies 1990b; McNeil 1998). Even with a large peasant population within the periphery of cities,
the rate of development and growth within cities and towns generally depended on the food supplied by the rural areas (Nicholas 2014). Changes and advancement in agricultural practices allowed for larger populations to be supported in urban environments, though the peasant class in these areas still mainly worked in the agricultural or labor sector.

2.4 Migration under Feudalism

In terms of autonomy, the peasantry was often suppressed in many ways. As many made their living as agriculturalists, the manor and fief were where their livelihood were centered. Because of their social status, peasants were at the mercy of the lord who owned the land and were often restricted from entering the land market and at times, moving from manor to manor. At the start of the high Middle Ages (around the eleventh and twelfth centuries) the relationship between the lords and peasants was mutually beneficial, as the emerging commercial sector needed a large labor force in order to develop. Lords were more likely to keep rent low and promote decent conditions in order to keep their peasant attached to their land (Hollister 1994). However, as the rural areas developed, populations increased causing a shortage of unoccupied land and increased rents for the peasantry. Moving for different opportunities became less and less of an option for the lower class and reduced their ability to negotiate to improve their conditions (Dyer 1994). Migration to other manors or to the urban areas may have seemed like a way to improve the lives of the peasant family though even if it was an available option, uprooting one’s family may not have been worth the risk.

This is not to say that the peasantry did not travel in some aspect. With the growing rural areas and towns starting to emerge, market areas attracted many and allowed some peasants to buy or sell surplus products (if allowed/able). While the merchant class, clergy, and nobility often traveled far distances for various reasons, the peasant class may have rarely traveled far, if at all.
There is a myth that many peasants did not travel more than five or six miles from their manor and, depending on their social status, that may have been true (Mortimer 2010). As most historical writing at the time was written by the nobility or clergy, the lack of records for peasant movement may be a product of illiteracy in the majority of the population (Fleming 2009). Some peasants may have traveled to local markets, though because of their obligations to their lord, may not have been able to travel in a far radius from their manor or fief (Mortimer 2010). As mentioned previously, the peasant class became integrated in the market to a certain degree, but their control of it was limited. The urban and rural sectors were connected and developed in tandem with one another during the feudal era, which promoted movement between different areas, though this movement was likely restricted for the entire peasant class, and the amount of intermixing between populations may have varied (Dyer 1994). In addition to the economy’s influence on movement, other factors such as war also had an effect on the population, either by conscription or displacement (Mortimer 2010). Temporary movement and migration do differ from one another, and while traveling to market areas or within nearby rural areas may have taken place, the permanence of migration (or the lack thereof) was influenced by different factors equally dependent on the peasant’s family, financial/ social status, and the relationship with their lord.

Migration for the peasant class was no small ordeal and the possible implications of uprooting one’s family and livelihood did not come without inherent risks: However, some found the risks worth taking. As medieval society in England began to grow economically, the lower class found that social mobility and economic opportunity was more achievable than before (Griffiths 2012). Though children often continued working on the fief in which their parents worked, some aspiring young individuals tried testing their luck by migrating to larger towns or cities (Hollister 1994). Developing towns often had need for a labor force, even one that may have
been initially unskilled. As few families raised a large number of children to adulthood, the value of laboring individuals was generally high in areas where populations had yet to grow (Gies & Gies 1990a; Dyer 1994). In the thirteenth century, the population in many rural areas began to surpass the amount of land that was available to the peasant class (Hollister 1994). Many families would remain on farms owned by lords, often working for a low wage or general subsistence. This gave reason for those landless peasants not tied to their lord’s manor to venture out of the rural areas and into the urban sector (Hollister 1994). As not everyone could gain a living in the rural sector, migration to towns may have seemed like a worthwhile risk for many underprivileged young people or those who may have lacked any sort of inheritance from the family farm (e.g. the second/ third son or daughter) (Dyer 1994). The influx of different skill sets (or the willingness to learn) allowed the expansion of towns and cities outside of purely agricultural needs and some aspiring individuals found success after migrating outside the countryside and training in a craft or skill set (Kowaleski 2014). Though the crux of migration may not always be known, it is not accurate to simply state that betterment was the main factor. Survival or forced migrations due to overcrowding may also have been a catalyst for many individuals (Postles 2000).

Many of the younger individuals who did migrate from the countryside to the urban sector were encouraged by the fact that larger towns may be able to offer better opportunities or the chance to gain land of their own. Peasants who decided to move to urban areas often become servants for nobility or for merchant houses performing low-wage, unskilled work (Kowaleski 2014). Children could also be bought and sold to an extent, with male children sold into apprenticeships or to work in other manors and female children often being married off in exchange for a modest dowry (Gies & Gies 1989). Historical documents written by the nobility as a type of census in the mid-thirteenth century note that in two villages between a third and a half
of adult children had left their village while another village showed that two-thirds of women married outside their village (Dyer 1994). Other records show the percent of migration out of a village in Essex was around three to five percent every year (Dyer 1994). While these reports do not mention where they moved to or how far, it does show that migration does occur to some extent within communities. Evidence from archaeological and historical studies do show a trend in the migration of younger individuals into urban areas. Examination of health and mortality within populations in medieval cities such as York (Watts 2011, 2015) and London (Lewis 2016; Yauss & DeWitte 2019) show that a large number of those buried within the cities were those under 25 years of age, women often making up the majority. This is thought to have been a result of the migratory practices from the countryside and the flux of younger individuals being adversely affected by their new environment.

Influences outside of an individual’s control often forced them to migrate to other areas in order to survive. Environmental effects on the landscape such as flooding, famine, and drought could render arable land useless or at least not sufficient enough for short-term subsistence (Magnusson 2013). In regard to epidemics of diseases, such as the Black Death, the high mortality rate in both rural and urban areas caused social and economic change in the value of the laboring class (DeWitte 2014; Cesana et al. 2017). For example, Lords may have increased the workload on many tenants in order to make up for the labor shortage within the manor. If the labor was not compensated or was more than some were willing to handle, migration to another manor or urban areas in need of additional labor may have seen like an attractive option, even if it went against the laws and bonds between the lord-tenant relationship (Mortimer 2010; Kowaleski 2014). These types of migrations were not optimal however and the lower-class often bore the brunt of the effects of environmental stressors (DeWitte 2015).
For the minority that left their rural homestead (either to urban areas or between other manors), the vast majority stayed attached the fief or manor and the general area in which they have spent most of their lives. Feudalism was compatible with the urban-rural dichotomy and much of the peasant class benefited in some way from spending the majority of their time on the manor and occasionally visiting town markets to trade (Dyer 1994). As previously mentioned, towns and cities sometimes had a costly effect on new migrants while the smaller, rural areas of manors often offered a level of stability, protection, and, generally speaking, a reliable food source. This also includes the nobility who owned the land (and to an extent those on it). As long as the tenants were content, they would continue to provide a source of income for the lord who they worked under. It did not benefit the lord to risk his economic security by suppressing his tenants and by allowing subsequent generations to “inherit” the land in which they lived, as peasants were less likely to leave their stable living, regardless of personal freedoms (Sayles 1961). A sense of belonging also came with the manor or village in which they lived. As many communities were close-knit, the membership of one such community may in fact be a part of an individual’s personal identity, something of which is not so easily discarded (Mortimer 2010).

Social status also played a role in the peasant classes willingness to migrate. Many of the tenants on manors were often unfree villeins who were legally bound to the lord’s manor. The risk of an individual leaving the manor without consent could result in backlash on their family or property (Mortimer 2010) Even if the individual were allowed to move, the lord may have all rights to the peasants’ property, making relocating difficult for those who sought to seek trades in other areas. This is not always the most attractive option as having the skills to start a new life could be rather hard without the capital or tools to begin an independent trade (Dyer 1994). Certain families also saw the risk of moving as unnecessary since they had more than enough labor to not
only satisfy both their imposed rent and their own subsistence, but occasionally had enough to sell their surplus in markets (Sayles 1961). The large amount of newly created towns during the high Middle Ages were not always successful either. One instance from Cumberland saw a town dissolved shortly after its borough status was granted when not enough people immigrated there to make it work, resulting in forced migration for the few residents (Dyer 1994). Survival was always at the forefront and many of the peasantry erred on the side of caution when it came to the livelihoods of their families.

2.5 Women and Migration

In the Middle Ages, it is important to understand the differential treatment of both women and men when it came to families and tenant relationships in the feudal era. If the peasant class had few rights and freedoms, women were often the ones most affected. The medieval church subordinated women to their husbands and feudal control subordinated women to the fief where she and her family lived (Power 2012). There are instances where women in the family were able to inherit land through their lord, though villeinage allowed the lord an option to choose who she married if she wished to stay on the manor (Sayles 1961). This guarded his financial interests and allowed further control over the tenants, and their future families, on his land.

Even in the instances where women were the head of the household in rural areas, feudalism often restricted rights and denigration of women’s autonomy was common (Power 2012). For many young women, marriage was seen as the universal objective. As many could not directly inherit land, marriage into a stable family allowed for a more secure life. The alternative for many rural women was to remain among her family as a laborer, initially for her father and subsequently under the inheriting brother (Gies & Gies 1989). Even marriage into another family came with consequences, as some lords could levy a marriage fee against the family for loss of
labor (Mortimer 2010) or an initially independent woman’s freedoms could be restricted if she married a tenant bound to a lord’s manor (Hollister 1994). Though their rights may have been restricted, marriage allowed for a livelihood that offered some sense security for many rural women.

Previous historical and archaeological research has shown women had a high rate of migration to urban areas in the medieval era (Power 2012). Both tax documents and cemeteries show that there was a large difference between the number of women in the urban areas and those in rural locations (Kowaleski 2014). Demographic data through skeletal analysis often shows a larger number of women within urban cemeteries (Grauer 2003). This may have been a result of unmarried women who could not find a livelihood on manors or fiefs and were more willing to support themselves by working as servants or laborers in the urban areas (Gies & Gies 1989). In some rural areas, not all women would be able to find a suitable partner to marry and had to support themselves through their own labor (Power 2012). As towns and cities began to grow in the thirteenth and fourteenth centuries, more women were heads of their household compared to the rural areas, where the head of the household was commonly male (Kowaleski 2014). The prospect of gaining more independence and establishing a life that otherwise may be unobtainable was the draw for many women to migrate from the countryside. Though it was not without risks, it seems that it was a trend that many women chose to follow.

2.6 The Rural/Urban Connection

The migration of people can be examined by understanding the relationship between the villages and homesteads in the rural areas and the nearby towns and cities scattered across England during the medieval era. During the high Middle Ages, the founding of new towns reached its high as a result of a large population growth. The few cities began to flourish as well in conjunction
with their rural counterparts, with London’s population at the start of the twelfth century at around 30,000 people, which increased to 50,000 at the start of the fourteenth as well as York doubling its population to 20,000 in the same time frame (Hollister 1994; Nicholas 2014). As both the countryside and the urban areas were dependent on money and trade for growth, the success of one often was linked to the success of the other (Dyer 1994). While major cities may have been an exception, the rural areas were often connected to larger settlements in some way. By 1300 nowhere in England was more than eight miles from a small market town or village (Dyer 1994; Mortimer 2010).

Looking at nucleated settlement areas in England, a trend can be seen involving urban supply zones and the villages that surround them. As the urban market often dictated the demand from the rural areas, the periphery villages of towns can be seen as rings of economic activity that support one another (Magnusson 2013). This trend is found not only within England during the Middle Ages, but also continental Europe as largely connected, structured settlement areas allow for more success economically and have a positive impact on population growth (Cesaretti et al 2016). This was often based chiefly on food and basic industrial products that the open land of the country could readily offer (Nicholas 2014). In some areas, especially around cities such as London or York, individuals would travel from a radius of 20 miles for markets (Dyer 1994). Connectivity was paramount to the economic success of the nobility who owned the land and it benefited the lord to have financial avenues to rely on.

This is not to say that every village had a large town or city nearby. Areas in northern England, such as those in Cumberland and Northumberland, had few inhabitants due to a variety of reasons that may have affected how villages operated (Mortimer 2010). In cases such as these, travel to the market was often few and far between, as traveling longer distances between villages
(either for migration or trade) was a risky affair due to harsh elements, unkept or nonexistent bridges and roads, or random acts of violence and accidents (Sayles 1961). The success of even the most remote villages still relied on outside factors and many scattered villages and homesteads were still able to sustain themselves to a degree.

2.7 Conclusion

The European Middle Ages marked a time of extensive growth and socioeconomic change. The imposition of feudalism onto the populace not only altered the lives of those in the system but was also a catalyst in how land use and development was structured in England. The vast majority who worked in the peasant class represented the backbone in which England was formed and lived their lives under the authority of the nobility. Experiences under feudalism were varied and feudalism had a strong effect on the autonomy of the peasant class, persisting for half a millennium. While certain freedoms were restricted, feudal society offered stable lives for many in the rural areas and allowed for urban growth and the construction of a more connected England.
Chapter 3: Nonmetric Traits and Biological Distance

3.1 Introduction

This chapter introduces nonmetric skeletal traits and their utility in biological anthropology and archaeological studies. A short overview is presented about nonmetric traits within the current literature and historically how they were used in population studies. A history of biological anthropological and genetic studies is provided to set context for the methodology while highlighting the connection between nonmetric traits and genetic affinity. As this study is primarily a question of migration in medieval England, biodistance literature is examined in order to place the current research in an accepted methodological context. Finally, two hypotheses are presented in relation to the biodistance framework and their relevance to previous historical literature.

3.2 Nonmetric Traits

Nonmetric traits, also referred to as discrete, discontinuous, or quasi-continuous traits, are traits that can be macroscopically analyzed from skeletal and dental remains. While there are numerous nonmetric traits that can be observed macroscopically, certain traits are more common than others and used more often when analyzing nonmetric traits for skeletal-based research. Standards: For Data Collection from Human Skeletal Remains lists 24 nonmetric traits of primary importance (21 of which are located in the cranium) that are used most often for research involving nonmetric traits (Buikstra & Ubelaker 1994). In addition, Michael Finnegan (1978) lists 30 nonmetric traits that can be observed on the post-cranial skeleton (Finnegan 1978).
examined in the case of missing cranial remains. Nonmetric traits are usually placed on the spectrum of hypostotic (i.e. incomplete osseous development) or hyperstotic (i.e. an excess of bone growth) (Hauser & DeStefano 1989). When located in the cranium these normally take one of four forms: ossicles or small bones that occur within cranial sutures, proliferative ossifications such as bony spurs or bridges, ossification failure leading to defects such as the septal aperture of the humerus or the tympanic dihiscence of the external auditory meatus, and variation in foramen number and location (Ossenberg 1970; Buikstra & Ubelaker 1994; Saunders & Rainey 2008).

Developmental defects have been considered by some to represent nonmetric traits, however, the rarity of some of these anomalies has excluded them from standard data collection protocols (White & Folkens 2005). Normally nonmetric cranial traits do not impair the function of the individual, therefore should not be considered pathological in nature (Saunders & Rainey 2008). Cranial modification, either natural or artificial, can have some effect on an individual’s observed trait presentation (Ossenberg 1970). However, some craniometrics can be affected to a larger degree by the influence of artificial deformation (mainly in the neurocranium) though nonmetric cranial trait frequencies are not significantly affected, which can still be used to gather information about local population dynamics (Konigsberg 1993).

Nonmetric traits also have advantages over craniometrics when utilizing them for population-based research questions. First; nonmetric traits can be recorded in fragmented, incomplete, and poorly preserved material. This allows some reliability with data collection, especially with archaeological populations where taphonomic damage is often present. Second; nonmetric traits can be scored with ease and efficiency, with resulting data used dichotomously in statistical tests. While issues of intra- and inter-observer error must still be considered, scoring
nonmetric traits are more straightforward than some measurements when taking the craniometric approach (Buikstra & Ubelaker 1994).

3.3 Genetics and Heredity

Following the publication of the “New Physical Anthropology” by Washburn in 1951, scholars began incorporating different methods for research and opening biological anthropology to more rigorous hypothesis testing via multidisciplinary and interdisciplinary approaches (Fuentes 2010). More theoretical and methodological research was conducted to help understand the underlying causes for phenotypic attributes that researchers were observing. In the case of the heredity of skeletal traits, one of the first to test these ideas was Hans Grünberg in the 1950’s with case studies based around common house mice. His research sought to understand the skeletal traits in subsequent mouse generations and how they were inherited.

Initial studies by Grünberg based on phenotypic characteristics showed that inbred mice often have the same skeletal characteristics as their parents and that subsequent generations were homogenous in their phenotypic expression; those without the certain traits were more alike as well (Grünberg 1951, 1952, 1954, 1955). However, this was not the typical idea of Mendelian genetics as previously thought. Coining the term quasi-continuous, Grünberg applied this term to describe the trait variations that were observed in tested strains of mice. He proposed that traits were on a continuum with a population-specific threshold for expression. Additional effects from environmental and genetic makeup allowed the trait potential to surpass that threshold and manifest itself phenotypically. Rather than a single gene for a certain trait, random mutations or environmental effects in utero can allow characteristics to manifest (Grünberg 1952).

In regard to nonmetric skeletal traits, examples include osseous defects such as the foramen acetabuli perforans and dyssymphysis ischio-pubica (Grünberg 1952), both of which
are located in the innominate, as well as the absence of a third molar (Grüneberg 1951) which
was attributed to a physiological effect of the tooth germ not fully developing, rather than a
genetic absence or presence of the tooth germ itself. Follow-up studies have been performed on
Grüneberg’s work, notably with one study showing the effects of dietary changes of parents and
its effects in relation to their offspring; notably that different diets cause different expressions on
third molar development (Searle 1954). However, a combination of research by Deol et al.
(1960; including both Searle and Grüneberg) showed that 14 out of 27 observed skeletal traits
occurred at different rates between the homogeneous strains of mice, leading to a genetic basis
for phenotypic traits and that dietary effects could be seen as a variant mutation among
homogeneous strains (Doel et al. 1959).

Other studies involving the heritability of nonmetric and metric traits on familial lines in
animals include research on Rhesus Macaques by Cheverud and Buikstra (1981, 1982). Their
hypothesis was that, as there is a distinction between nonmetric traits and metric traits based on
their respective etiologies, phenotypic expression through genetic heritability would differ
between the two. The results showed that certain nonmetric traits, namely hyperstotic traits, were
more heritable than metric traits while foraminal nonmetric traits were less heritable overall in
comparison to metric traits (Cheverud & Buikstra 1982). The authors claim that hypostotic or
hyperstotic traits are more useful for the purposes of genetic studies and that while heritability
values are more than likely population specific there are patterns of heritability that can be used
on a general scale (Cheverud & Buikstra 1981).

Early studies on heredity with nonmetric traits in humans saw research with smaller
sample sizes and specific traits. One early study by Torgersen (1951) examined the frequency of
metopism (i.e. the presence of an unfused metopic suture in the cranium) within different
families in Scandinavia. He found the trait highly heritable within the populations, with the facial bones often being more malleable to developmental genetics (Torgersen 1951). Another from Laughlin and Jørgensen (1956) examined the variation from different regional groups of Greenland Eskimos based on eight nonmetric cranial traits. Their results showed varying frequency of nonmetric traits that showed possible genetic variation based on migration patterns (Laughlin & Jørgensen 1956). These studies were some of the first to provide evidence of genetic heritability of nonmetric traits in human populations.

The notable work by Berry and Berry (1967) provided one of the first large scale studies on nonmetric traits and the heritability of various populations. Berry and Berry list and describe 30 nonmetric cranial traits that were examined on just under 600 individuals from eight different populations across the world to find genetic correlations. Their reasoning for the assertion that nonmetric traits were genetically controlled were: 1) previous familial studies on nonmetric traits had shown that certain nonmetric traits had a high heritable frequency. 2) Frequency among populations were consistent and would be consistent in different groups where gene flow occurred. 3) Evidence from Grüneberg’s previous mouse studies determined the quasi-continuous nature of nonmetric traits in mice strains which are analogous to those in humans. Berry and Berry noted that different populations had different frequencies of the traits and the results supported their hypothesis of heritability in different geographical groups (Berry & Berry 1967). The study came under criticism by later researchers as their assertion that age, sex, and side occurrence did not affect the frequency or variation in the nonmetric trait occurrence was not supported by their sample populations or their methods. However, this study spurred the use of nonmetric traits in population studies and became the foundation for subsequent methodologies in genetic studies of the skeletal system (Saunders & Rainey 2008).
Insight into the heritable nature of skeletal traits (both metric and nonmetric) was often questioned for its use in population studies as direct familial links could not be easily studied and were absent in previous research. A unique collection from the village of Hallstatt, Austria was the sample population for research conducted by Torstein Sjøvold in 1984. The cranial collection, consisting of over 600 decorated crania, were able to have their pedigree traced via church records as well as some names and death/birth dates painted on the skulls themselves. Using this data initial results from Sjøvold showed that many of the craniometric traits were considered heritable and most of the nonmetric traits were heritable to some degree. While a few of the nonmetric traits he describes were unobserved at the time of the study, he does conclude that a small minority of nonmetric traits are highly heritable but states that, “Measurements are not all hereditary characters because of being possible to measure, and nonmetric traits are not all hereditary because they are nonmetric” (Sjøvold 1984, p.244).

Carson (2006a; 2006b) revisited the work performed by Sjøvold with the Hallstatt population, applying a multi-variate component analysis to the nonmetric and metric traits scored on the crania and found that the results were different from the previous research. Her study showed that most of the nonmetric traits had a low to medium heritability score rather than the highly heritable scores that Sjøvold suggested. These results could be for a few reasons: 1) the difference in statistical techniques used; 2) Sjøvold’s inclusion of extended pedigrees within the sample; 3) variation in data collection and scoring techniques between the authors. Carson notes that while heritability variation does exist within populations, dichotomous scoring of traits can alter the results and needs to be taken into account on traits that can be scored on a multi-level scale (Carson 2006a). These findings reiterate previous research in which nonmetric traits are not

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controlled by a single gene, but rather are a combination of variables that affect phenotypic expression.

### 3.4 Age and Sex Variation

The threshold concept for trait heritability, conceived in Grüneberg’s 1952 study, is essentially acknowledging that environmental effects interact with the genotype to produce a phenotype in an individual. This is the basis in which nonmetric trait analysis is applied today which opens up questions of nongenetic effects on trait expression and physiological alterations. Lifestyle variation among individuals based on age and sex could have influence on trait frequency in some way as migration patterns, labor roles, and activity patterns can introduce environmental differences into a population (Saunders & Rainey 2008). Correlations between nonmetric traits and age/sex vary between populations, leading to a debate between the role age and sex play with phenotypic expression.

In regard to sex-based correlations, early studies found that the incidence between the sexes did not exist for nonmetric traits (Searle 1954; Berry & Berry 1967). Lane and Sublett (1972) found that sex-based correlations were significant in their study of different cemetery populations in the US. However, these were all nonmetric traits that had a continuous distribution and the authors stated their assumption that there were no differences in the incidence of traits between sexes in a single population (Lane & Sublett 1972). Carson’s (2006) research on the Hallstatt cranial population showed a few trait differences among the sexes that were previously unrecorded in the collection (Carson 2006a). These differences could be attributed to developmental or environmental factors on physiological thresholds rather than purely sex-based heredity.
Genetically, as males have one X and one Y chromosome and females have two X chromosomes, threshold potential for nonmetric traits could be influenced by sex-based genes as an additional factor, though explicit population examples have yet to be demonstrated. Growth and puberty between the sexes may also have an effect on trait frequency as males on average are larger and have more robust bones. Based on development males tend to show higher frequencies of hyperostotic traits and females show more hypostotic traits (Saunders & Rainey 2008). Some studies have also connected sex to trait expression, though this could also be due to population variation (Brasili et al. 1999). In research based on nonmetric traits, the exclusion of traits that may have a sex-based bias may alter the results and information may be lost. Finnegan (1972) suggests that an equal distribution of male and females will adequately correct for frequency differences. Results from such studies can get at different hypotheses about a population as well as affinities between distant populations without eliminating certain traits (Finnegan 1978).

Age is another aspect one must consider when determining relationships with nonmetric traits. While Buikstra and Ubelaker (1994) stress that both juvenile and adult remains should be coded, they consider age correlations a thorny problem that must be addressed. The issue is not necessarily that age affects the genotype of a trait, rather it affects the phenotypic expression as old age can reduce the “legibility” of certain traits, especially when a higher population of elderly people are included in a sample (Brasili et al. 1999). As juveniles are not osteologically fully developed some nonmetric traits that are characterized by a lack of fusion, such as the metopic suture, could not be considered a nonmetric trait until development has finished (Saunders & Rainey 2008). Torgersen’s (1951) study on the metopic suture had excluded some older individuals as the suture itself was obliterated in old age and therefore unobservable.
Controlling for age effect is possible if juveniles are excluded from samples and only developmentally complete adults are included (Saunders & Rainey 2008). It must be noted however that male and female osteological development occur at different rates and that population variation may affect results.

3.5 Historical Background

The science that would become the discipline of biological anthropology began in the 18th century and further expanded in the 19th century with key figures such as Carolus Linnaeus and Johann Blumenbach. Initially, biological anthropology was used to understand phenotypic differences between human populations. A taxonomic system, founded by Linnaeus and reworked by Blumenbach, included different categories of humans (in various species) that were based off of temperature, climate, and geography and were attributed to morphological and behavioral features depending on the group (Caspari 2003; Mielke 2010). Later, Samuel Morton accumulated a vast number of skulls and used a measurement system based on cranial capacity to denote characteristics to different groups. Through his experiments, Morton hypothesized that the larger the cranial capacity, the more intelligent the person was (Mielke 2010). Looking to provide evidence of racial superiority, cranial morphology was used to perpetuate racial differences, and this is one of the earliest research methods using morphological cranial traits to some degree to understand human variation, albeit erroneously.

Moving away from the race-science of previous researchers, Franz Boas sought to understand the differences between various groups of people, studying Native Americans and large immigrant populations in the US. He also rejected biological determinism and questioned the validity of human types, challenging racial essentialism (Caspari 2003). His immigrant study, published in 1912, examined thousands of immigrants from Europe in the United States as well
as their children. The cephalic index, a combination of metrics taken from the crania, was calculated for all foreign-born and US-born individuals in the study. Overall, his study showed the cranial differences between foreign-born parents and their US-born children based on geographical location during developmental stages in life (Gravlee et al. 2003). His landmark study was one of the first to show the effect environments can have on cranial plasticity as well as being pivotal in altering ideas of racial groups and biological determinism.

Modern biological anthropologists often use nonmetric traits to categorize individuals based on ideas first conceived by physical anthropologist E.A. Hooton. The traits, pioneered by Hooton based on his work with the Indians of Pecos Pueblo (see Hooten et al. 1930), are used today by many forensic anthropologists and his contributions to skeletal biology have had a major impact on the current philosophies and methodologies for ancestry prediction in a forensic context (Hefner 2009). These traits are primarily located in the cranium, mostly within the facial bones with many involving the nasal aperture, and in studies these elements seem to be the most variable when it comes to group categorization and show similarities and dissimilarities between groups. It is worth noting however, that traits recorded by forensic anthropologists and bioarchaeologists differ in this sense. Hefner (2009) tested the validity of these traits on different populations across the world, from far population groups. However, a combination of nonmetric traits, in addition to other cranial measurements, showed higher validity than single traits alone. Hefner (2009) also mentioned that among the populations, at least one trait that was common among all groups that would normally belong to a differing group. His study empirically investigated the “typical” morphoscopic traits thought to be indicative of African-, Amerindian, Asian-, and European-derived groups and has shown that they are not found at the frequencies
suggested by earlier studies. He also attributes this folly to the lack of knowledge of the variation within groups themselves (Hefner 2009).

The use of cranial morphology for racial/ancestral categorization continues to be a contentious topic. The impact of the “New Physical Anthropology”, a groundbreaking work by Sherwood Washburn, helped the discipline distance itself from its more infamous past and rely more on methodological and theoretical based questions (Washburn 1951). Modern-day researchers do not look for biological evidence for races in the historical sense as the idea of discrete races in the typological mindset of past centuries clearly does not apply to humans (Relethford 2009).

3.6 Biodistance

To answer questions about population movement and group affinity researchers use biological distance, or “biodistance”, studies to help understand population structure. Biodistance uses evidence from polygenic traits to show divergence between populations as these are affected both by environmental and genetic factors through gene flow and/or genetic drift (Buikstra et al. 1990; Stojanowski & Schillaci 2006; Relethford 2016). The biodistance approach is based on the assumption that cranial, dental, and postcranial size, shape, and morphology are genetically conditioned to some degree and can be used to investigate evolutionary processes (Berry & Berry 1967; Buikstra 1980; Buikstra et al. 1990; Relethford 1994; Stojanowski 2013). The underlying consensus is that populations that are more genetically related will be phenotypically similar, while those that are not will show the variation in frequency of traits, either metric or nonmetric (Stojanowski & Schillaci 2006).

Biodistance studies follow a base model in which a variety of populations can be examined. The basic tenets of biodistance analysis consist of the following assumptions: 1) allele
frequencies are affected by both genetic drift and gene flow within and between populations in similar environments and geographical proximity; 2) the archaeological skeletal samples used are accurate representations of the population in question over an extended period of time; 3) allele frequency variation can have phenotypic effects on skeletal traits that are measurable and quantifiable; 4) there are minimal or randomly distributed effects on phenotypic expression in a population due to environmental factors; and 5) the inheritance of phenotypic traits is strong among those genetically related (Stojanowski & Schillaci 2006). This theoretical framework uses multidisciplinary methodologies to understand genetic lineages throughout a population’s history and answer questions based on skeletal remains.

As mentioned previously, there are multiple areas of examination in the skeletal system that can be used for biodistance research. Current biodistance research often employs craniometric, non-metric, and dental traits to understand populations dynamics in various ways depending on the amount of skeletal material that is available from a population (Buikstra & Ubelaker 1994; Brasili et al. 1999; Gualdi-Russo et al. 1999). Craniometrics were most often used in early literature as they have a long history within biological anthropology though nonmetric traits are also used to a large degree within subsequent research following Berry and Berry’s (1967) influential work. Currently, nonmetric traits are more often used to understand inter/intra-regional and local levels of population interaction up to the region scale (Saunders & Rainey 2008). While post-cranial nonmetric traits are a standard part of osteological examination, they are rarely used for biodistance research. This could be due to the assumption that weight-bearing postcranial bones are more functional and would not show phenotypic genetic variations to a high enough degree to answer questions about inter/intra-group variation (Stojanowski & Schillaci 2006). Dental nonmetric traits are also used frequently in biodistance
research as they show a high amount of genetic affinity in a population and are often subject to less environmental stress and postmortem alterations than nonmetric or craniometric traits (Khudaverdyan 2014). Regardless of the methods used, the larger the sample population the better. Sample sizes of at least 100 unbiased, adult individuals are ideal for comparison for inter/intra-population studies (Ubelaker 1999).

From an analytical standpoint, the ability to conduct biodistance analysis within a population genetics framework depends on the advancement and the use of quantitative trait theory (Konigsberg 2006). Historically and currently, the two primary statistical methods used in biodistance studies are the Mean Measure of Divergence (MMD) or Mahalanobis D2 distance with some scholars preferring one over the other (Nikita 2015). Critiques have often been made over the use of the MMD (Konigsberg 2006; Konigsberg & Buikstra 2006) for biodistance analysis though recent studies have shown that it can work satisfactory and comparably to Mahalanobis D2 (Irish 2010; Nikita 2015).

### 3.7 Post-Marital Residence and Kinship Studies

Early studies using archaeological models sought to understand the differences between past human populations based on evidence from burial practices and cemetery studies to examine behavioral patterns. Initial studies on intra-group variation within populations were based on material culture (e.g. ceramics) in combination with mortuary and skeletal analysis (see Longacre 1964; Hill 1965; Deetz 1968). However, these were often criticized for the contentious interpretation of artifact association with individuals or family groups (Konigsberg & Buikstra 1995). Researchers began to explore questions of intra-group variability rather than to compare populations on the assumption that they were individually genetically homogenous (Lane & Sublett 1972; Saunders & Rainey 2008). Research based on nonmetric, craniometric, and dental
traits has been shown to be more promising in estimating hetero-/homogeneity, as the relationship between osteological data and the biological/social reality tend to help answer variation questions and the data tends to reflect true genetic relationships and patterns of behavior within a population (Lane & Sublett 1972; Stojanowski & Schillaci 2006).

Intra-population studies are an important tool in helping to understand social organization and social relations within a population. Kinship studies and post-martial residence can be used to understand culturally defined systems within a social unit at different levels. Post-martial residence in particular is important as it can answer questions of social roles within a community as well as integrate members from an outside community that may show migration or trade networks between populations (Schillaci & Stojanowski 2003). Kinship analysis is an organizational strategy to help understand community identity and membership (or the exclusion of) within a social unit at different levels of a population (Prevedorou & Stojanowski 2017). Using osteological data, the presence of rare or anomalous phenotypic nonmetric traits (both cranial and post cranial) and craniometric data, potential relatives can be categorized together and compared to other members of the group to assess affinity (Stojanowski & Schillaci 2006; Pilloud & Larsen 2011). Kinship analysis can also be used to set baseline osteological data for specific groups to be used in larger comparison studies (Stojanowski & Schillaci 2006).

Post-marital residence operates under three basic premises in genetic-based studies: 1) populations that have male-male homogeneity and female-female heterogeneity are considered virilocal; females will live with or near the male’s family group; 2) populations that have female-female homogeneity and male-male heterogeneity are considered uxorilocal; males will live with or near the female’s family group; 3) female-male heterogeneity would be evident within the previous two premises (Lane & Sublett 1972; Spence 1974). A higher frequency of migration of
a certain sex will lead one sex to have a greater variance of within-group phenotypic traits (Konigsberg & Buikstra 1995). Early applications of the biological framework on kinship and post-marital residence by Lane and Sublett (1972) and Spence (1974), focusing on groups in the US and Mexico respectively, were some of the first to adopt the materialist model by previous archaeologists and utilize data from skeletal traits. Subsequent research by Konigsberg sought to improve on their analytical model so that multiple generations could be included in the analysis (Konigsberg 1988). Regardless of methodology, kinship and post-marital residence studies began to gain popularity in the 70’s and 80’s with the emergence of more research based on metric and nonmetric skeletal traits as well as the rise of the post-processual paradigm in the discipline⁴.

3.8 Current Biodistance Research

Research centered around biodistance models waned in overall publication trends around the late 80’s and early 90’s. However, new methodologies, emerging technological advances, and the applications of improved statistical models saw a resurgence of biodistance studies around the start of the 21st century (Buikstra 1990; Saunders & Rainey 2008; Stojanowski & Duncan 2015). Recent studies have seen a higher focus on evolutionary and behavioral processes within populations rather than the descriptive and methodological analyses that was the common focus of many earlier studies (Saunders & Rainey 2008). Currently, there is an advocacy for research in bioarchaeology that continues to answer questions about the past, but also has applications in modern day populations and a draw for the wider public to also engage in (Stojanowski & Duncan 2015). Multidisciplinary research has become more prevalent among biodistance studies (and bioarchaeology in general) which allows for greater application of methodological and theoretical approaches while reaching a broader audience.

⁴ See Stojanowski & Schillaci (2006) for an in-depth list of kinship studies with varying methodologies from the 1960’s to the present.
Current multidisciplinary research in biodistance covers a wide array of theoretical models and subject matter from populations across the world. Recent studies have highlighted questions of power and influence of empires on regional populations (Scherer 2007; Tung & Knudson 2011; Bethard 2013; Pink 2013; Hens & Ross 2017), post-marital residence and kinship groups (Steadman 2001; Schillaci & Stojanowski 2003; Stojanowski & Schillaci 2006; Carson 2006a, 2006b; Pilloud & Larsen 2011; Khudaverdyan 2012, 2014; Sarfo 2014; Prevedorou & Stojanowski 2017), and regional migration patterns (Kopp 2002; Irish 2010; Movesesian 2013; Relethford & Crawford 2013; McIlvaine et al. 2014; Movesesian & Bakholdina 2017). The increased focus on intra-group variation has allowed more specific populations to be analyzed with research questions that can be connected to larger regions and groups as a whole.

In regard to research within England, while a large amount of bioarchaeological research has been conducted, overall there is a lack of biodistance studies in the literature with most being represented by unpublished theses or dissertations (Mays 2010). Craniometric applications have been used on a chronological scale to understand population changes with British populations throughout various periods (Jones 2014) as well as comparing genetic relationships between both British populations and those from nearby Denmark (Russell 2007). Burrell’s (2018) in-depth dissertation examined three different cemeteries within England to understand relatedness among the skeletal populations using both nonmetric traits and craniometrics with her results showing different levels of genetic variance (Burrell 2018). Though the reason for the lack of biodistance studies in medieval English literature is unclear, access to certain samples may be one of the issues. There are a few large collections that are often used as representative samples within England while smaller collections may be overlooked as the lack of individuals within many
collections is not ideal for statistical tests often involved in biodistance studies. Access to a wider variety of collections has been limited within recent years because much of the published research has focused on a small handful of sites. As such, there has been a push for greater access to collections and data sharing, so the scope of English skeletal studies is not represented by a small minority of individuals (Roberts & Mays 2011).

3.9 Theoretical Approaches in Bioarchaeology

To help understand the ways in which the human remains have been used in biological and archaeological sciences, theoretical approaches that use the skeletal as material culture are used in a biocultural approach to population questions (Zuckerman & Armelagos 2011). The idea of embodiment, that is how the body is shaped and affected by both individual and social factors during ontogeny, allow for investigations of outside influence from social systems on the individual body (Buikstra & Scott 2009). As the skeletal system is at the intersection between both biological and cultural studies, it works well under theoretical models framing bioarchaeological questions (Agarwal & Glencross 2011). Social theories are an important framework in order to examine questions of outside influence on a population and show how broader interpretations can be addressed based on the descriptive data from material culture, in this case the human remains themselves (Martin & Harrod 2015).

As the feudal structure in England was based around agricultural labor and trade, a political economic framework lends itself to studies involving the populations during the Middle Ages. Political-economic perspectives in biocultural research have been an important factor in bioarchaeological and biological anthropology as the idea of embodiment is tied to the structural systems in which a population lives (Zuckerman & Armelagos 2011). Literally speaking, political economy is the social science that studies the interrelationships between the political
and the economic (Gupta 1992). These aspects are paramount to the formation of states (or larger social systems) and their inactions with the those that exist within it. The structure of society becomes important for understanding the true nature of the state and various aspects in which defines it, such as economical, ideological, and population structure. A political economy framework aims to accomplish three primary goals: 1) to understand the social analysis of the formation and dynamics (or movement) or social forces of class and non-class factors; 2) political analysis of the formation, working and movement of political forces of the state, state apparatuses, political parties and others; and 3) economic analysis of sociopolitical forces as they impinge on the information, working and the dynamics of socioeconomic policy formulation and execution (Gupta 1992). For many American anthropologists, political economy began as a way to look at European colonial dominance over other societies, the movement of peoples to these areas and the reemergence of class systems (Roseberry 1988). Social systems no longer existed in a singular common area, but rather a political, social, and economical entity that is interconnected with one another.

The phrase “political economy” has had different meanings and applications since its inception. For Adam Smith, it was the science of managing a nation’s resource so as to generate wealth. For Marx, it was how the ownership of the means of production influenced historical processes. In the 20th century, it is viewed as an area of study while at other times it is viewed as a methodological approach (Weingast & Wittman 2008). Karl Marx’s ideas are often used in a political economy approach, especially involving class system and the body politic in economics. People enter areas of modes of production to survive and in doing so, a class system evolves which controls social, political, and intellectual life (or access) (Roseberry 1988). Marx also classifies the wage worker as one in a perpetual cycle that is generally under the rule of someone
of a higher class or rank. Social productions are determined by laws from a social system, which in turn affect how the economy is developed (Marx 1859). The structure of a state is usually based on those of the working class. It can be argued that one of the main influences on the nature of a state is by which the worker-class (in some form or another) is used. Economics and production are integral to a larger society, either from a commercial standpoint or that of subsistence of the population itself.

Political Economic “rules” are not always concrete and a population under the state may be viewed differently depending on the systems in place. A study done by Mark Bailey (1989) claims that the most prosperous areas of medieval England under the feudal system were those of fertile land, which were able to export more agricultural products, while sustaining a larger population that the nobles could tax. As a result, the surplus of products in some areas among the peasantry allowed more commercialization and autonomy within the economy. This shows that even under the same ruling state, different groups may have diverse experiences (Bailey 1989).

The influence of power is malleable, and it is common that a minority who run social institutions hold the majority of power and exert that power on those that exist within the system (Foucault 1978; Biddick 1990). Peasant groups within feudal societies were often at the mercy of the state, either for land use, resources they could not gather themselves, or protection. Even in their own space, autonomy was not always theirs, as lords who owned the land also had the power to relocate the peasantry in order to maximize profits of the estate (Wolf 2010). Lordship was a determining but variable influence in the process of migration for the peasant class, both in controlling people and defining spaces (Postles 2000).

Contextualizing social or economic systems is important as not all systems are the same. For example, there was a change in the structure and form of agricultural labor from the feudal
era to the industrial era. The workers in agricultural labor in the feudal system were allowed to keep a portion of their labor for subsistence, where the traditional capitalist view is that laborers turn over the totality of their production to the landowner in exchange for wages (Wallerstein 1974). The Marxist idea of an economic system cannot be viewed in the same way as individual interests, as the elite and peasantry have different motivations. There have also been critiques when focusing too much on production and wealth, usually when following the Marxist model. Ortner (1984) claims that current views on political economy are “too economic, too materialist,” and do not have enough to say about “real people doing real things,” and has too much of a “capitalism-centered” approach (Ortner 1984; Roseberry 1988, pp.161-162). This critique is a fair one and implies that many of the scholars examining political economy do not focus on the individual (or group) agency, which can affect the system in place in different ways. This is also a product of the lack of studies on historically lower-class populations or the labor force, either through lack of interest or lack of available information (Kowaleski 2014). The economic structure is important to contextualize social systems; however, the agency of individuals is needed to understand the value of goods, how or why trade networks are created, and the catalyst for the social structure.

As archaeology focuses on material remains, bioarchaeological theories (such as embodiment) using the body as material culture can help investigate the biological and social implications of societal structure and their effect on populations (Boutin 2011). While written records may be absent for the peasant class, skeletal evidence can record the lived experiences and conditions in which generations of people were shaped (Agarwal & Glencross 2011; Larsen 2018). The political economy framework used with embodiment theory lends itself to
biodistance studies, as this allows researchers understand questions of movement and control in areas where traditional archaeological evidence may be lacking.

3.10 Research Questions

This study aims to examine population movement among the peasant class in medieval England and how the feudal system may have influenced urban/rural connections. As all the individuals included in this study are from the high middle ages (11th century-15th century), migration of the peasant class out of their lord’s land may have been restricted in some way. As the nobility had influence over the peasant class, questions about power dynamics and landscape control and its effects on movement can be addressed. Was gene flow limited during this period for a majority of the population or were more villages and towns interconnected than previously thought? The following research questions will be tested in the subsequent chapters of this study:

1. Do the nonmetric trait frequencies from rural sites show differences from the urban sites from London, correlating with the idea that peasant migration was more contained?
   a. If so, do the rural sites show differences or similarities from each other supporting Cesaretti et al.’s (2016) hypothesis?

2. Using the post-marital residence model, are there sex-based differences among the English sites compared to both rural and urban populations?
Chapter 4: Materials and Methods

4.1 Introduction

This chapter provides an overview of the materials and methods used in the present study. The different sample populations within England are discussed further, expanding on the history of the sites and briefly discussing the skeletal collections. A short discussion of the nonmetric cranial traits examined is included followed by summarized descriptions (with accompanying pictures) as well as some the methodological aspects of trait and population selection within the skeletal samples. Finally, a broad overview of the applied statistical methods used in biodistance studies is presented.

4.2 English Sites

The skeletal populations presented for this study were chosen in order to help understand migratory patterns of communities in feudal society. By utilizing a biodistance model with nonmetric cranial traits, medieval communities from various areas can be compared and examined for genetic relatedness. Under the assumption that England had become a network of towns, villages, and cities (Dyer 1994, Cesaretti et al. 2016), the use of communities with differing distances can help test the previously mentioned hypothesis. Sites were chosen based on geographical location in relation to one another within England (Fig. 4.1). Generally speaking, church graveyards contained many of the general parishioners and lay individuals in the surrounding urban or rural areas. Occasionally, high status individuals may have separate burials inside church, but cemeteries were usually mixed to some degree (Pitfield et al. 2019). As a thriving medieval city, London offers good representation of not only a diverse population, but
one that may include migrants from neighboring areas. The other two communities in this study were chosen for both the distance from London and one another, as well as the difference between the communities themselves (i.e. urban vs. rural). The skeletal populations include:

- **Merton Priory (London, England):**

  The priory in the Merton borough of London was initially founded as an Austinian priory in the year 1117 after the manor was granted to Gilbert the Norman by Henry I in 1114. The subsequent years saw growth of the priory and construction of a permanent church, of which expansion continued in the 12th century until around 1175 (“House of Austin Canons” 1967). The education of Thomas Beckett, the Archbishop of Canterbury, in 1128 as well as a crown wearing ceremony of King Henry VI in 1437 shows that Merton Priory was an important and respected institution within London during its use. However, during the 15th century it slowly delved into a dilapidated state until it’s eventual closure and subsequent dismantling by Henry VIII in 1538 (Saxby n.d).

  The skeletal population discovered within the church grounds of the priory are those of a mixed population of both monastic and lay individuals from the surrounding area with a total number of individuals recovered from archaeological excavations numbering at 678. Those buried at the priory were a part of the local community, but also consisted of the clergy who may or may not have originated from the area (Marklein & Crews 2017). Following the trend of many monastic sites, the majority of those individuals were over 25 years of age, with relatively few subadults recovered, and the majority of the population determined to be male (Mikulski 2007). Nonmetric trait data for 208 individuals were available for study.

- **Guildhall Yard (London, England):**
TheGuildhallYardsitewasexcavatedfromanarealocatedonlandusedinLondonby
the medi eval churchyard ofSt. Lawrence Jewry. The church itself was built in the early
twelfth century while some of the earlier burials discovered are thought to be dated to the late
eleventh century. Theoriginal church was in use throughout the medieval period until it was
destroyed in the Great Fire of London in 1666 and subsequently rebuilt by Sir Christopher
Wren in 1677. While the church itself is dedicated to St. Lawrence the additional name Jewry
is in reference to the geographical location of the church on Old Jewry Street, which was
situated near the medieval Jewish quarter of London (“A History of the Church” n.d.).

Archaeological excavations in the late twentieth century uncovered a small skeletal
population (N=68) that represents a typical medieval population living in neighboring
tenement community in London during the eleventh and twelfth centuries (Marklein &
Crews 2017). Both males and females (as well subadults) are represented within the
population (Cowal 2007). For the purposes of this study, a total number of 31 individuals met
the available criteria in regard to cranial elements present.

- **Spital Square (London, England):**

  The Spital Square site is associated with St. Mary Spital, a large priory and hospital that
was located on the fringes of medieval London. Founded as an Augustian priory and
infirmary in 1197 by a wealthy London merchant, St. Mary Spital grew to be one of the
largest infirmaries in medieval England, able to accommodate 180 individuals. Surviving
documentation shows that in addition to lay persons, royal servants and wealthy benefactors
were also taken care of at St. Mary Spital, marking the infirmary as an important resource for
all social classes. This makes the sample from Spital Square a good representation of not
only a medieval community in London, but also a stratified population living in close
proximity and one that is also associated with the local urban poor (Marklein & Crews 2017; Bekvalac et al. n.d.). Archaeological excavations throughout the twentieth and twenty-first centuries have uncovered more than 10,000 individuals from various sites associated with the priory and infirmary, with around 4,000 of those recovered from mass graves in response to disease and famine (Milohnic 2017).

Excavations of the Spital Square site accounted for 124 individuals that were buried near or in the St. Mary Spital cemetery, though nonmetric traits for only 86 individuals were scored. Preservation was generally good in regard to skeletal elements and there is a variety based on age and sex within the population. Scored. Preservation was generally good in regard to skeletal elements and there is a variety based on age and sex within the population.

- **Wharram Percy (Yorkshire, England):**

Arguably one of the most famous and influential English archaeological sites, Wharram Percy has been extensively studied by archaeologists and skeletal biologists for over 60 years (Taylor 2013). Located in northeastern England in Yorkshire, Wharram Percy was founded as a small, rural community in the early Middle Ages, only to grow during the 10th-15th centuries. Evidence shows that a standing church was established in the early 13th century and continued to be in use into the modern day, even after the village itself was abandoned (Derevenski 2000). Excavations at St. Martin’s church, as well as the churchyard, resulted in the recovery of 687 individuals with great preservation and could be dated during the medieval period (10th-16th centuries). As these individuals represented the peasant community who lived and worked at Wharram Percy and the surrounding rural areas with a large number (almost 50%) of those being less than 18 years of age (Richards et al. 2002).
This skeletal population has been used for multiple studies on medieval communities and offers great insight to the lives of those living in rural, medieval England. Due to the good
preservation of the skeletal elements of the Wharram Percy community, nonmetric traits of 
359 adult individuals were able to be recorded. The Wharram Percy population will be an 
important group for this study as it represents not only a large, medieval community but also 
one that is from a different geographical area than the others included.

- **St. Lawrence’s Church (Warwickshire, England):**

  The borough of Warwick is situated geographically south-central in England and 
historically consisted of a small medieval town among a large expanse of land. The town of 
Warwick itself was fairly small until William the Conqueror founded Warwick Castle in 
1068 as a military base within England (Harfield 1991). Historical records show that the 
strategic value of the castle was more significant than the town itself and as such, the 
population of Warwick stayed relatively low and stable until recent centuries (“The borough 
of Warwick: Introduction” 1969). St. Lawrence’s Church was one of many initial parishes in 
the town itself and one of the smaller churches in Warwick. Its use during the early medieval 
period eventually fell out and the church itself went into a state of disrepair. In 1367 St. 
Lawrence’s Church (as well as a number of other small churches) was consolidated with one 
of two larger parishes (St. Mary’s Church), its parishioners moved, and the graveyards closed 

  The skeletal population recovered from the churchyard of St. Lawrence’s Church 
numbered 151, including both adults and juveniles. Overall, the preservation of the skeletal 
elements for adults was good, though for the purposes of this study 53 individuals had the 
necessary cranial elements to be scored. The community buried at St. Lawrence’s church is 
important as it highlights a small medieval community living outside of larger cities while 
still being in a centralized area within England.
Data for the three London-based samples (Guildhall Yard, Merton Priory, and Spital Square) were acquired from the Museum of London’s Wellcome Osteological Database (museumoflondon.org.uk). This database archives numerous skeletal populations from multiple time periods from the greater London area, including osteological inventories as well as nonmetric, pathological, and demographic data. Nonmetric trait data from Wharram Percy was graciously shared by Dr. Simon Mays who has worked extensively with the skeletal collection from Wharram Percy. The sample population from Warwick was personally scored by the author (November 2019) at the University of Sheffield (Sheffield, UK) with permission from Dr. Sophie Newman. The scoring of the nonmetric was based on the procedures from Standards: For Data Collection From Human Remains (Buikstra & Ubelaker 1994), with recording conducted on the hardcopy forms provided. The total number of individuals initially examined is presented in Table 4.1.

<table>
<thead>
<tr>
<th>Site</th>
<th>Total Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guildhall Yard*</td>
<td>31</td>
</tr>
<tr>
<td>Spital Square*</td>
<td>86</td>
</tr>
<tr>
<td>Merton Priory*</td>
<td>208</td>
</tr>
<tr>
<td>Warwick</td>
<td>53</td>
</tr>
<tr>
<td>Wharram Percy</td>
<td>359</td>
</tr>
<tr>
<td></td>
<td><strong>737</strong></td>
</tr>
</tbody>
</table>

*Indicates London-based population

4.3 Nonmetric Cranial Traits and Trait Selection

The nonmetric cranial traits chosen for this study were based on the 24 listed in Standards: For Data Collection From Human Remains (Buikstra & Ubelaker 1994). Initially, 30 nonmetric cranial traits were listed and defined by Berry and Berry (1967). However, studies have shown higher heritability of some traits over others, causing the list of traits used in populations studies to be redefined in recent years (Sjovold 1984; Saunders & Rainey 2008). The following traits are
associated with the present study and were scored by the author on the Warwick skeletal sample:

1. **Metopic Suture (Metopism):** Located mesio-frontal between bregma to nasion. The suture normally disappears within the first two years but may persist in some individuals, either as completely retained or extended a short distance from nasion.

2. **Supraorbital Structures:** Notches or Foramina may be present at the supraorbital margin of the frontal bone. Foramina must present openings on both orbital and external surfaces.

3. **Infraorbital Suture:** Located on the orbital and maxillary surfaces. Suture extends from the orbital margin to the infraorbital foramen.

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5 Nonmetric trait descriptions are taken from Berry & Berry (1967), Hauser & DeStefano (1989), and Buikstra & Ubelaker (1994).

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Figure 4.2 Frontal View of Cranial Nonmetric Traits.  
*Source: Buikstra & Ubelaker 1994*
4. **Multiple Infraorbital Foramina:** Foramina satiated on the external, anterior surface of the maxilla, above the canine fossa.

5. **Zygomatico-facial Foramina:** Foramina located on the facial surface of the zygomatic. Can vary in both size and number.

6. **Parietal Foramen:** Foramina located on the parietal bone, often near the suture at obelion.

7. **Sutural Bones:** Separate ossicles located in specific points in the cranial vault.

---

![Figure 4.3: Superior and lateral view of cranial nonmetric traits.](Source: Buikstra & Ubelaker 1994)
o **Epipteric Bone**: Located at the junction of the frontal, parietal, temporal, and sphenoid bones.

o **Coronal Ossicle**: Located within the coronal suture.

o **Bregmatic Bone**: Location at the junction of frontal and parietal bones.

o **Sagittal Ossicle**: Located within the sagittal suture.

o **Apical Bone**: Located at lambda.

o **Lambdoid Ossicle**: Located within the lambdoid suture.

o **Asterionic Bone**: Located at the junction between the occipital, parietal, and temporal bones.

o **Ossicle in Occipito-Mastoid Suture**: Located in the suture between the temporal and occipital bones.

o **Parietal Notch Bone**: Ossicle located between the squamous portion of the temporal and parietal.

8. **Inca Bone**: Failure of fusion of the squamous portions of the occipital during development. A transverse suture commonly divides the squamous portion at the highest nuchal line.

9. **Condylar Canal**: Canal opening within the condylar fossa, posterior to the occipital condyles.

10. **Divided Hypoglossal Canal**: Located superior to the occipital condyle. Can be divided by spines located within the canal or internally adjacent to the foramen magnum.

11. **Direction of Flexure for Superior Sagittal Sulcus**: Variation in flexure: Right, left, or bifurcation.

12. **Foramen Ovale Incomplete**: Foramen ovale open to foramen lacerum.
13. **Foramen Spinosum Incomplete**: Foramen spinosum open to foramen lacerum.

14. **Pterygo-spinous Bridge/Spur**: Bony bridge due to fusion of lateral lamina between the lateral pterygoid plate of the sphenoid and the spina angularis.

15. **Pterygo-alar Bridge/Spur**: Bony bridge due to fusion of lateral lamina between the lateral pterygoid plate of the sphenoid and the inferior surface of the greater wing.

![Figure 4.4: Posterior and basilar view of cranial nonmetric traits.](image)

*Source: Buiksta & Ubelaker 1994*

16. **Tympanic Dihiscence (Foramen of Huschke)**: Incomplete closure of the tympanic plate of the temporal bone. Present in early life but can persist after the fifth year.

17. **Auditory Exostosis (Torus)**: Bony nodule developed within the internal auditory meatus.
18. **Mastoid Foramen:** Foramen located posterior to the mastoid process. Typically on the temporal bone, but occasionally on the occipital or within the occipito-mastoid suture.

19. **Multiple Mental Foramen:** Multiple foramina located on the external aspect of the mandible, inferior to P3.

20. **Mandibular Torus:** Bony ridge or nodules that develop on the lingual aspect of the mandible near the premolars and the canines.

![Figure 4.5: Basilar view of cranial nonmetric traits. Source: Buikstra & Ubelaker 1994](image)

21. **Mylohyoid Bridge:** Bony bridge over the mylohyoid canal of the mandible, either in the center of the groove or near the mandibular foramen.

   Scoring the paired nonmetric traits in this study used a denotation of bilateral absence, bilateral presence, and presence of left/right while unpaired traits received either presence or
absence. The metopic suture was counted as present if either the suture was observable from the entire frontal bone or just a small portion from nasion (Gualdi-Russo et al. 1999).

Unobservable traits in fragmentary crania are also noted and scored as such. Individual sex-estimations (either Male, Female, Probable Male/Female, or Undetermined) were recorded and included with nonmetric trait data for two reasons: 1) Certain nonmetric traits have been shown to have a sex-based association in certain populations (Brasili et al. 1999; Carson 2006). 2) Division of sexes will be used to help understand any sex-based migration patterns based on post-marital residence analysis (Lane and Sublett 1972; Konigsberg 1988; Prevedorou &

Figure 4.6: Lateral view of the cranial and mandibular nonmetric traits.  
Source: Buikstra and Ubelaker 1994
Stojanowski 2017). As previously mentioned, while age does not necessarily affect the genetic threshold for trait expression itself, it does affect the phenotypic expression as osseous elements may not fully be formed (Saunders & Rainey 2008). Therefore, the individuals chosen were all those classified as adults (i.e. ≥18)\(^6\).

Data from the three London sites, as well as Wharram Percy, were previously scored and reported by their respective authors. Therefore, the data was reorganized to match the formatting for traits scored for the Warwick sample, including exclusion of those classified as non-adults, by the present author. As the data from three sites in London and Wharram Percy had their own specific traits available for comparison, the 29 traits above (following Buikstra & Ubelaker 1994) were narrowed down to match those that were scored for Warwick (Fig. 4.2). In terms of intra-observer error, nonmetric trait scores for Wharram Percy and the London sites were recorded by their respective authors with no conflict of interest relating to the scores. A smaller skeletal sample from Warwick (N=6) was rescored by the author at a different time in order to test for intra-observer error. A Kappa test of agreement was performed on the subsample following Veria & Garrett (2005). Comparison of the original and rescored values showed no significant difference in trait observation with all individuals resulting in substantial or almost perfect agreement (Table 4.3).

<table>
<thead>
<tr>
<th>Table 4.2: Nonmetric cranial traits chosen for the present study.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metopsim</td>
</tr>
<tr>
<td>Supraobital Foramen</td>
</tr>
<tr>
<td>Infraorbital Foramina</td>
</tr>
<tr>
<td>Parietal Foramen</td>
</tr>
<tr>
<td>Epiphreric Bone</td>
</tr>
<tr>
<td>Coronal Ossicle</td>
</tr>
<tr>
<td>Bregmatic Bone</td>
</tr>
</tbody>
</table>

\(^6\) While there is a difference between social age and biological age, 18 is generally considered the cutoff biological age for skeletal studies focusing on adults. Biological development and social age categories vary in populations, however. See Lewis et al. (2016) for an example of biological and social adulthood status variation in medieval England.
Table 4.3: Values for Kappa Statistic of Agreement

<table>
<thead>
<tr>
<th>Individual #</th>
<th>Kappa Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS09 357</td>
<td>0.763</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>WS09 324</td>
<td>0.931</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WS09 459</td>
<td>0.945</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WS09 559</td>
<td>1.000</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WS09 491</td>
<td>0.931</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>WS09 508</td>
<td>1.000</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kappa</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0</td>
<td>Less than chance agreement</td>
</tr>
<tr>
<td>0.01–0.20</td>
<td>Slight agreement</td>
</tr>
<tr>
<td>0.21–0.40</td>
<td>Fair agreement</td>
</tr>
<tr>
<td>0.41–0.60</td>
<td>Moderate agreement</td>
</tr>
<tr>
<td>0.61–0.80</td>
<td>Substantial agreement</td>
</tr>
<tr>
<td>0.81–0.99</td>
<td>Almost perfect agreement</td>
</tr>
</tbody>
</table>

Figure 4.7: Interpretation of Kappa Statistic

4.4 Statistical Tests

Smith’s Mean Measure of Divergence (MMD) is a dissimilarity measure in which phenotypic traits can be compared within and between groups; higher values indicating a larger phenetic distance while lower values indicate similarities (Irish 2010). In regard to genetics, groups with higher values are assumed to be less related genetically through time and/or distance, a result of any manner of social or environmental phenomenon (Harris & Sjøvold 2004). Originally designed by C. A. B. Smith, the MMD method was first applied to human populations by Berry & Berry (1967) and later popularized in biological anthropology studies (Irish 2010; Santos 2018). Subsequent revisions of the MMD formula were proposed by Sjøvold (1977) and Harris & Sjøvold (2004) to adjust for trait selection and population sizes. The MMD is calculated based on sample size and the frequency of traits within those samples, and is defined by the following formula:
where $r$ is the number of dichotomous traits, $n_{1i}$ and $n_{2i}$ are the numbers of individuals examined for the $i$th trait in samples 1 and 2 respectively, and $\theta_{1i}$ and $\theta_{2i}$ are the angular transformations of the relative frequencies of the $i$th traits in the two samples, given in radians (Green et al. 1979; Santos 2018).

The MMD method was chosen for the present study for two reasons: 1) it has been used by a variety of scholars in biodistance studies with compelling results to assess genetic affinity, group affiliation, and migratory patterns (Prowse & Lovell 1995; Irish 2010; Matsumura & Oxanham 2014; Weiss 2017; Thorson 2018; Velasco 2018; Wiig et al. 2019); and 2) accessible statistical programs allow for easily read results and analysis (Santos 2018). There have been critiques regarding MMD analysis in population studies, such as negative values, trait redundancy, and a partial dependency of a large sample size (Movsesian 2013; Nikita 2015). However, the MMD approach does perform well and can be correctly applied if sample sizes, careful trait selection, and statistical transformations (e.g. Freeman and Tukey/Anscombe) are utilized with datasets (Irish 2010; Nikita 2015).

As sex-based correlations with nonmetric cranial traits can vary from population to population, it is necessary to run multivariate tests in order to exclude results that may skew MMD results (Buiksta 1976; Prowse & Lovell 1995; Pink 2013). The final traits chosen for this study (Fig. 3.9) were examined using a phi coefficient, with the Bonferoni correction (0.05/19 = <0.005) for the larger sample size and multivariate comparisons, to test for significance between traits and the individuals associated sex (following Velasco 2016). Only individuals with a designation of either male (“M”) or female (“F”) were included in the analysis. Tests were run
using SPSS v. 24. Any traits that showed significance at the $\leq 0.005$ level were removed from the study. Sjøvold (1977) also recommends eliminating traits within the sample that have either a low ($\leq 5\%$) or high ($\geq 95\%$) frequency among the populations. Individuals were also excluded from the final analysis depending on the frequency of overall traits overserved and those with less than 50% observed traits were eliminated in the final examination (following Pink 2013).

The final dataset was imported into the statistical program R (R Core Team, 2019) and ran using the package *AnthropMMD* (Santos 2018), which was installed through the Comprehensive R Archive Network, CRAN. This package uses a graphical user interface (GUI) in order to calculate the MMD. The analysis within the GUI has in-depth options that allows the user to apply angular transformations, exclude traits based on desired frequency, as well as filtering traits based on nonpolymorphic/ quasi-nonpolymorphic traits and significance among groups based on Fisher’s exact test (Santos 2018). Downloadable MMD matrices and graphics such as Ward’s hierarchical clustering and multidimensional scaling (MDS) charts allow for visual representation and easily readable results when comparing trait frequency and the subsequent MD values between sample sites.

In order to test the second hypothesis proposed in this study, post-marital residence analysis will be used to examine residential patterns of English populations. This analysis can be useful in showing adult resident patterns, mate exchange, and other social interactions between and within different communities (Walker 2015). While post-marital residence is a broad term that may or may not be relevant to all communities in terms of marriage practices or other cultural differences, in general it is used to test if sex-based differences exist in residence patterns (Konigsberg & Frankenberg 2016). As the question of migratory patterns in medieval England is based on the assumption that younger individuals may have migrated to larger urban
areas and/or inheritance of rural land through male children was more common than female children, Adam’s (1947) terms virilocal and uxorilocal may be more applicable in this case.

Following Konigsberg & Frankenberg (2016), dichotomous data for was coded as A(absent), C (presence), and ? (unobservable) and run through the R software with a script using a package designed to read DNA data (Konigsberg & Frankenberg 2016). Empirical density charts can be created through the program to understand male-to-female relationships based on nonmetric trait data. As individuals needed to be assigned either as male (M) or female (F), those individuals with designations of possible male (M?), possible female (F?), and undetermined were excluded from the post-marital residence analysis. The individuals from the rural sites of Wharram Percy and Warwick were tested separately while those from the three London-based sites were pooled together to be compared (Table 4.4).

Table 4.4: Total number of males and females.

<table>
<thead>
<tr>
<th>Site</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>London*</td>
<td>140</td>
<td>31</td>
<td>171</td>
</tr>
<tr>
<td>Wharram Percy</td>
<td>138</td>
<td>102</td>
<td>240</td>
</tr>
<tr>
<td>Warwick</td>
<td>18</td>
<td>10</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>296</td>
<td>143</td>
<td>439</td>
</tr>
</tbody>
</table>

*Consists of Guildhall Yard, Merton Priory, and Spital Square.

4.5 Conclusion

This chapter offers a brief look at the rationale of why the various sites/ populations were chosen and as well as the procedures in which traits and individuals were included or excluded from this study. Statistical methods were also outlined briefly, though a more in-depth look into MMD (and other such methods) can be explored through some of the aforementioned authors.
(e.g. Sjøvold 1977; Green et al. 1979; Irish 2010; Nikita 2015). After combining the different datasets into a uniformed document, the AnthropMMD R package will be able to produce results which will help examine the proposed hypotheses regarding biodistance within medieval England.
Chapter 5: Results

5.1 Introduction

This chapter examines the statistical tests performed by the program R (R Core Team, 2019) and the resulting output in order to understand possible genetic relations between the sample populations. Two different types of tests were run in R to test the two different hypotheses: First, the R package AnthropMMD was used to access biological distance among the different sites in England and second, an R code developed by Konigsberg and Frankenberg (Konigsberg & Frankenberg 2016) was used to test for possible genetic differences among both males and females of the respective sites. The resulting tables, figures, and matrices are presented to help show any differences or similarities among the groups.

5.2 Nonmetric Trait and Sample Selection

Careful trait selection for nonmetric traits is an important part of MMD analysis and data should be chosen in such a way that does not create redundancy and negative values in the biodistance model (Irish 2010). Using SPSS, the list of nonmetric traits was examined with a multivariate analysis (phi coefficient and a Bonferroni correction), allowing traits that may have sex-based correlations within the sample populations to be excluded from the study (Table 5.1). The mandibular torus was the only observed trait that had correlations with sex in the sample populations.
Sjøvold’s (1977) recommendation to eliminate traits that show both low (≤5%) or high (≥95%) frequency among the sample was applied to the populations used in this study. However, out of the 19 traits initially chosen for this study, this did not apply to the combination of the five sample groups. As missing data can also skew results of the MMD analysis, traits that were not well represented (i.e. a large amount of missing data in the samples) were excluded if they showed a less than 50% frequency in the overall populations (Harris & Sjøvold 2004, Pink 2013). Table 5.2 shows the frequency of traits among the sample sites based on the designation of unobservable in relation to the total number of individuals in all populations. Three traits (multiple infraorbital foramina, epipetric bone, and parietal notch bone) had a high frequency of missing data and therefore were excluded.

Individuals who were missing most or all of the appropriate data were also eliminated from the final analysis. Those who did not show at least 50% of the selected traits (Table 5.3) were excluded from the study (following Pink 2013) as a large amount of missing data can cause
issues with MMD analysis. Table 5.4 shows the total number of individuals excluded based on an inadequate number of traits (n=202) as well as those included (n=535). This final list of individuals (with their associated nonmetric trait data) was imported into R for MMD and post-marital residence analysis.

Figure 5.1: Nonmetric sutural traits from a Warwick individual. (A.= Lambdoid ossicles; B.=Apical Bone)

Source: Author photo with permission from the University of Sheffield.
Table 5.3: Final list of nonmetric traits (traits in bold excluded from final analysis).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metopsism</td>
<td>Sagittal Ossicle</td>
</tr>
<tr>
<td>Supraorbital Foramen</td>
<td>Apical Bone</td>
</tr>
<tr>
<td><strong>Infraorbital Foramina</strong></td>
<td>Lambdaid Ossicle</td>
</tr>
<tr>
<td>Parietal Foramen</td>
<td>Asterionic Bone</td>
</tr>
<tr>
<td>Epipteric Bone</td>
<td>Parietal Notch Bone</td>
</tr>
<tr>
<td>Coronal Ossicle</td>
<td>Inca Bone</td>
</tr>
<tr>
<td>Bregmatic Bone</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.4: Total number of individuals included based on trait frequency.

<table>
<thead>
<tr>
<th>Site</th>
<th>Total Individuals</th>
<th>Excluded in Study</th>
<th>Included in Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guildhall Yard*</td>
<td>31</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Spital Square*</td>
<td>86</td>
<td>40</td>
<td>46</td>
</tr>
<tr>
<td>Merton Priory*</td>
<td>208</td>
<td>35</td>
<td>173</td>
</tr>
<tr>
<td>Warwick</td>
<td>53</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>Wharram Percy</td>
<td>359</td>
<td>110</td>
<td>249</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>737</strong></td>
<td><strong>202</strong></td>
<td><strong>535</strong></td>
</tr>
</tbody>
</table>

* indicates a London-based population

5.3 Smith’s Mean Measure of Divergence

Once the finalized list of nonmetric traits was determined, data from the different English sites was imported into the R program *AnthropMMD* for analysis. The GUI for *AnthropMMD* allows exploration of the dataset in order to see what traits have larger effects among the populations. Table 5.5 shows the overall measure of divergence each trait has in relation to the populations and their frequency. The higher the number, the more discriminatory power that trait has. In this case, the condylar canal, parietal foramen, and mastoid foramen have some of the higher values, indicating their strength within the MMD among different groups. Negative results should be avoided as an MMD matrix that contains negative values can no longer be seen as a distance matrix (Harris & Sjøvold 2004; Santos 2018). Traits that show a negative value (Table 5.5) have little variation among the sample groups and those should be excluded from the study in order for the MMD to work efficiently (Nikita 2015; Weiss 2017). Stipulations
regarding nondiscriminatory traits within the AnthroMMD GUI allows traits to be excluded if under a certain value; in this case, traits < 0.00 were removed from the final analysis.

Table 5.5: Overall measure of divergence for each trait.

<table>
<thead>
<tr>
<th>Nonmetric Trait</th>
<th>Overall MD</th>
<th>Nonmetric Trait</th>
<th>Overall MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condylar Canal</td>
<td>6.464</td>
<td>Bregmatic Bone</td>
<td>0.190</td>
</tr>
<tr>
<td>Parietal Foramen</td>
<td>3.887</td>
<td>Supraorbital Foramen</td>
<td>0.106</td>
</tr>
<tr>
<td>Mastoid Foramen</td>
<td>3.090</td>
<td>Mylohyoid Bridge</td>
<td>0.006</td>
</tr>
<tr>
<td>Apical Bone</td>
<td>1.114</td>
<td>Lambdoid Ossicle</td>
<td>-0.166*</td>
</tr>
<tr>
<td>Asterionic Bone</td>
<td>0.766</td>
<td>Inca Bone</td>
<td>-0.214*</td>
</tr>
<tr>
<td>Auditory Exostosis</td>
<td>0.507</td>
<td>Sagittal Ossicle</td>
<td>-0.350*</td>
</tr>
<tr>
<td>Tympanic Dihiscence</td>
<td>0.242</td>
<td>Coronal Ossicle</td>
<td>-0.388*</td>
</tr>
<tr>
<td>Metopism</td>
<td>0.239</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Negative values were excluded from final analysis.

AnthroMMD runs the biodistance model based on dichotomous trait frequencies and corrects itself based on sample sizes. As long as the sample sizes are large enough, the MMD can handle missing data values, though care should be taken to avoid this as much as possible (Irish 2010). Table 5.6 shows the frequency of data from each skeletal population for both present and absent results (1/0 respectively) in relation to the sample size. Table 5.7 shows the relative frequency of traits coded as present (i.e. individuals who showed phenotypic evidence of a certain trait) in relation to sample size, represented as a percentage. These amounts are what ultimately are compared using the biodistance formula and produces the MMD matrix in AnthroMMD. A higher or lower frequency among a specific group can help distinguish groups when compared to one another and overall percentages are reflective on the discriminatory power of traits (Table 5.5).
Table 5.6: Number of Individuals in relation to nonmetric trait data (both presence/absence).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Guildhall Yard</th>
<th>Spital Square</th>
<th>Merton Priory</th>
<th>Warwick</th>
<th>Wharram Percy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metopism</td>
<td>20</td>
<td>40</td>
<td>156</td>
<td>42</td>
<td>245</td>
</tr>
<tr>
<td>Supraorbital Foramen</td>
<td>20</td>
<td>42</td>
<td>132</td>
<td>36</td>
<td>214</td>
</tr>
<tr>
<td>Parietal Foramen</td>
<td>19</td>
<td>39</td>
<td>145</td>
<td>46</td>
<td>243</td>
</tr>
<tr>
<td>Bregmatic Bone</td>
<td>15</td>
<td>35</td>
<td>131</td>
<td>46</td>
<td>231</td>
</tr>
<tr>
<td>Apical Bone</td>
<td>17</td>
<td>39</td>
<td>120</td>
<td>46</td>
<td>231</td>
</tr>
<tr>
<td>Asterionic Bone</td>
<td>12</td>
<td>31</td>
<td>50</td>
<td>44</td>
<td>204</td>
</tr>
<tr>
<td>Condylar Canal</td>
<td>13</td>
<td>35</td>
<td>44</td>
<td>38</td>
<td>220</td>
</tr>
<tr>
<td>Tympanic Dihiscence</td>
<td>20</td>
<td>44</td>
<td>155</td>
<td>42</td>
<td>229</td>
</tr>
<tr>
<td>Auditory Exostosis</td>
<td>20</td>
<td>44</td>
<td>157</td>
<td>44</td>
<td>223</td>
</tr>
<tr>
<td>Mastoid Foramen</td>
<td>19</td>
<td>45</td>
<td>158</td>
<td>44</td>
<td>227</td>
</tr>
<tr>
<td>Mylohyoid Bridge</td>
<td>18</td>
<td>45</td>
<td>135</td>
<td>38</td>
<td>208</td>
</tr>
</tbody>
</table>

Table 5.7: Relative trait frequency present among populations.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Guildhall Yard</th>
<th>Spital Square</th>
<th>Merton Priory</th>
<th>Warwick</th>
<th>Wharram Percy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metopism</td>
<td>0%</td>
<td>12.5%</td>
<td>8.3%</td>
<td>9.5%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Supraorbital Foramen</td>
<td>45%</td>
<td>47.5%</td>
<td>50%</td>
<td>44.4%</td>
<td>29.4%</td>
</tr>
<tr>
<td>Parietal Foramen</td>
<td>15.8%</td>
<td>20.5%</td>
<td>51%</td>
<td>34.8%</td>
<td>70%</td>
</tr>
<tr>
<td>Bregmatic Bone</td>
<td>6.7%</td>
<td>0%</td>
<td>0.8%</td>
<td>0.0%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Apical Bone</td>
<td>0%</td>
<td>2.6%</td>
<td>9.2%</td>
<td>19.6%</td>
<td>16.9%</td>
</tr>
<tr>
<td>Asterionic Bone</td>
<td>16.7%</td>
<td>16.1%</td>
<td>40%</td>
<td>11.4%</td>
<td>13.7%</td>
</tr>
<tr>
<td>Condylar Canal</td>
<td>46.2%</td>
<td>14.3%</td>
<td>38.6%</td>
<td>18.4%</td>
<td>83.2%</td>
</tr>
<tr>
<td>Tympanic Dihiscence</td>
<td>5%</td>
<td>9.1%</td>
<td>10.3%</td>
<td>7.1%</td>
<td>22.3%</td>
</tr>
<tr>
<td>Auditory Exostosis</td>
<td>0%</td>
<td>2.3%</td>
<td>10.8%</td>
<td>2.3%</td>
<td>0%</td>
</tr>
<tr>
<td>Mastoid Foramen</td>
<td>26.3%</td>
<td>24.4%</td>
<td>44.9%</td>
<td>70.5%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Mylohyoid Bridge</td>
<td>27.8%</td>
<td>17.8%</td>
<td>13.3%</td>
<td>13.2%</td>
<td>17.3%</td>
</tr>
</tbody>
</table>
Table 5.8: Matrix of MMD values (upper diagonal).  
Associated Standard Deviation Values (lower diagonal).

<table>
<thead>
<tr>
<th></th>
<th>Guildhall Yard</th>
<th>Merton Priory</th>
<th>Spital Square</th>
<th>Warwick</th>
<th>Wharram Percy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guildhall Yard</td>
<td>0</td>
<td>0.083</td>
<td>0.007</td>
<td>0.121</td>
<td>0.259</td>
</tr>
<tr>
<td>Merton Priory</td>
<td>0.029</td>
<td>0</td>
<td>0.090</td>
<td>0.079</td>
<td>0.190</td>
</tr>
<tr>
<td>Spital Square</td>
<td>0.035</td>
<td>0.015</td>
<td>0</td>
<td>0.074</td>
<td>0.377</td>
</tr>
<tr>
<td>Warwick</td>
<td>0.035</td>
<td>0.014</td>
<td>0.021</td>
<td>0</td>
<td>0.230</td>
</tr>
<tr>
<td>Wharram Percy</td>
<td>0.027</td>
<td>0.006</td>
<td>0.013</td>
<td>0.012</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5.9: MMD values (upper diagonal) and their significance (lower diagonal).

<table>
<thead>
<tr>
<th></th>
<th>Guildhall Yard</th>
<th>Merton Priory</th>
<th>Spital Square</th>
<th>Warwick</th>
<th>Wharram Percy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guildhall Yard</td>
<td>NA</td>
<td>0.083</td>
<td>0.007</td>
<td>0.121</td>
<td>0.259</td>
</tr>
<tr>
<td>Merton Priory</td>
<td>*</td>
<td>NA</td>
<td>0.09</td>
<td>0.079</td>
<td>0.19</td>
</tr>
<tr>
<td>Spital Square</td>
<td>NS</td>
<td>*</td>
<td>NA</td>
<td>0.074</td>
<td>0.377</td>
</tr>
<tr>
<td>Warwick</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>NA</td>
<td>0.23</td>
</tr>
<tr>
<td>Wharram Percy</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>NA</td>
</tr>
</tbody>
</table>

(* indicates significance, while ‘NS’= ‘non significance).

MMD values are calculated by the *AnthropMMD* software representing multivariate analysis based on trait frequency. The sample groups are examined, and symmetric matrices are produced to show any differences in divergence. Table 5.8 shows the associated standard deviation values between two compared populations (lower diagonal) as well as the MMD values (upper diagonal). Within the MMD equation, any value of two compared populations that is over twice the standard deviation are considered significant in terms of divergence (Harris & Sjøvold 2004; Santos 2018). Table 5.9 shows the same symmetrical matrix with associated significance highlighted by a ‘*’, while those that are not considered significant (and therefore more closely related) are shown as ‘NS’.

70
All sites were compared with one another to understand possible differences in nonmetric trait frequency. MMD results indicate significant differences in traits frequencies between all samples except for Guildhall Yard and Spital Square (Tables 5.8 and 5.9). Wharram Percy shows significant results when compared to all other sites, with the highest values overall in the MMD matrix, most notably from Spital Square (v=0.377), which could be attributed to the high frequency of the condylar canal trait in the population. Warwick and Merton Priory also show significant results when compared to each other as well as the other sites, though their values are lower than Wharram Percy’s when compared to the same sites. Higher frequency of the parietal foramen and mastoid process traits (the 2nd and 3rd highest trait in regard to discriminatory power) within these groups caused a significant divergence. Guildhall Yard and Spital Square show no significant results when compared to one another, though are significant when compared to all other sample groups respectively.

A hierarchical clustering figure was generated in AnthropMMD to show a visual grouping of the sample sites based on divergence and affinity (Figure 5.2). This figure illustrates the MMD matrices provided and the overall divergence associated with MMD as well as creating proximities for more related groups (see Figure 5.2). Guildhall Yard and Spital Square’s non-significant result is evident while Merton Priory and Warwick are more closely related than the other sites, though still more closely related to Spital Square and Guildhall Yard than Wharram Percy (Figures 5.3 & 5.4). Wharram Percy shows a farther proximity to all of the other sites which is reflective of its high MMD values and higher divergent status (Figure 5.3).
Figure 5.2: Ward’s Hierarchical Clustering of the sample populations.

5.4 Post-Marital Residence Analysis

In order to examine intra-population differences between male and females based on nonmetric traits, the ratios of male-to-female pairwise mean differences were calculated in R using Konigsberg and Frankenber’s (2016) post-marital residence script. The expectation is that the sex with higher migration rate, and therefore possible greater phenotypic variability, would
be statistically significant when comparing male-to-female ratios (Konigsberg & Frankenberg 2016). The nonmetric trait data was converted and run through the R script and compared to a 95% confidence interval (based on 10,000 bootstrap samples) with an actual ratio value. The

Figure 5.3: 2-D Multidimensional scaling of MMD values.
resulting empirical cumulative density graphs are formatted with 0.025 and 0.0975 percentile values, while the median is situated at 0.5 (H₀=1; or no difference in trait heterogeneity between sexes) for all tests. A result farther from the null hypothesis would therefore indicate phenotypic differences between males and females in the populations.

As post-material residence analysis looks at possible phenotypic variation between populations in a specific area, three separate tests were performed to test the second hypothesis on Wharram Percy, Warwick, and London. As the Merton Priory, Spital Square, and Guildhall Yard cemeteries are all located within the city limits of medieval London, these populations were
pooled together to represent a single site. Figure 5.5 shows the ratio of the collective London sites (actual value=1.013933) and slightly greater than the null ratio (ratio=1). Figure 5.6 shows the Warwick sample slightly under the null ratio (actual value=0.928489) while figure 5.7 shows the Wharram Percy sample just over the null ration (actual value=1.092216). While there are phenotypic differences between males and females among the sites, none exceed what may be expected by chance. Results show no significance among the sites and all results lie within the 95% confidence interval.

**London (discrete traits)**

![Cumulative density plot](image)

Figure 5.5: Empirical cumulation density (10,000 bootstrap samples) of London where the ratio is of male-to-female pairwise differences (actual=1.013933).
The London, Warwick, and Wharram Percy site results can be interpreted in the case of male-to-female differences to some degree. The males within the London samples are slightly less homogenous phenotypically. However, the result is not significant and the initial sample ratio (M=140, F=31) may not be the best representation of city populations. The site analysis for Wharram Percy and Warwick have bit more balanced sample representation in regard to sex, though like the London sample the results are not significant. The results show that all of the study populations are essentially equal in the phenotypic variability in their respective sites as most of the actual values are very close to the null ratio (ratio=1).

![Warwick (discrete traits)](image)

**Figure 5.6**: Empirical cumulation density (10,000 bootstrap samples) of Warwick where the ratio is of male-to-female pairwise differences (actual=0.928489).
Figure 5.7: Empirical cumulation density (10,000 bootstrap samples) of Wharram Percy where the ratio is of male-to-female pairwise differences (actual=1.092216).

5.5 Conclusion

This chapter outlines the results of the statistical tests used to examine both biological distance and post-marital residence analysis with the various English sites. The MMD matrices presented significant results that support the study hypothesis of phenotypic differences between the different sites (and in the case of London, different cemeteries) and allowed for interpretable grouping patterns. Post-material residence analyses had non-significant results in terms of the
populations being virilocal or uxorilocal. The following chapter will discuss these results in more
detail and how they relate to migratory patterns and genetic diversity in medieval England.
Chapter 6: Discussion

6.1 Introduction

This chapter broadly discusses the relationship between the individual and the social system with results from the previous chapter discussed in more detail in order to answer some of the questions about gene flow in medieval England. As both biodistance and post-marital residence analysis are the methodological approaches used for this study, they will be placed in respective historical contexts in order to help understand the relationships between the social system of feudalism and how it relates to migratory patterns of the population. A combined theoretical approach of embodiment and how it relates to the economic system in England is used in order to answer the hypotheses in question.

6.2 The Medieval Body

Migratory patterns in the medieval era are discussed frequently within historical literature (Gies & Gies 1989, 2016a, 2016b; Hollister 1994; Danziger & Lacey 2000; Kowaleski 2014), though much of this information is based on historical records and archaeological work. It has not been until fairly recently that the body has been examined as a source of information in the connection between social systems and the individual (Buikstra & Scott 2009). History has often focused on the cultural and social construction of the body, rather than the actual physical bodies of past communities (Fleming 2009). Skeletal material offers a great source of information on daily lives of populations living in the medieval era. As with archaeological material culture, bioarchaeologists can look at the body as a source of material culture and information. Fleming (2009) asserts that because outside influences such as poor environment, diet, migration, and
disease are often dictated by social, political, and cultural practices, the physical body is in part a social construction. Biodistance studies offer insight to social and cultural change, with the analysis of migration treated as “patterned, dynamic human behavior rather than unique events” (Mays 2010, p. 199). Ultimately, methodological applications with skeletal data can help understand how social systems influenced individuals’ behavioral patterns and subsequently, their physical bodies.

The evidence provided for this study (i.e. cranial nonmetric traits) help answer questions of not only migratory patterns and gene flow within medieval England, but also how individuals are physically affected by their surroundings. Biodistance studies serve as good examples of the intersection between biological and cultural studies while combining historical evidence with that of (bio)archaeological data (Agarwal & Glencross 2011). The individuals chosen for this study were done so because it was hypothesized that English social systems had developmental effects on the body that could be used in order to answer population-based questions. Biodistance and post-martial residence analysis need to be examined from a biological as well as cultural perspective in order to fully understand what influenced migration.

If migratory patterns can be understood from either an urban-rural or male-female view, the embodied nature of such systems should be visible on the physical bodies of individuals who were a part of it. As the aim of this study is to test genetic affinity between populations in England, the subsequent discussion with these medieval communities is focused on both the biological, material culture (i.e. the skeleton) and the social system of English feudalism. It is the goal of this research to understand how we can use this evidence to determine how and why the socioeconomic policies had effects on individuals, but also how geographical distance and township networks contribute as well.
6.3 Biodistance in Medieval England

To understand possible migratory patterns during the medieval period in England, I applied a biodistance model to clarify genetic affinity that existed between population, making patterns of gene flow interpretable. As the underlying assumption of the heritability with non-metric traits (Stojanowski & Schillaci 2006) is the key aspect to this study, and biodistance is a good methodological approach to answering historical questions using skeletal material. Since this study uses a limited sample from select areas within England, only broad conclusions can be made about the lives of people that lived in the short span of ~500 years. However, the results from the MMD analysis show trends that match with how historical records and more recent writings describe not only population movement, but how lives were shaped in the Middle Ages.

Referring back to the MMD analysis of the sample populations, we can see slight clustering between the different site areas, and significant results that show genetic diversity between groups (see Chapter V, specifically Tables 5.8 & 5.9, Figures 5.3-Figures 5.5). The obvious outlier among the five sites was Wharram Percy. Merton Priory, Guildhall Yard, and Spital Square are all located fairly closely to one another within the London area. Warwick was located ~100 miles northwest of London. Wharram Percy, in north Yorkshire, was over 200 miles from London. As the three London-based populations were in the same city, one could expect that these sites would be fairly similar genetically. This is true for Guildhall Yard and Spital Square, which resulted in no significant differences based on the MMD analysis. As just one of the many cemeteries in medieval London, those buried there probably represented citizens of London or at least from the immediate areas as migration to large cities was becoming more prevalent by the early Middle Ages (Dyer 1994). It is interesting to note that the results for Merton Priory were significantly different in the MMD analysis when compared to both
Guildhall Yard and Spital Square. There could be two possible reasons for these results: First, from a methodological standpoint, the sample size was much larger (n=173) than those of Guildhall Yard (n=21) and Spital Square (n=46) which may have had an effect on the statistical analysis. Second, as an Austinian priory, many of those buried within it were more than likely of monastic origin (i.e. priests or those of religious affiliation) (Mikulski 2007). This could also explain the high number of males found within the population. London was a large city, especially by medieval standards, that could have easily had plenty of local priests from the area. However, priests tended to travel quite frequently in the Middle Ages (Mortimer 2010) and many of those younger men from smaller areas around London could have migrated to the city in order to gain education within the priesthood.

Warwick represents an area that was not quite a periphery village of London. The distance between the two areas is ~100 miles which would not have been an easy journey for most people. Even those individuals who would travel larger distances for markets or festivals, the distances are estimated to be no more than 20 or so miles (Dyer 1994, Magnusson 2013). It is hard to imagine that those living in the Warwick area would use London as their main source of resources, especially if other villages or larger towns were closer. As Merton Priory and Warwick were more closely related genetically through the MMD analysis, this could speak more to Merton Priory’s population of those who may have immigrated from outside the southeast of England. Military importance of Warwick in the early Norman era could have altered the migratory habits of its residents or allowed for a constantly mixing population from other areas of England as soldiers stationed there may not have been from the area initially (Harfield 1991). While the Domesday book places Warwick as a smaller village in the center of England, it was probably not necessarily a trade hub, rather those permanent residents may have
interacted with other smaller villages and towns, or closer urban areas at the time (e.g. Gloucester or Oxford; Hinde 1985).

Wharram Percy offers an ideal sample population in order to test the biodistance methodology within medieval England and genetic affinity of those populations. Since the village was situated in northeastern England and over 200 miles from London, it is not surprising that the MMD analysis for Wharram Percy against all other sites was significant. Two hundred miles is a significant distance to travel, especially by standards of the Middle Ages, and those that lived in the Wharram Percy community more than likely were not the most affluent and may not have been able to (or want to risk) travel that far south. Yorkshire as a county was fairly sparse and uninhabited overall in the Middle Ages, though the nearby city of York had a substantial population (~20,000) by the end of the 13th century (Nicholas 2014). Regular travel between residents of Wharram Percy may have been even more confined by the lack of notable villages surrounding the area. York may have been the obvious choice for any outside resources those living in the village may have needed (though it was considered a thriving rural community at the time), especially as the Domesday Book describes smaller settlements around Wharram Percy as a “waste” (Hinde 1985).

The results from the MMD analysis support the first hypothesis addressed in the previous chapter. Genetic differences are present within most of the samples to some degree. Collectively, the London-based sites show how populations did vary from the more rural sites of Warwick and Wharram Percy. Although Warwick was geographically close to the London area, the distance between the two was enough to restrict gene flow to a certain extent. As these two sites differ, it is no surprise that Warwick and Wharram Percy also differ from one another, which supports the secondary question in hypothesis one.
6.4 Post-Marital Residence

Just as I applied biodistance analysis to address gene flow between populations/communities, I used post-martial residence to analyze hetero-/homogeneity at the intra-population level. As these kinds of analyses can help show population behavior (Lane & Sublett 1972; Stojanowski & Schillaci 2006), the results can be helpful in seeing how migratory patterns may have differed between the sexes in medieval England for a number of reasons. Following Adam (1947), the terms ‘virilocal’ and ‘uxorilocal’ are used in this study as a more general way to understand sex-based migration. The traditional terms of ‘patrilocal’ and ‘matrilocal’ often come with a connotation of marriage (or other sort of family unit) and/or the presence of children. Though marriage and family units may have been a catalyst for many individuals’ living situations, either migrating or residing in their birthplace, it was not always the sole reason for migration. Young men and women leaving the countryside for better financial opportunities was certainly not unheard of, and in some ways may have been forced through uncontrollable factors (e.g. disease, conflict, famine, etc.) (Mortimer 2010). Males pursuing a life in the clergy may also have traveled on a more frequent basis to churches or monasteries, as may be the case with Merton Priory.

The results from the London sites (Merton Priory, Guildhall Yard, and Spital Square; Figure 5.5) indicate no significant differences between the male-to-female ratio, with the results close to the null ratio (actual=1.013933). By the Middle Ages London had become the largest city in England, as well as one of the largest in Europe (Dyer 1994). It also served as one of the prominent trading hubs to continental Europe (Sayles 1961). It can be assumed that while London did have individuals that were born and raised for generations within the city, the number of immigrants, from other parts of England as well as outside England, must have been
fairly large. In this case, gene flow and intermixing between populations would likely cause a more heterogenous population that could not be differentiated in terms of a patterned virilocal and uxorilocal society. As members of both sexes had reasons to move to larger urban areas it is not surprising that the results show phenotypic similarities in London. The sample size ratio is also something to consider, as mentioned in the previous chapter. Since the London sites were pooled together, a larger number of males were sampled in relation to females, possibly due to Merton Priory’s monastic status. While adding more female individuals to the sample size could alter the results, the mixed nature of London’s populace would likely produce the same results as the constant influx of new members may have made heterogeneity difficult for a single group.

Since historical reports tend to discuss in varying lengths of the rural-urban migration (Dyer 1994; Kowaleski 2014; Cesaretti et al 2016), rural areas also offer areas to test for virilocal or uxorilocal patterns. In comparison to larger, urban areas, smaller villages and towns may not have seen the influx of new individuals and/or societal norms in place may have seen sex-based migratory differences among the population. The results of the post-marital residence analysis show similar trends from the rural sites of Warwick and Wharram Percy with that of London in regard to phenotypic homogeneity among the populations. Both sites were fairly close to the null ratio, showing little difference in phenotypic variability among males and females. One of the main arguments for the variability of males and females within rural settings was the sustained lifestyle and inheritance of property or land within the family, causing those who sought better opportunity to relocate (Mortimer 2010). While medieval England tended to have a more patriarchal society when it came to land ownership, there were exceptions in the fact there are historical accounts of women acting as heads-of-households and being the sole landowner in both rural and urban areas (Power 2012). As the older sons were more often inheritors, this left
both younger sons as well as daughters in a position to make their livelihood elsewhere, either in the same village/town or by migration to larger areas. Therefore, rural migratory patterns in medieval England seem not follow a strict sex-based trend (either a more virilocal or uxorilocal population), though of course it could have varied from village to village.

6.5 The Effects of English Feudalism

The feudal system in England during the Middle Ages shaped not only the economic structure of the country, but also determined geographical networks, defined spaces, and had a large influence on the lived experience of those who populated the numerous villages, towns, and cities. The effects of such a system can be seen in the biodistance analysis in which different populations are related genetically more than others. In this case, the larger geographical distance seemed to have an effect on gene flow within medieval populations, as one may expect. The sociocultural effects of feudalism can be discussed to see possible connections with the hypotheses previously stated. Is physical distance what is restricting people, in which it could be seen as dangerous and risky to make long-distance migrations as Sayles (1961) argues? Or is it the restriction of movement on the peasant class by which the lords or landowners who employ them?

With the introduction of the typical system of feudalism that is often associated with medieval England by William the Conqueror, migratory patterns changed as well. People were moving much more frequently during the mid-late Middle Ages than they were before the new millennium (Danziger & Lacey 2000). This was not necessarily related to personal freedoms or the rise of the more agricultural peasant class, but more to do with the developing urban economy. Trade happened much more frequently from urban areas to villages and towns and the reliance on agriculture shaped the way the class systems worked with the production of goods.
The rise of the agricultural economy shifted the focus of many peasant class workers from a more subsistence economy to that of a feudal-capitalist system. Peasants began to work not for themselves but for their lord, especially in more rural areas (Dyer 1994). While travel may have increased overall for some (e.g. merchants, military forces, or the clergy), the typical working-class individual was still somewhat confined by their social situation. Those living in rural areas such as Wharram Percy or Warwick were more than likely reliant on agriculture to make a living, with those inhabiting the areas owned by the local lord and by proxy, the crown.

Post-Norman medieval England saw a surge in economic activity which allowed both a rise in population as well as sustainability for families that worked in the agricultural sector. Unlike some areas of continental Europe, the isolated nature of the British Isles allowed for a more sprawled urban development, rather than the more defensive-based design of many continental European cities (Lilley 2002). Referring back to the research by Cesaretti et al. (2016), the foundation of new boroughs, villages, and towns (in addition to the growth of cities) could have created networks through England and connected urban centers with their periphery dwellings. While cities such as London or York had a thriving economy, they were still reliant on rural communities for a constant source of resources such food, wood, and animal byproducts (Nicholas 2014). In creating these networks, cities and large towns may have had trade relations with many of the neighboring villages, often which may have been under supervision of the local lord or baron. This mutualistic relationship between the rural and urban areas allowed the sustainability of villages, which allowed the urban areas to grow and supply village resources that would not normally be available to them.

Based on the results from the biodistance analysis, the significance shown by both Wharram Percy and Warwick (and to an extent Merton Priory) matches migratory patterns of
rural/urban life in medieval England as well as Cesaretti et al.’s (2016) hypothesis of networked connections in Europe. Phenotypically speaking, the differences between Wharram Percy and Warwick to London indicates that migration to the larger city may not have happened as frequently, or at least enough to allow significant gene flow between populations. As an already established village Warwick may have been self-sustaining, especially after Warwick Castle was built. A closer town or surrounding villages may have supplied Warwick with resources, making traveling the distance to London unnecessary. In the case of Merton Priory, if the population of the cemetery was largely monastic, priests (or newer initiates) may have traveled from nearby areas outside London for education or religious pilgrimage. As some scholars (Hollister 1994; Dyer 1994; Mortimer 2010) claim individuals traveled more frequently in the Middle Ages, it is often more prominent members of society (clergy included) who were willing or able to travel.

As the distance from Wharram Percy to the other sites in question was quite large, it would make sense for individuals living in Wharram Percy to rely on other nearby areas for resources and trade. While northern England was not as densely populated as the center or south, the city of York became a large urban hub in the post-Norman era (Nicholas 2014). Given its proximity to York, it is likely residents from Wharram Percy had a mutualistic relationship in which trade and protection may have been facilitated. Traveling from Wharram Percy to either Warwick or London would have been a large undertaking, especially for the peasant class, and was not something that probably happened on a frequent basis.

The other question that can be asked about migration in medieval England is of the autonomy of the peasant class and the relationship with those who owned the land. Research into the lives of the peasant class and their constriction by feudalism offers varied results. Cases can be made for a serfdom being very restrictive in the lives of peasant families in which they were
pledged to a certain manor or lord, restricting movement between areas. If families were able to move, it may not have always been the best choice. Village life (either in the form of a small landholding or on the lord’s demense) offered a fairly sustainable living which may not have been not worth the risk of traveling to find other opportunities (Schofield 2009). Small villages may have had a limit when it came to population sustainability and overcrowding may have forced migration for some individuals as evident in many demographic studies on urban England (Postles 2000; Yaussy & DeWitte 2019). What can be said in this case of this study is that while social factors may have contributed to some extent, it seems geographic location is a large determining factor of medieval migration. If Cesaretti et al.’s (2016) hypothesis is correct, individuals in clustered dwelling areas would have no need to travel outside the immediate geographical radius and genetic relationships between populations in England could vary region by region as a result.

6.6 Conclusion

This chapter outlines and discusses results from the present study in an attempt to understand migratory patterns and the subsequent gene flow of population in medieval England. Statistical analysis can help show significant differences between populations phenotypically while historical narratives can help understand the social and economic factors that may have influenced an individual’s movement (or lack thereof). While no clear link can be ascribed to migration patterns for the sites in question, this chapter has presented certain ideas which may have been the catalyst for population movement, as well as how the rural and urban sectors in England may have interacted. Ultimately, this economic relationship between villages, towns, and cities had biocultural effects on individuals integrated in its system.
Chapter 7: Future Directions and Conclusion

7.1 Future Directions

The results and discussion presented in this study represent just a small fraction of research on those individuals living in medieval England. At the time of writing, biodistance methodology is underrepresented in published bioarchaeological literature, with few studies focusing on movement and genetic relationships between communities. Historical records and modern studies offer great insight into the lived experience so those who lived and worked during the Middle Ages. The use of skeletal remains as material evidence opens up a variety of possibilities in bioarchaeological research that, when combined with previous historical research, can help understand the sociocultural effects that shaped the way the everyday individual.

England offers a wide range and variety of skeletal samples that could potentially expand on this research. Generally speaking, preservation among skeletal collections is fairly good, with a large amount of demographic data included as well. In order to expand on the network theory of the rural-urban connection, skeletal populations from a wider area could be included and analyzed under the biodistance model. Ideally, taking samples from large urban hubs and their associated surrounding areas could show migration patterns. As Wharram Percy was in the vicinity of York, a sample from York and another smaller rural area nearby could be a good representation of northern England, while central and south England (London included) could also be expanded to understand migration in the more densely populated part of the country. If networked patterns exist, clustered grouping of sites/populations could show regional migrations within large urban hubs and their peripheral rural areas throughout England.
7.2 Conclusion

This study sought to examine phenotypic variation in medieval England to understand migratory patterns and/or constrictions that may have been present during the feudal period. As the results showed, significant findings were associated with almost all sites tested. Wharram Percy and Warwick showed phenotypic dissimilarities to one another, as well as to the London-based sites. This shows that gene flow was restricted in some way among populations in England. Previous research offers some explanation as to why this could be the case, though it may not be one clear reason. While sociocultural factors did dictate movement for many individuals, there were factors that could have dictated migratory patterns. By the Middle Ages, the English economy was on the rise and urbanization across the country offered opportunities to those who may not have wanted a rural lifestyle. Conversely, the rural areas were still the lifeblood of the commercial economy in medieval England and the mutualistic relationship that existed between the urban and rural areas had allowed for the English economy to grow while supporting a burgeoning population.
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