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Bodily Memory in Digital Space: Personalized Bioarchaeological Research and Musculoskeletal Modeling at the Milwaukee County Poor Farm Cemetery

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BODILY MEMORY IN DIGITAL SPACE: PERSONALIZED BIOARCHAEOLOGICAL RESEARCH AND MUSCULOSKELETAL MODELING AT THE MILWAUKEE COUNTY POOR FARM CEMETERY

by

Jessica L. Skinner

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ABSTRACT

BODILY MEMORY IN DIGITAL SPACE: PERSONALIZED BIOARCHAEOLOGICAL RESEARCH AND MUSCULOSKELETAL MODELING AT THE MILWAUKEE COUNTY POOR FARM CEMETERY
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A well-contextualized account of personal experience and identity is essential to any study of social dynamics and is crucial to the enactment of critical and socially active bioarchaeology. New technology, including digital bioarchaeology, can enhance the growing body of work that examines embodiment, agency, and identity, particularly when used with a holistic and ethical approach. This dissertation utilizes three-dimensional (3D) scanning, a method that creates digital representations of human skeletal remains, to bolster identifications of individuals once interred at the Milwaukee County Poor Farm Cemetery (MCPFC) whose identities were erased by construction in the 1900s.

Embodied life experience is also revealed for these individuals through holistic analysis, maintaining personhood with an ethically situated, personalized approach, rather than focusing on isolated anatomical features, pathologies, or trauma. In conjunction with 3D scanning, this dissertation employs techniques including: (1.) Personalized musculoskeletal modeling, which examines walking patterns for identifying personal characteristics; (2.) 3D pathology and trauma assessment, used in concert with medical literature to explore illness, injury, and treatment experiences; and (3.) whole-body skeletal change analysis, to contextualize the effects of these experiences. These assessments are supported by historical and material culture data as well as multidisciplinary collaboration with a wide range of researchers.

All aspects of this work are united by a common thread of personalized research and health as a matter of social justice. Using these memorializing techniques, this project works to reincorporate these once unidentified individuals into a community while centering humanistic research in bioarchaeology.

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LIST OF ABBREVIATIONS

ABBREVIATION	MEANING
MCPFC	Milwaukee Poor Farm Cemetery
RBMCPFC	Register of Burial of the Milwaukee County Poor Farm Cemetery
MCH	Milwaukee County Hospital
MCHS	Milwaukee County Historical Society
WHS	Wisconsin Historical Society
MSK MODEL	Musculoskeletal Model
STAPLE	Shared Tools for Automatic Personalized Lower Extremity Modeling

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Chapter 1 : Introduction and Historical Background

"It is therefore the responsibility of those of us who have now chosen to interact with these dangerous dead to provide the rite of incorporation denied them for so very long." (Richards et al. 2016:231)

Project Introduction

Burial 20-24 is listed in the Register of Burial at Milwaukee County Poor Farm as belonging to Mary Henke, who died in 1924 at County Hospital (Richards 1997:582). Ninety-four years later, however, no definitive physical or documentary link remains to connect her to that location. Several factors, including a lack of permanent burial markers and construction of a new nurses' residence just eight years after Mary Henke's burial, contributed to her erasure, and that of many others, from the Milwaukee County Poor Farm Cemetery (MCPFC, Figure 1.1) in Milwaukee, WI. Construction again enters Mary Henke's story, though in this case revealing instead of obliterating.

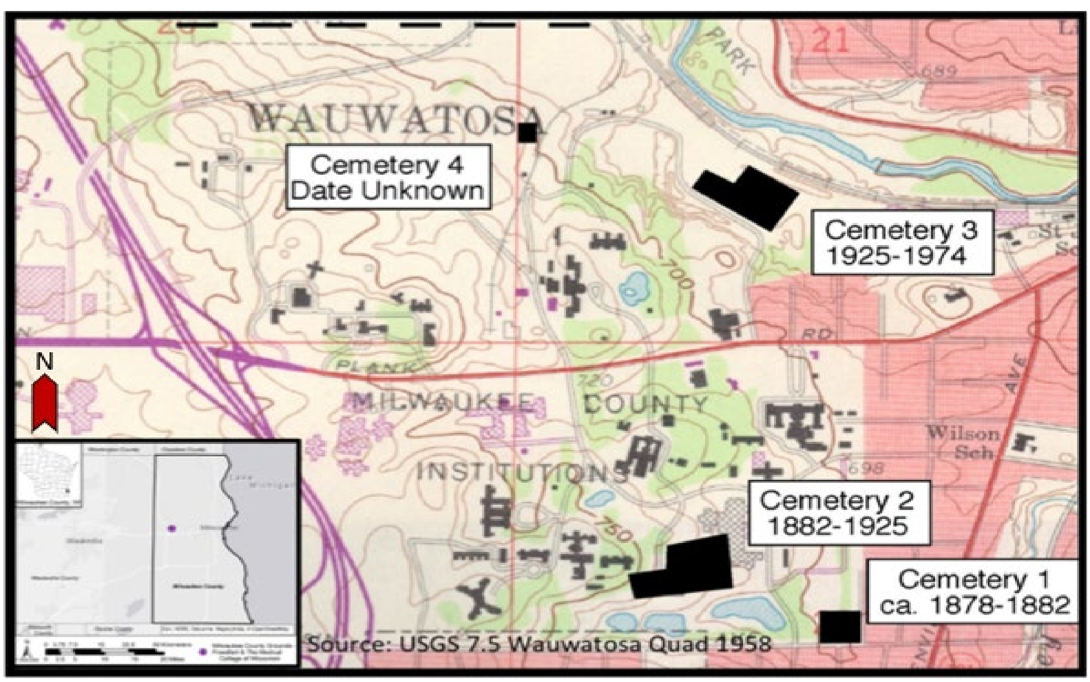


Figure 1.1. The location and organization of Milwaukee County Institutional Cemeteries (Adapted from Richards et al. 2016:4).

In 1991, 1992, and again in 2013, construction disturbance coupled with state encoded protection for burial sites provided by *WIS STAT* 157.70 resulted in the excavation of burials from the Milwaukee County Poor Farm Cemetery (MCPFC), recovering the skeletal remains of Mary Henke as well as 2,480 unmarked burials from the center of what is now the Milwaukee Regional Medical Center (Richards et al 2016, Richards 1997). Novel archaeological techniques, including virtual gait analysis, holistic three-dimensional osteological analysis, and an individualized research focus can help to re-forge the connection between some of these individuals and their identities even after almost a century of loss.

The site, Cemetery 2 (Figure 1.2), was utilized by the Milwaukee County Institutions between 1888 and 1925 as a resting place for many; the poor, institutionalized, unknown,

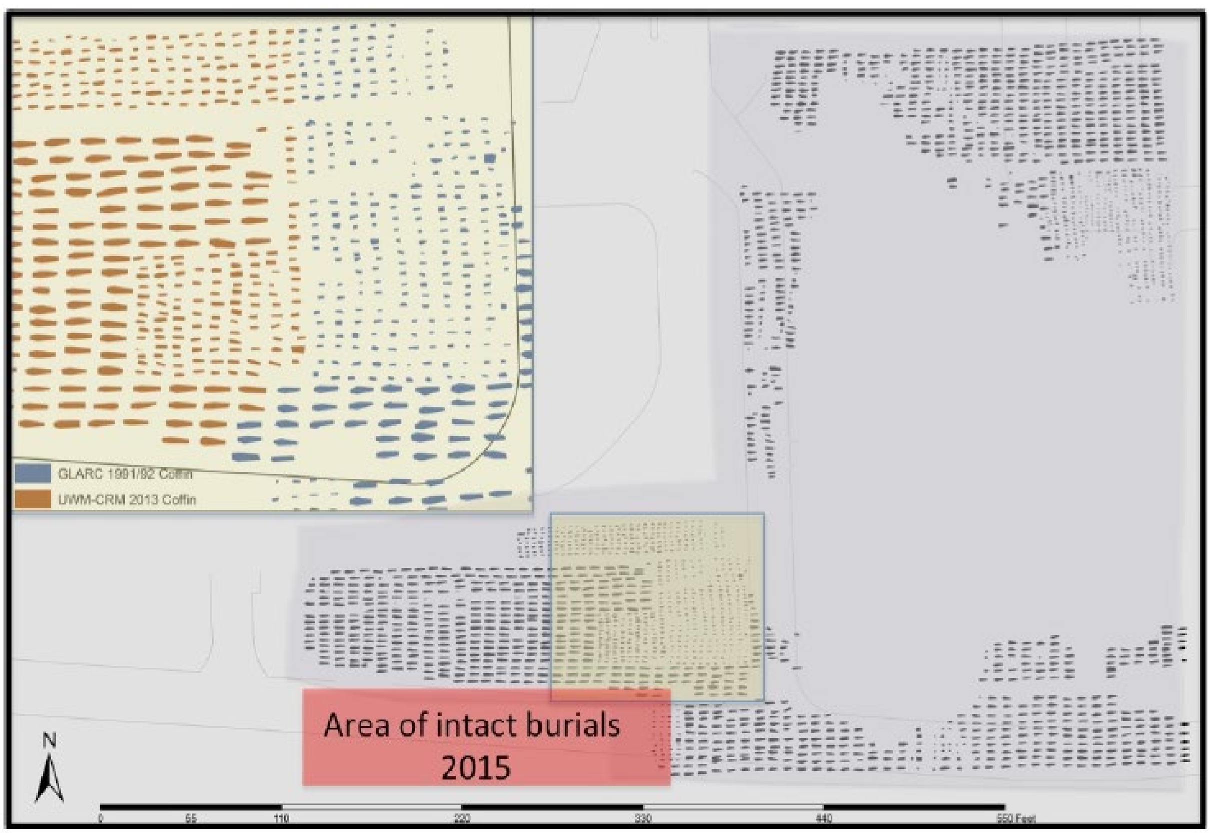


Figure 1.2. Overview of Cemetery 2 mapped burials. Disruption of burials highlighted here represents the construction of the nurses' school and residence (Richards et al. 2016).

and unclaimed all found places there (Richards 1997:11), for brief moments before becoming erased- of identity, individuality, and of place. Though the Milwaukee County Institutions, particularly the Almshouse, were established as a refuge for the poor (Richards et al. 2016), this refuge was incomplete and impermanent. In life, many contracted serious disease or injury due to poor conditions in the county institutions—in death, markers were removed, and ground was broken for construction of the School of Nursing less than ten years after the close of Cemetery 2 (associated with the Almshouse and other institutions). Figure 1.2 illustrates all mapped burial locations, the large void in the map representing burials disturbed during the construction of the School of Nursing (Richards et al., 2016).

The Milwaukee County Medical Complex School of Nursing, established in 1888, was a necessity constructed at the behest of the Milwaukee County Board of Supervisors, who stated that the purpose of the school was to "induce better educated persons to form the same and take service as nurses in the hospital…" (Weihing 1988:05). The school operated with modest means until 1932 when the rise in demand for nurses precipitated the construction of a large nurses' school and residence on the county grounds within the boundaries of Cemetery 2 (Weihing 1988). Figure 1.3 represents the School of Nursing history, chronicled by Barbara Weihing.

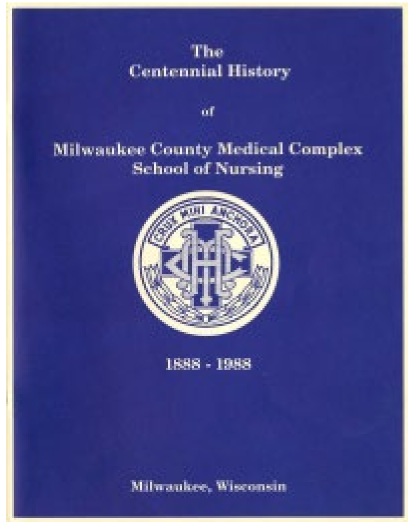


Figure 1.3. Cover of the Centennial History of the Milwaukee County Medical Complex School of Nursing 1888-1988 (Weihing 1988) Courtesy of MSOE Archives.

What began as an expedient means of improving medical care during a widespread illness eventually resulted in the loss of identity for thousands, many of whom are now stewarded by the University of Wisconsin-Milwaukee Archaeological Research Laboratory with no geographic or other data to connect them with their names, written in cursive, in the Register of Burial at the Milwaukee County Poor Farm. Many more, previously located within the disturbed footprint of the School of Nursing, and, according to an April 6, 1932 Milwaukee Journal article, "crushed into the ground as the basis for a proposed landscape project" (Milwaukee Journal [MJ], 6 April 1932: L1), will never be identified.

As part of the collaborative Milwaukee County Poor Farm Cemetery Project (MCPFCP), this dissertation uses three-dimensional scanning, including gait simulation, to bolster identifications of ten of the individuals recovered from the MCPFC during the 1991, 1992, and 2013 excavations. This is done using a blend of digital and traditional osteological analyses in concert with modern clinical literature and primary historical documents used to create holistic studies of select individuals. This research is in line with existing outstanding works of identification and contextualization that have focused on individuals interred in Cemetery 2.

Prior to this research, Richards (1997), Freire (2017), and Drew (2018) have contributed to identification and contextualization of life experiences of the dead of Milwaukee County through varied methods. Richards (1997:291) "made use of historical and contextual information to understand the material culture variability revealed by the excavations," as well as employing this information towards the putative identification of several individuals within the cemetery. Freire (2017) utilized strontium isotope signatures to "interpret and complement historical document research, refine current understandings of internal spatial and temporal organization within the southwestern portion of Cemetery 2 (47BMI0076), and contribute to the identification of 10 individuals." Drew (2018) complements this work through "a multi-scalar research program", using a combination of demographic data, historical document analysis, and artifact analysis. These works each contribute to improving the possibility of identification for many individuals recovered from the cemetery.

Instead of focusing on specific anatomical features, pathologies, or trauma, a holistic analysis seeks to maintain personhood for individuals through the application of ethically situated, person-centered methods. In conjunction with three-dimensional scanning, traditional osteological analysis, documentary analysis, and material culture analysis, this dissertation employs varied techniques including: (1.) three-dimensional gait analysis, which use human movement models to determine individual idiosyncrasies and reactions to treatment by examining gait patterns; (2.) pathoetiology analysis, which use osteological analysis of three-dimensional scans in concert with modern and historical medical literature to explore injury, illness and treatment experiences; and (3.) whole-body entheseal change analysis, to contextualize the impact of these experiences. These analyses are united by a common thread of health as a matter of social justice (Gowland 2018), and the understanding and treatment of a whole individual, within a person-centered archaeology framework. Walking gait was chosen for this study because it is an essential component of the human experience. Much of our daily life experiences, as well as illness and injury experiences are mediated through walking. Not only is it an activity that most humans partake in every day, it also is a part of human habitus that marks each person: people can be easily recognized by their walking gait and this individual identifier would have been part of how a person was recognized in their community.

This approach provides new and holistic information not available through osteological population surveys, historical analysis, or material culture analysis alone, and serves as a method for robust bioarchaeological study. Additionally, this research is conducted with the goal of providing the "rite of incorporation" (Richards et al. 2016) through human-centered practice that works to counteract the othering of these individuals and of individuals struggling with poverty at the turn of the century and today.

Illness and Injury in Practice

Based on institution records, death certificates, coroner's reports, and hospital data that many of the individuals passing through the Milwaukee County Institutions at this time identified as immigrants or the descendants of immigrants. Though census data from 1910 documents that 17 percent of the general population was German born, 53.5 percent of city residents identified themselves as of German heritage (Richards, 1997:87), illustrating the strong ties to natal regions and the communities formed by immigrant families during this time.

It is evident that these experiences of immigration and settlement made their mark on these individuals. Leavitt (1996:9) discusses the cultural and practical burdens associated with the public health movement in Milwaukee during the nineteenth and twentieth centuries. While public health efforts led to declining mortality rates and offered many Milwaukeeans increased life expectancy, such efforts also changed the social landscape for those already under social distress.

The encumbrance of health reform, particularly in the form of pressure to alter culturally important traditions surrounding death and mourning, appeared to particularly burden immigrants and the poor as they impacted long-held mortuary customs (Leavitt, 1996:8). In addition, the costs of improved medical care and the inaccessibility of some biomedical techniques practiced in this time period hampered the improvement of medical conditions for these individuals, a change which is visible both in the archaeological record and contemporary medical documents.

Examples of medical treatment, or lack thereof, are well-recorded among the individuals recovered from Cemetery 2. Evidence of wide-ranging treatment of fractures, for instance, provides context for ideas about health and injury management during this time. Modern orthopedic literature can help further contextualize these practices as well as the underlying biological processes that create visible skeletal change and how these injuries may have been experienced by the individual that sustained them. One example comes in the form of one individual who had sustained several fractures to the left arm during life. These include the distal humerus, proximal radius, proximal and medial ulna, the scaphoid, and the first metacarpal. The medial ulna fracture sustained non-union, and the two halves of the bone created a pseudoarthrosis, or "false joint". Several complications of these fractures were also skeletally observable: osteophytic lipping, irregular bone remodeling, and exostoses are some of the examples (MCPFC Human Remains Analysis Paperwork: Skinner 2016, on file at the University of Wisconsin-Milwaukee Archaeological Research Laboratory). Figure 1.4 illustrates both the non-union fracture of individual 5014, and the imaging approach used in this project.

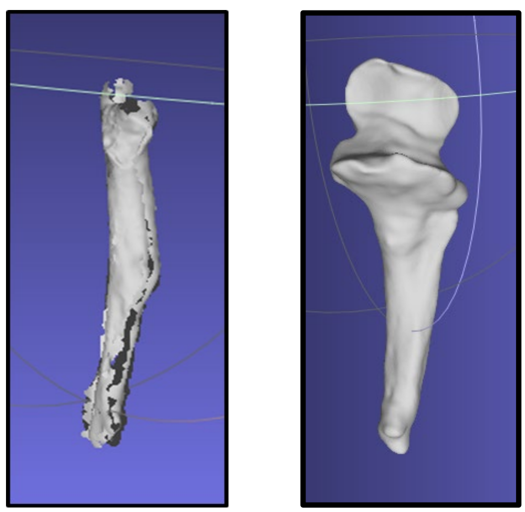


Figure 1.4. Healed fracture and associated pseudoarthrosis of the left ulna of a middle adult male (Lot 5014).

Analysis of these fractures leads to a possible mechanism of injury: the cascade of fractures from the proximal hand all the way to the distal humerus is characteristic of a fall onto an outstretched hand. These fractures are well-represented in clinical literature and are common amongst people of all backgrounds; Whiting and Zernicke (2008) cite outstretched hand falls as one of the leading causes of first metatarsal, scaphoid, and medial ulnar fractures, with the proximal radius and distal humerus often involved.

The non-union of the ulnar fracture and pseudoarthrosis raise the question of medical treatment. There are modern studies concerned with correcting non-union, which results from improperly aligned fractures, poor vascularity, and pressure on the fracture site (Whiting and Zernicke 2008). However, modern fractures rarely reach the point of the one sustained by this individual, and this is where modern clinical research fails to assist with creating more complete profiles of injury and treatment during the historic period. Technology and treatment strategies have clearly improved to the point where some injury outcomes are no longer analogous or available in clinical literature.

Historical literature gives some insight into the cause of this outcome: it was not due to a lack of technology or available treatment: advanced techniques for proper fixation and healing of fractures were well accepted even as early as 1868 (Callender 1868:144). This type of persistent non-union may have been more likely caused by a lack of resources. "The non-union of fractures has been attributed to a great variety of causes, constitutional and local. Mr. Amesbury, however, remarks, "by far the most frequent cause of non-union that I have noticed is want of rest, in consequence of the inadequacy of the plans of treatment which have been employed. I consider this to have been the primary cause in almost all the cases I have examined" (Callender 1868:144). This and other studies (Senn 1893; Marcy 1876) illustrate that a possible cause of non-union for this individual was the inability to stop work long enough for the breaks to heal. During the late 1800s, this was common, often leading to infection and early death (Poland 1870). However, health is only one aspect of daily life and alone does not define the total personal experience of these individuals.

Because there is such a diverse group of individuals buried at the MCPFC, from long-term patients of institutions such as the Muirdale Sanitarium (a Tuberculosis treatment facility, discussed later in this chapter) to individuals with almost no identifying information (John and Jane Doe cases), a variety of roles and layered identities are visible in the archaeological record. The intersection of several competing roles, as individuals in a new landscape, is made manifest in the osteology of these individuals. In addition, habitual ways of being in the world that are determined by objects and transcend class and social standing due to their "unexpected capacity to fade out of focus and remain peripheral to our vision and yet determinant of our behavior and identity" (Miller 2005:5), may give us a glimpse into their daily lives.

Bioarchaeology in Holistic, Personalized Analysis: Limitations and Benefits

Bioarchaeology is distinguished from the broader discipline of archaeology by its concern for context-dependent mortuary analysis, incorporating spatial, archaeological, osteological, material culture, and historic document data (Buikstra 1977). Though these contextualized studies have contributed more robust analyses to the field of archaeology, many have struggled to maintain a paradigm of holistic mortuary study supported by a clear theoretical framework. This is further complicated when new technology is incorporated into bioarchaeological analysis: beyond a well-contextualized analysis, ethical implications are not always fully explored or accounted for (Errickson and Marquez-Grant 2017, Speakman and Shackley 2013). This research is a systematic incorporation of new technology, three-dimensional scanning, into a contextualized analysis of individuals recovered from the Milwaukee County Poor Farm Cemetery, supported by a theoretical framework of embodiment, which emphasizes the collection of lived experience inscribed on the body through social engagement (Crossland 2009, Sofaer 2006, Joyce 2005, 2004). Framing all techniques of this research is consideration for the individual human person and ethical engagement.

In addition to scientifically and ethically sound research with well-integrated theory, living researchers have a responsibility to the dead (Barilan 2006), including the restoration of personhood and the return of marginalized groups to a public consciousness. Part of this return to public consciousness includes "restoring or creating trust and hope in a shared sense of value and responsibility" (Walker 2006:28), which can be done by exploring the place of these individuals within the public consciousness over many years. The reasons for the creation of the MCPFC Cemetery 2, as well the reasons for its excavation in recent years (and disturbance before that) are rooted in the processes of collective social memory. Paul Connerton (1989, 2009) describes these trends of both remembrance and forgetting as occurring on a large social scale: the former as a result of ingrained cultural institutions and the latter a product of the rapid change of modern culture. The establishment of the Milwaukee County institutions and the creation of Cemetery 2 reveal evidence of memory, as represented by community involvement with the institutions (Milwaukee Journal [MJ] 10 February 1900:1), *and* societal forgetting—an erasure of the cemetery and the individuals buried there to accommodate the rapid change of modern culture, namely a new nurses' residence built on top of Cemetery 2 not ten years after the close of the cemetery (Richards et al. 2016:15).

The acts of erasure evident at the Milwaukee County Grounds illustrate a need for memory-building projects as part of an effort to reestablish the personhood of individuals from the MCPFC. Several reports (Richards et al. 2016, Richards and Kastell 1993), dissertations (Charles (2019; fetal/infant age and constructions of personhood); Charus (2010; female health); Drew (2018; demographic study for individual identifications); Dougherty (2011; trauma); Freire (2017; strontium isotope analysis and individual identifications); Milligan (2010; public health); Polli (1997; childhood health); Richards (1997; an extensive report of the archaeology, material culture, and mortuary practices at the cemetery with individual identifications); Werner (2019; tuberculosis and public health), and theses (Anthony (2019; dissection and material culture); Burant (2019; a temporospatial analysis of the cemetery); Florence (2007; subadult health); Freire (2011; wormian bones); Hutchins (1998; infant development); Jones (2011; use of portable x-ray fluorescence in commingled contexts); Klingman-Cole (2016; spatial analysis); Ozga (2009; vertebral conditions); Shillinglaw (2010; subadult assessment); Skinner (2015; entheseal change); Werner (2015; tuberculosis) have contributed to this effort through skeletal analysis, material culture studies, strontium isotope analysis, spatial analyses, and other methods. This dissertation aims to contribute to this memory building effort in yet another new way. Using three-dimensional scanning to both record and curate representations of the individual remains and conduct further analysis, primary historical documents to contextualize this analysis, and ethical study to ensure best practices, this work contributes new representations of lived experience for the individuals from MCPFC. Such novel approaches change our understanding of what archaeology can do and challenges how data is collected and analyzed—despite being ignored in the past, individualized, smaller studies can match large studies as valid methods of inquiry.

State Burial Assistance

The state of Wisconsin spent $8.4 million on burial assistance in 2016 (CBS WSAW Channel 7 Reports 11 November, 2016), and nearly every state in the US provides funerary assistance of some sort. The high number of individuals in the US that currently qualify for burial assistance speaks to the dysfunctional state of the funerary industry, the large wealth disparity currently observed in the US, and the relevance of public assistance programs such as the Milwaukee County Institutions. State burial assistance has been part of Wisconsin legislative code and Milwaukee County policy since before Wisconsin was actually a state-language mandating "decent burial" for the poor dates to the 1838 Wisconsin territory laws (1838 Wis. Terr. Laws 22), and this function of the state is woven into the history of the Milwaukee County Poor Farm Cemetery (for an in-depth discussion of institutional burial law in Wisconsin and beyond see Freire 2017). While indigent community members and the unidentified dead do not represent the entirety of cemetery demographics, the public assistance programs provided by Milwaukee County constitute a primary motivator for the creation, utilization, and subsequent destruction of this archaeological site (Richards et al. 2016).

Milwaukee County Poor Farm Cemetery

Cemeteries 1, 3, and 4

The MCPFC encompasses four burial locations (Richards 1997, Richards et al. 2016) (Figure 1.1), which are distinguished spatially and temporally (Richards et al., 2016). The location and boundaries of Cemetery 1 were confirmed in 1992 (Overstreet and Sverdrup 1992; Richards et al., 2016) to be opened in 1878 (possibly used earlier) and closed in 1882. Cemetery 3 was utilized by the county from 1925 (after the closure of Cemetery 2) until

1974, when indigent burials began to be contracted out to private cemeteries (Richards 1997; Richards et al., 2016). Cemetery 4, last named because dates for it are unknown, is sometimes referred to as the Asylum Cemetery (MI-0529, BMI-0174 – Asylum Cemetery). This cemetery is located near Cemetery 3, and though dates are not documented, use may span 1884-1914 (Richards et al. 2016). Richards et al. (2016:217) note: "the only surviving written documentation of [burial within] the cemeteries is called the Register of Burial at Milwaukee County Poor Farm (RBMC, Register of Burial) and dates from 1882 to 1974."

Richards (1997) and Drew (2018) derived occupational data from the historical sources, illustrating that housekeeping and labor were two of the primarily held occupations of individual buried in Cemetery 2. In addition, the Register of Burial and county board of supervisor documents give further insight into the demography of Cemetery 2; for instance, it was rare for County employees to be buried in the cemetery (as documented by the Register, which lists occupation), and only one physician is listed in the Register of Burial (Drew 2018; Richards et al. 2016). These documents confirm that the cemetery was primarily utilized by Milwaukee County for individuals too poor to afford burial elsewhere, for inmates of the county institutions, unidentified or unclaimed individuals, and for those that had been dissected by the area medical colleges.

Cemetery 2 Archaeological Investigations

In 1991, 1992, and again in 2013, excavations were undertaken at the Milwaukee County Institution Grounds Froedtert Tract in Wauwatosa, WI (site # MI-0527, BMI–0076). The excavated area, Cemetery 2, opened in 1882 and closed in 1925, as a replacement for the original County Cemetery (Cemetery 1 MI-0528, BMI-0173) that was no longer useable (Richards et al. 2016: 218). This cemetery was utilized by Milwaukee County for individuals too poor to afford burial elsewhere, for inmates of the county institutions, unidentified individuals, and for those that had been dissected by the Milwaukee Medical College. Based on excavated burial density and Milwaukee County Death Certificates, Cemetery 2, if continually utilized until abandonment, may have held 7222 burials (Richards et al. 2016). Excavations of Cemetery 2 were conducted due to Wisconsin State Statute s.157.7, which accords for "the respectful treatment of human remains in cases when burial sites are accidentally disturbed or discovered by construction" (Wis Stats s.157.7).

These disturbances occurred due to the use of the land by county institutions and other medial agencies, which has continued, uninterrupted, since the county's initial purchase. Indeed, prior to the introduction of the burial sites preservation law in 1985, institutional interaction with the cemetery was marked by erasure.

This study focuses on data concerning the adult individuals excavated from the MCPFC during the 1990s and during the 2013 excavations of Cemetery 2. The complete age and sex distribution for individuals recovered during the 1991-1992 excavations are not yet available as a complete analysis of these individuals is currently underway. The current statistics of the 1991 and 1992 excavations are as follows. There are 1640 total burial locations, 987 of these locations categorized upon initial inventory as "adult" and 586 lots categorized as "juvenile", and 67 "indeterminate". The following age categories have been determined for the 1991-2 adults at this point: 54 young adults (20-34.9 years), 285 middle adults (35-49.9 years), 126 old adults (50+ years), 54 ambiguous adults, 58 individuals of indeterminate age, and 50 individuals with no age markers intact (n=627). Of the currently analyzed adults for whom sex could be determined (n=512), 12 percent are female (n=62) and 88 percent are male (n=450) (MCPFC Project Paperwork, 2019). These individuals are permanently housed in the University of Wisconsin-Milwaukee Archaeological Research Laboratory.

The 2013 excavations facilitated the recovery of 632 individual burial locations containing the remains of a minimum of 665 individuals, including 381 adults and 284 juveniles. The following age categories were determined for the adults: 40 young adults (20-34.9 years), 174 middle adults (35-49.9 years), 84 old adults (50+ years), and 83 individuals of indeterminate age. Of the adults for whom sex could be determined, 82 percent are males (n=267) and 18 percent are females (n=57). There are 50 commingled lots in addition to the single adult lots. These represent a minimum number of individuals (MNI) of 166, which brings the total number of potential individuals represented by the 2013 excavations to 831 (Richards et al. 2016). After the excavations, all recovered individuals and material culture items were brought to the University of Wisconsin-Milwaukee Archaeology Research Laboratory (UWM ARL) for stabilization and analysis. These individuals are now housed at the University of Wisconsin-Milwaukee Archaeology Research Laboratory until final disposition is determined by the Wisconsin Historical Society. Table 1.1 contains the distribution of age and sex among currently analyzed adults from the 1991-1992 excavations.

Table 1.1. Table illustrating distribution of age and sex among currently analyzed adults from the 1991-1992 excavations and 2013 excavations (adapted with permission from UWM ARL documentation).

Sex/Age Group		*Number*
Adult Females (n=119/13.29%)		
	Young Adult (18-34.9 years)	29
	Middle Adult (35-49.9 years)	48
	Old Adult (50+ years)	22
	Indeterminate Age	20
Adult Males (n=717/80.12%)		
	Young Adult (18-34.9 years)	125
	Middle Adult (35-49.9 years)	329
	Old Adult (50+ years)	207
	Indeterminate Age	56
Adult Indt. Sex (n=59/6.59%)		
	Young Adult (18-34.9 years)	4
	Middle Adult (35-49.9 years)	17
	Old Adult (50+ years)	7
	Indeterminate Age	31
Total		**895**

For more information about major excavations at the Milwaukee County Poor Farm Cemetery, Cemetery 2, see Richards and Kastell 1993, Richards 1997, and Richards et al. 2016. A table summarizing these excavations can be found in Freire (2018: 28).

Milwaukee County Institutions

The Milwaukee County Poor Farm (MCPF) was first occupied in November of 1852 as a result of the burgeoning "Indoor Relief" program designed as a refuge for the poor (Richards et al. 2016:230). The original purchase of land encompassed 160 acres in Wauwatosa, Wisconsin, approximately seven miles west of the City of Milwaukee. The county grounds continued to expand as the county added a hospital in 1860 and by 1898 the grounds and institutions included a larger General Hospital, the Milwaukee County Asylum for the Chronically Insane, the Home for Dependent Children, and a new Almshouse for the poor (Richards et al. 2016:14). The timeline for these institutions is represented in Figure 1.5.

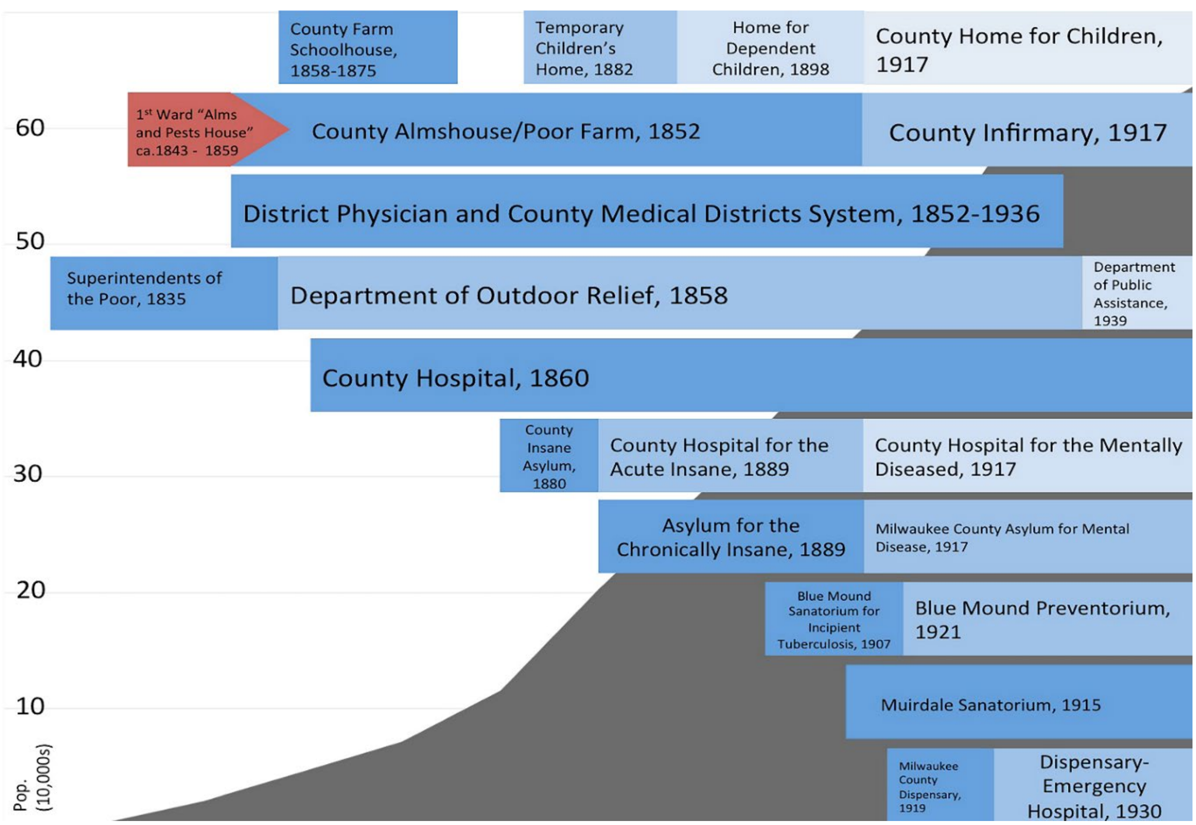


Figure 1.5. Timelines of the Milwaukee County Institutions. Source: Richards et al. 2016:15. Reproduced with permission.

By the 20th century, the county had established several Milwaukee County institutions around the Almshouse in Wauwatosa, WI. These additional institutions included the Rehabilitation Hospital and the Muirdale Sanitarium for tuberculosis patients. The Almshouse, later renamed the Milwaukee County Infirmary, held up to 700 inmates by the late 20th century (Richards et al. 2016:14). These institutions served the Milwaukee County community in many different ways- some individuals received "indoor relief" on a residential basis, working on the county grounds to support their presence, while others received non-residential aid in the form of rationed food, dry goods, or other necessities (illustrated by this February 1900 coroner's inquest: "The janitor from the home [for dependent children], who tried to help put out the fire, said the mother was at the Home trying to get food for the children because they were poor" [Coroner's Inquests, MCHS Box 103]). In addition, Wisconsin residents from Milwaukee county and beyond were accommodated by the County Hospital, the Tuberculosis Sanatorium, and the Asylum (Drew 2018).

Richards (1997) argues that rather than levels of status, the cemetery represents three distinct populations:

> Despite its name, and despite its reputation, this cemetery served as more than a place of interment for the institutional paupers of Milwaukee County. The analysis of grave goods and spatial patterning observed at the Milwaukee County Poor Farm Cemetery allows the identification of three diverse populations of individuals. These individuals do not necessarily differ in terms of status but represent three distinctly different populations: (1) community poor; (2) residents of the various county institutions; and (3) suicides, victims of murder or accidents, other unidentified individuals, and those with no kin (1997:11)

The MCPFC 2016 research supports and expands these assertions through the examination of burial context, burial container, material culture, and historical documents. The result is four categories delineated primarily by material culture (Richards et al. 2016:163):

> 1. Those who died as [institution] residents likely to be buried in shrouds secured by pins.
>
> 2. Those who may have died as residents or elsewhere but who were used for medical purposes either by local medical colleges or by the Milwaukee County Hospital. These individuals may be buried with Medical and Hospital Items as well as miscellaneous items disposed of along with the body (utilitarian items).
>
> 3. Those buried in the cemetery via the coroner's office as unclaimed or unidentified individuals who were NOT used for medical purposes –these individuals may be buried in clothing with a variety of modest personal items.
>
> 4.Community Poor who could not afford a burial but for whom family was a part of the burial ritual and whose family may have continued to visit the gravesite. These individuals may be buried with more personal items (2016:163).

This evidence illustrates that the individuals represented in the archaeological record encountered the county institutions through a variety of paths. Some were inmates at the institutions for long periods, others only for a short time near death, and still others only arrived at the county grounds after death. It is through a holistic analysis of their materialized relationships with the cemetery and institutions that we can further engage with their stories and bring their personhood to the forefront.

Thesis Outline

Chapter 2 examines the role of embodiment in archaeological practice with particular emphasis on embodiment's potential within ethical archaeological paradigms. Chapter 3 provides an in-depth discussion of ethics in digital archaeology, examines the contributions of theoretical framework to ethical practice, and finally outlines a practical framework for ethical digital bioarchaeology. Chapter 4 introduces digital bioarchaeology, three-dimensional scanning methods and best practice, personalized musculoskeletal modeling, and foundational biomechanics in addition to the methodological approach of this project.

Chapter 5 explicates the statistical analyses used in this project and presents the results. Finally, Chapter 6 outlines identifying data recovered for each individual and the significance of this data to discuss the broader significance of this research and summarize the project.

Chapter 2 : The Anthropology of Experience, Embodiment, and Personalized Research

> "We cannot live other people's lives, and it is a piece of bad faith to try. We can but listen to what, in words, in images, in actions, they say about their lives." (Geertz 1986): 373)

Introduction

Just as social meaning is produced and reproduced (Joyce 2005, Hodder 1985, Bourdieu 1977), individual life experience and social encounters are reproduced and made manifest in the physical body. Bourdieu (1977) provides a foundation for this inscription, in the form of habitus. Habitus is a result of the intersections of learned dispositions on the body and encompasses a set of practices, improvisations, bodily attitudes, and means of cultural situation which inform and are informed by social interaction (Bourdieu, 1977). The Milwaukee County Institutions and experiences of poverty in turn-of-the-century Milwaukee constituted a social backdrop characterized by constraint. This constraint had its effects on people encountering the institutions and characterized their choices but did not erase their agency entirely. One way to engage with this agency is by examining embodied life experience through historic record, material culture, and the body, using information from the less institutionally regulated components of the burial context- clothing worn, personal items in pockets, habitual dental modification, and other markers. We can also use this framework to explore the role of personal choice in inscribing the skeleton even within this constrained environment.

What is Embodiment?

The concept of embodiment springs from multiple intellectual traditions, including phenomenological (Merleau-Ponty 1962, 1968), practice theory (Bourdieu 1977; Giddens

1984), and feminist (Jones 1999; Kristeva and Roudiez 1984) scholars interested in the interplay of the physical body with the mind and the outside world. Scholars including Mauss (1973) and Bourdieu (1977) centered their work on the influence of socially and environmentally acquired dispositions. Mauss describes 'techniques of the body', arguing that individuals develop specialized body actions that reveal aspects of culture, and are often situational (Mauss 1973). Bourdieu expands this concept, contending that self-perception and habit contribute to social reproduction, generating and regulating practices that make up social life (Bourdieu 1977). These ideas and others about the intersection of body and world (Binford 1962; Foucault 1970; Gallagher and Zahavi 2020; Merriman 2004) were influenced by Merleau-Ponty's conception of the body as having a co-penetrative relationship with the world (Merleau-Ponty 1945).

Embodiment and the Past

Early social constructionist views of the body tended to categorize it as a "stable biological ground" on which gender and other social categories were written (Crossland 2010). Post-structuralist interpretations of the body discarded the notion of a naturalized "pre-discursive, empirically verifiable, sexed body," (Crossland 2009) calling into question the separation of the body into a separate, biologically objective category separate from the mind. This emphasis on embodiment and lived experience honed in on the practices that form and shape bodies in the past (Hamilakis et al. 2002; Joyce 1998; Meskell 2000). This emphasis on practice, action, and experience generated a paradigm of the body as historically contingent and in flux-subject to cultural norms and constraints. The research concerning the body as a social object shares a critique of the Cartesian separation of mind and body, subject and object (Crossland 2009, 2010).

More recent work delves into the mechanisms behind embodiment, attempting to disentangle the circumstances that produce habitus. Jones (1991) posits that habitus plays a role in the subjective class distinctions that arise in institutions where inequality of power is part of daily life as well as in how these distinctions are grounded in dynamic social conditions. Social identification of class, ethnicity, and social status are not passive reflections of similarities and differences in the "cultural practices and structural conditions in which agents are socialized" (Jones, 1991:226). Instead, it can be argued that the construction of identity in these contexts is grounded in the shared dispositions of habitus which shape and are shaped by commonalities of practice (Jones, 1991: 226-227). These conditions and commonalities make their mark on individuals in organic, yet durable ways that enable a combination of personal expression and institutional influence.

Nystrom (2011:164) follows this logic further, arguing that there is a distinct and observable difference in the manifestations of self-ascribed identity and external social inscription of identity. The first may be observed in personal adornment or modification, while the second is not only observable in the burial program, but also in the osteological health of individuals.

Challenges to Embodiment

Critics of embodiment theory argue that some scholars engaging with the theory do not account for agency, giving too much credence to structural inscription on the body via embodiment of inequality or other approaches (Noland 2010). In addition, logical flaws of description and application of embodiment theory persist. Csordas (1990:8), for example, argues the limitation of Bourdieu and Merleau-Ponty's perspectives on embodiment, stating that Bourdieu collapses the duality of structure-practice, and that Merleau-Ponty conflates the subject-object paradigm. Csordas challenges that the collapsing of these dualities then requires us to view the body as "nondualistic," In reality, the body seems to be pluralistic (Crossland 2010) and strictly adhering to a dualistic or collapsed paradigm may preclude a full understanding of agency in the analysis of individuals in peripheral contexts.

Bakhtin's (Bakhtin 1981) concept of "authoring of self" provides an alternative that escapes these pitfalls by acknowledging the multifaceted agency of individuals.

Authoring of Self

Morris (1994) argues that Bakhtin characterizes the relationship of self and other as like that existing between mother and child or between lovers, asserting that the gift of self requires passive receptivity, with the other acting as the dynamic creative in the self-other dynamic.

The passive reception of self has been well explored by Bakhtin and others (including Goffman 1978, Holquist 1990), resting on the cognitive tension that one can never experience oneself in such a final way as the other can experience a person. Morris states: "My subjective experience can never be so complete, finalized and consummated. Subjectively I never quite coincide with myself, I feel I am never completely contained in any representation of myself. 'I always have a loophole' (p.40) in the sense that my meaning is always yet to be completed" (Morris 1994:6).

Morris acknowledges the validity of vision created only by an authorial excess of seeing, but recognizes the undertow of attraction towards a sense of the "unfinalizability" of self, arguing it to be most evident in the linkage of authorial knowledge with death:

> Artistic vision presents us with the whole hero, measured in full and added up in every detail; there must be no secrets for us in the hero in respect to meaning …From the very outset, we must experience all of him, deal with the whole of him: in respect to meaning, he must be dead for us, formally dead. In this sense, we could say that death is the form of aesthetic [consummation] of an individual...The deeper and more perfect the embodiment, the more distinctively do we hear in it the definitive completion of death and at the same time the aesthetic victory over death (Bakhtin 1990:131).

Despite this attraction towards a final and decentralized self, much of Bakhtin's work shifts beyond a decentralized self to the investigation of relations between social and personal facets of human development, especially the development of identity or self-understandings in cultural worlds. Holland and Lachicotte (2001) emphasize that dialogism pays special attention to the variety of ways in which the self as author incorporates the words and voices of others via dialogism. "The voice of the speaking person and the

voice of the social language through which it is ventriloquated" are sometimes seemingly unalienable, simple, foundational. However, words, discourse (and social expression through personal choices and material culture) are socially charged, dialogically engaged with the past, present and future (Bakhtin 1981:293). In this way we take action and author self against a backdrop of social change and constraint but maintaining agency through bodily autonomy. The Archaeology of Experience incorporates this tension to encompass daily experiences.

Anthropology of Experience

This project then expands upon the ideas of authoring the self to encompass the anthropology of experience (Bruner 1986, Turner 1986, Geertz 1986) to synthesize ideas about the body (Sofaer 2006), embodiment (Bourdieu 1977; Csordas 1990, 1994; Mauss 1973; Merleau-Ponty 1945), and personhood. Strathern and Stewart (2011) contend that "theorizing about the body reached a new stage when it began to center on embodiment," and that the interplay of ideas about embodiment, the body, and personhood provide access to a larger scope of life experience through bodily perception, experiential inscription.

Embodiment as a Tool for Ethical Research

Despite criticism and reform, anatomization of the dead persists in medical science. Striking instances such as the mass disposal of donated remains on Hart Island, NY (Dyer 2016), Yale students posing with donated remains in the style of turn of the century anatomy schools (Staff Reports, Associated Press, 13 February, 2019), and the rise in "body brokers," those trading in anatomical donations by shirking informed consent laws and exploiting the altruism and financial concerns of donor families (Jayakumar et al. 2020) illustrate that the concerns raised against modern anatomization are still valid.

It also persists physically and analytically in anthropological science. From the disposition of contemporary unclaimed remains curated at the National Museum of Natural History in Lisbon (Alves-Cardoso 2019) and the institutional ownership and treatment of individuals housed in anatomical skeletal collections (de la Cova 2020), to the epistemological and analytical conception of the dead as specialized objects (recently interrogated by Grauer 2018, Nystrom 2018, and Zuckerman 2018), the power imbalance between archaeology professionals, the dead, and descendant communities continues to place archaeologically recovered individuals at the service of professionals, rather than the other way around. “Archeology [has historically been] viewed as embodying and growing out of the epistemological divide between subject and object of study. The treatment of excavated human remains as research materials "exposes this apparent sense of detachment and alienation within archaeological practice,” (Crossland 2009:102). Not only does the conception of the dead as object transgress stated tenets of anthropology and archaeology, not only does it result in superficial analyses of humans that fail to capture humanity, it also leads to the commodification of human remains in a way that supports exploitation of people, living and dead. The demand for a shift in the treatment of all human remains, but particularly those resulting from anatomization, is clear:

> “As the discipline moves forward, we must recognize that our anatomical collections comprise the most vulnerable, impoverished, and mentally ill citizens within their respective cities. These individuals, although legally dissected, did not consent to the anatomization of their bodies.” (de la Cova 2020:230)

This demand is particularly great when dealing with vulnerable populations, such as the MCPFC individuals, many of whom were exploited bodily in both life and death (Richards 1997, Richards et al 2016, Richards et al 2017, Freire 2017, Jones 2018). Change in process stems not only from our acknowledgment of past violence, but also to end the possibility of enabling that violence through epistemological consent of such activities. “Conceptualizing dissection as a manifestation of structural violence extends the concept to encapsulate postmortem manifestations of social inequality” (Nystrom 2014:1).

Biologically based anatomization lies in deep contrast to recent work that recognizes the body as socially constructed in part (Gowland 2015, Sofaer 2006). Decontextualized bioarchaeological specialization has led to specific knowledge production that is useful but struggles to encapsulate and address the complexity of human experience. Examples from the field abound, as discussed by Sherran and McKenna (2017) and Curtin (2002). A first step is to "cut across the tight and ever-narrowing disciplinary bounds" (Curtin 2002:608), using multiple theoretical perspectives, anthropological methods, and interdisciplinary tools to create robust and compassionate portrayals of human experience as seen through the archaeological record. As Sofaer (2006:62) posits: "the divide between the living body as cultural and the skeletal body as natural cannot be sustained as bodies will always be both, albeit in different and changing configurations." In addition to revealing individual lives, embodiment also enables an analysis of large social moments: "When intersected with other critical concepts such as gender, race, nation, class, caste, and sexuality, embodiment becomes a bridge to the past for understanding how key moments were experienced and lived," (Topdar 2019:1) Critical use of embodiment theory combined with holistic analysis enables researchers to expand their conception of the individuals represented by the remains they study, as well as their surroundings. "In practice we look along all axes at once. The results are cumulative; the richer the context into which we set the burials, the more powerful the interpretation will be"(Morris: 1992:24). By attempting to access those experiential selves, we are more likely to see their humanity, representing and treating them accordingly.

Embodiment Applied to Personalized Digital Representation

As individualized bioarchaeological analyses have the power to clarify our understanding of the past by centering people from the periphery of large historical movements, digital gait simulation has the power to create analyses that are extraordinarily personal and to capture habitus in a more direct way than ever. As a striking marker of self and one of the first noticeable things about a person, gait and movement are often central to discourse concerning identity. In addition, distinctive movement or altered movement due to injury are often featured in descriptions of individuals or are sometimes even discernible in photographs. The human tendency to focus on movement makes gait analysis a prime candidate for identity-bolstering research and for an intimate glimpse of experience.

Conceptual models of the musculoskeletal system existed "as early as the 18th century when Newton's equations of motion were formulated by hand to investigate animal limb movement and dynamics" (Seth, 2009). From this, musculoskeletal models have changed rapidly, matching the growth in computing advancement. New technology has enabled nonlinear dynamical equations, typical of musculoskeletal models, to be solved numerically; from the dynamic computer simulations of Chow and Jacobson (1971) to AnyBody, OpenSim, and other more recent projects (Mouzo et al. 2017), models have advanced to provide greater insights into human gait.

Personalized musculoskeletal modeling provides a unique opportunity to examine embodied life experience. By combining the spheres of external cultural mediators and internal mental and physical factors through a synthesis of material culture data, historical records, biological data and gait simulation, a more complete exploration of personal embodiment is possible. This enables researchers to examine the role of embodiment in archaeological practice and ethical archaeological practice.

Embodiment Conclusions

By using embodied relationships and experiences to better contextualize osteological analysis in this and future studies, we can use the manifestation of materialized and internalized relationships juxtaposed with lived experience (Renfrew 2004:26) to enable recognition of the humanity inherent in past individuals. Embodiment allows an examination of the physical body as a political artifact, a scene of display of group affiliation or status, and a site of embodied agency (Nystrom et al., 2010). Within the framework of embodiment, modifications of the biological self that reflect aspects of the social world and individual lived experience can be examined to begin the memory building endeavors that build a culture of restoration.

Chapter 3 : Ethics in Digital Bioarchaeology

"The struggle of man against power is the struggle of memory against forgetting."
(Kundera 1999:2)

What are our Ethical Duties to the 'Slightly Alive'?

Arnold (2014) cites the alternative fairy tale The Princess Bride in her examination of postmortem social relationships, quoting William Goldman's character, Miracle Max, as he tells the anxious group awaiting the resurrection of the hero Westly, 'There's a big difference between mostly dead and all dead. Mostly dead is slightly alive'(Goldman 2007:313). Arnold challenges that only a select group of the dead can be characterized as being 'slightly alive', in the post-mortem agency sense, elaborating on contingent factors in death-scapes, social congruence/tension, and recovery context that change the postmortem agency, or 'slightly alive' nature of individuals in archaeological settings.

Intersecting with these factors are the concepts of structure and institutional durability. These often play a role in the manifestation of identity and individuality of living folks by shaping the avenues available to human actors and by creating the landscape and environment in which these actions are carried out. However, through these durable institutions move volatile agents who can act tangentially within the often-immobile institutional environment, and whose actions can echo past their lives, enabling a 'slightly alive' state through the transmission of unspoken information in the archaeological record. As those living at the time of the defacement of the MCPFC attempted the erasure of the cemetery through acts of institutional forgetting (Connerton 2009, discussed later in this chapter), the 'slightly alive' individuals below the soil retained their postmortem agency, holding information about themselves and the erasure of the cemetery as recovered by archaeologists in the current era.

Barilan (2006) asks if we, the living, have moral duties to the dead. Researchers of human remains ethics (Marquez-Grant and Errickson 2017, Tarlow 2001, Barilan 2006 and Brodwin 2002) make the resonant point that we *do*, in fact, have an ethical burden of responsibility to the dead, especially as researchers with a privileged access to human remains. As technological tools for bioarchaeology become more accessible, scholars have called for a 'digital ethics of bioarchaeology', which constitutes a still-emerging subset of the field arising from the need to reevaluate ethical practice in the face of new technology.

Scholars point out that we should have been reevaluating ethical practice in the face of old technology as well (Zuckerman 2014, Tarlow 2001, Csordas 2001), but the point remains that with information access and sharing at its height, a thorough and ethically contextualized protocol for working with human remains and their digital representations is more necessary than ever before. One of the reasons that research with the dead, and digital research with the dead, is so contested, is the fact that the dead are never simply that- they also hold social power that is as potent as it is misunderstood. Arnold (2014), Crossland and Bauer (2017), Joyce (1998) and others emphasize the power of the body and how this power has led to an uncomfortable dynamic between archaeologists and the individuals they research that leads to varied conceptualizations of archaeological best practice with consequences ranging from loss of provenience and curatorial commingling (Jones 2018; Zejdlik 2014) to disregard for the remains entirely, with the result of flawed archaeological analysis (Arnold 2014). This dissertation seeks to understand just what our ethical duty is to these contingent individuals and to work towards a baseline of best practices that can be utilized by other researchers.

Despite seminal anthropology studies of bioethics calling for more critical, inclusive, and personalized practices (Csordas 1994; Tarlow 2001), there remain ethical issues surrounding the excavation and analysis of human remains that have not been fully addressed (Crossland 2010; Sayer 2010), and a robust protocol for digital work is even further behind. More recently, studies have focused on the ethical aspects of documentation, dissemination, curation, and repatriation (Gordon and Buikstra 1981; Larsen and Walker 2005; Taylor 2014). However, many works on digital bioarchaeology (Garrido-Varas et al. 2015; Hassett 2018; Hughes 2011; Reyman 2009; Sumner and Riddle 2009) maintain a concentration primarily on applications, techniques, logistics, or raising the concern of ethical practice, without forming actionable strategies for ethical practice.

A Landscape of Differential Respect

The study of human remains is a privilege and as most researchers agree, these once-living individuals should be treated with respect. The answer to *how* this treatment should be handled, not only in museum, educational, and other public settings, but particularly in digital settings, has yet to be authoritatively answered (Crouch 2018; Jani et al. 2021; Larsen and Walker 2005 ; Márquez-Grant et al. 2019).

Of Larsen and Walker's three universal principals of bioarchaeological ethics, one and two hold true in digital settings:

1) Human remains should be treated with dignity and respect.
2) Descendants should have the authority to control the disposition of their relatives' remains.

3) Because of the importance of human remains for the understanding of our common past, human remains need to be preserved when possible so they are available for scientific research (Larsen and Walker 2005:114)

However, the "discourse of 'respect'" (Crouch 2018) often fails to create a practice of respect: actual definitions are rare and culturally contingent, leaving archaeologists in a fog of competing guidelines (Crouch 2018:78). Attempts to standardize treatment of the dead in archaeology are also ill-suited to the field as 'respect' can mean a myriad of things to different groups of people (Tarlow 2001). Therefore, when possible, collaborating with descendant communities should be the top priority when working with human remains. It is by engaging with individual cultural perspective that we may determine what constitutes dignity and respect for a particular group of people. Though all individuals recovered in archaeological settings deserve respectful treatment that also encompasses the wants and needs of descendant communities, the archeologically 'slightly alive' come with the special provision of listening to the postmortem message they carry.

Determining Ethical Treatment in the Absence of Descendant Communities

What to do when there is no descendant community to collaborate with? The third principle, "because of the importance of human remains for the understanding of our common past, human remains need to be preserved when possible so they are available for scientific research," (Larsen and Walker 2005) does not quite solve this problem, but it does provide opportunity for answer. This dissertation suggests that in the absence of descendant communities to consult, all scientific research including human remains should serve the individuals represented by the remains, above service to the researcher. This is a difficult boundary to tread due, in part, to the structure of the field of bioarchaeology. The very act of conducting research contributes to one's credentials, so it is nearly impossible to conduct peer-reviewed, rigorous research without tangential benefits. However, we can put the individual first in our research, taking time and care to work to understand their specific experience, as a human being rather than as an object. The following hierarchy may seem like common sense but seems to get lost in translation when research projects are burdened by time constraints, lack of funding, and competing stakeholder interests:

Bioarchaeological research should….

1. Benefit descendant communities if they are present.
2. Benefit the dead.
3. Benefit humanity.
4. Benefit the researcher.

Crossland (2009) and Nystrom (2018) argue this point from slightly different perspectives, Crossland pointing out that the intentional separation of researcher and human remains leads to the unintentional objectification and fetishization of the human remains, while Nystrom argues that our role as bioarchaeologists is much more than passive. We must engage intimately with the individuals we analyze, and we must not isolate academia as the sole beneficiary of our findings, but rather we must take our privileged position as an opportunity to affect positive change in the world, change that was not enjoyed by the individuals we study. The remainder of this chapter addresses the theoretical basis for ethical treatment via personalized research and proposes tangible methods to enact this style of research. These arguments by no means imply that large population-based studies, particularly demographic studies of individual cemeteries or communities, are unethical; personalized research could not take place without those studies. However, if we pair the two approaches, we not only gain a more robust understanding of these people, places, and times, we also meet them where they are as human beings, rather than as objects for study or 'poor unfortunate souls'.

Complications of Digital Formats

Even this effort, however, is complicated by the digital techniques that can contribute to contextualization, but also may cause undue, unexpected harm. "We may view these techniques as reformatting the remains of an individual into another form" (Errickson and Thompson 2019). A positive is that these techniques are noninvasive, handle limiting, and a way to protect remains from further harm. However, they also represent the creation of a digital record of a person who once lived and thus should be treated with as much dignity and respect as the remains themselves and should be guarded with an equal or greater level of security to that afforded to medical documents, x-rays, MRIs, and other personal data. Considering three-dimensional scanning as a reformatting of remains is a striking idea and one that means the scans are in some ways 'dangerous'. Digital curation opens the door to theft of digital scans, which are representations of individuals that are intensely intimate. That is why the handling, curation, and security of the scans must be done with care and must constitute a continually evolving discussion.

Public Perception and Practice

Brodwin (2002) points out that a way to start changing the nature of ethical discussion in the field is to incorporate ethics into daily practice as completely as other components of scientific process. This dissertation and the MCPFC project strive not only for best practices but for ethical practices that prioritize the individual with stringent provenience, handling, file security, and privacy protocols (see Chapter 4). These stringent practices provide a baseline with the purpose of prioritizing and acknowledging the humanity of each individual in the study.

However, as technological advances become more enmeshed in day-to-day life, the concerns about these techniques will become more urgent. Charges (Eisen and Berry 2002; Larsen and Walker 2005; McGrath 2020) to integrate ethics instruction into science and anthropological education may not cover the most "vociferous objections to bioscience research in the future,"(Brodwin 2002:57). Therefore, work in this pioneering science requires balancing reservations about new technology against the opposite, also harmful, call to do nothing. Each choice requires extensive reflection and collaboration. Enabling the dead to be in place and at peace is of paramount concern in many research initiatives, however the meaning of this is so culturally dependent that a great deal of collaboration is always required to make it work. Keeping burials in place or reburial are not universal solutions. For instance, we need to evaluate the alternatives to research, which in some instances include burial in a mass grave or the construction of utility lines through burials. Within this context, retrieving individual identities and possibly succeeding in repatriating individuals to their descendants with the help of technology becomes a more positive option.

Ethical Practice Through an Understanding of Collective Memory and Institutional Forgetting

This research asserts, through the lens of Paul Connerton's work in memory studies (1989, 2009, 2011) that collective memory and forgetting take place at loci of the group at large and on individual bodies. In practicing bodily reincorporation through the lens of embodiment, this project attempts to address and ameliorate institutional erasure through acts of incorporation and remembrance that are physical and theoretical.

Forgetting

Connerton (2009) discusses the concept of 'forgetting', and how the pace of modern society engenders erasure of people and things. We live our lives at great speed in cities are so large they are unmemorable, while disconnected from the creation of the things we consume, which are often seen as disposable. The speed of life, communication and consumption erode the "foundations on which we build and share our memories" (Connerton 2009). The phenomenon of "cultural amnesia" is not isolated to modernity but is certainly a hallmark of it. Obvious examples include the vast amount of information now stored on computers rather in our own consciousness, ever larger societal landscapes where it is impossible to know all your neighbors, and "fast consumption", the mass production, consumption, and disposal of modern goods.

Connerton argues that certain types of structural forgetting are specific to the culture of modernity and frames this modern forgetting as the erosion of shared memory by "structural transformations in the life-spaces of modernity" (Connerton 2009:14) The result of these transformations is severance from locality and human dimensions (Connerton 2009).

To explore the erasure of locality, Connerton details two types of 'place memory' – *memorial* and *locus*. Both place memory types are mediated by bodily movement, action, and repetition. Memorialized places, such as commemorative sites, cemeteries, war memorials, pilgrimages etc., are characterized by specific experiences and cultural moments. In addition, these *memorial* locations are constantly in flux, reacting to cultural changes in the world at large, and those of the memorializing community. "Meanings of [deathscapes] continue to evolve and are always tied to reality of the living"(O'Gorman et al. 2020).

Places that Connerton considers *loci* are places of multifaceted memory creating and maintenance, such as houses, streets, and neighborhoods (2009). *Loci* build memories of different kinds –unofficial, localized, personalized, mundane memory. In this way, *loci* and *memorial* places are similar to the human body as sites of personal and mundane experience as well as social and monumental experience. Indeed, Connerton draws out the interwoven nature of house and body as mnemonic structures:

> Both have in common a quality of taken-for-grantedness; just as we tend to take our bodies for granted until they fail us through accident or illness or ageing, so too we take houses for granted until exceptional circumstances, a house-moving or a family row or a fire or a war or penury, forcibly remind us of the house's central significance in our lives. There is another moment when these two life histories are graphically expressed: the projection of the self, which is a bodily self, onto the house, is clearly glimpsed in western children's drawings of houses which characteristically contain two windows and a door, features we might translate as two eyes and a mouth. The house's furnishings also remind us of the shared history of the house and the body. (Connerton 2009:29)

In contrast to bodily-place situated memory, Connerton (2011) outlines several types of forgetting, two of which are of particular relevance to this research: *Coerced Forgetting* and *Structural Amnesia* (Connerton 2011, after Barnes 1947).

Coerced Forgetting, or repressive erasure, is at its most brutal in the history of totalitarian regimes where giving voice to memory becomes a dangerous act. The holocaust experiences and testimony of Elie Wiesel, for instance, was written in defiance of the threat of erasure and at great personal risk. Connerton argues that these acts of memory are political and therapeutic acts: to write was to decry the violence survived, and a way to make sense of "a destructive, violent past" (Connerton 2011:33). *Coerced Forgetting* is nearly always mediated by a state entity and often serves to exonerate the state or relieve the state's responsibility towards harmed persons.

Connerton writes of the paradoxical acts of memorialization and erasure that typified state and individual actors after World War I. "The colossal loss of human life gave rise to an orgy of monumentalism; memorials to commemorate the fallen went up all over Europe" (Connerton 2011:48). What of the still-living, however? At the same time of this sweeping memorialization effort, the 10 million mutilated soldiers that survived the war were being shunted aside.

> They were dismembered – not remembered – men; many were subject to chronic depression, frequently succumbed to alcoholism, begged in the street in order to be able to eat, and a considerable number of them ended their days in suicide. All sorts of institutional provisions were put in place to keep those mutilated soldiers out of public sight. Every year, the war dead were ceremonially remembered and the words 'lest we forget' ritually intoned; but these words, uttered in a pitch of ecclesiastical solemnity, referred to those who were now safely dead. The words did not refer to the survivors. The sight of them was discomforting, even shameful. They were like ghosts haunting the conscience of Europe. The living did not want to remember them; they wanted to forget them. (Connerton 2011:48)

The use of institutional mechanisms to erase "shameful" members of a community is not limited to modernity but does appear to become heightened in recent times of sweeping socio-economic change or social trauma.

The individuals that interacted with the Milwaukee County Institutions certainly experienced the complex power differential associated with being the shameful survivors and dangerous dead- as Cook (1988) observed, public institutions at the turn of the century distinguished in non-standardized and covert ways between "worthy poor" and "unworthy poor". The protestant morality attached to poverty in the United States then as now resulted in a fraught relationship between providers and receivers of public assistance. Often this complex relationship was a (perhaps unconscious) force behind the institutional erasure of these individuals, both in life and in death. Considered an uncomfortable burden to bear, these individuals were discarded as quickly as possible, to the dissection room, the mass secondary grave, or the foundation of a new building (Drew 2018; Freire 2017; Richards 1997; Richards et al. 2016, 2017). In this context, the possibilities of social death increased, and the bodies of the poor were ever more vulnerable to the pressures of modernity. "[T]he funeral (proper and pauper) and the antifuneral (dissection and exhumation) became more central to the work of the dead" (Laqueur 2018:313).

Forgetting in Summation

Many examples demonstrate the consequences of modern forgetting, most notably in the destruction of historic sites and the disturbance of cemeteries to make way for urban expansion and technological development. Institutional erasure, both in the form of *Coerced Forgetting* and *Structural Amnesia* shaped the life and postmortem experiences of individuals buried in the MCPFC (Richards 1997, Richards et al 2016) not only through the intentional erasure of the cemetery in the 1930s, but also through the "forgetting" of resident and patients' rights and the patients themselves during their time at the institutions through depersonalization, poor treatment, unsafe conditions, anatomization, and with finality, through impermanent burial markers.

Remembering Through Practice in Bioarchaeology

Though many of their experiences were shaped by institutional forgetting, the 'experiential selves' of individuals from the MCPFC are situated in memory. Connerton emphasizes two features of the art of memory- the dependence on a stable system of places, and that remembering relates implicitly to the human body and that "acts of memory are envisages as taking place on a human scale"(Connerton 2009:14). These individuals were stable parts of their community. They were recorded and mourned when they passed, even if their resting place was not protected. Historical documents, newspapers, and other evidence supports their durable place in the community. When a child of the community died unexpectedly, the Milwaukee Journal's reporting shows that she was mourned by more than just her family, illustrating the interconnected role of the institutions with the community.

> Cause of the Fatal Burn
>
> Little Louisa Sackersdoffer, who was burned to death yesterday afternoon while at play with her little brother in their home opposite the home for dependent children ignited her clothing by dropping a match upon it while attempting to smoke her father's pipe [Milwaukee Journal [MJ] 10 February 1900:1].

Connerton also discusses that incorporated practices are an essential part of memory building and provides an account of how they are transmitted within and as traditions, arguing that images and recollected knowledge of the past are conveyed and sustained by ritual performances, and that performative memory is bodily (Connerton 2009). Connerton's

"Incorporating practices" create bodily memory of these individuals and open a place for them in a community of sorts- practices that exist in, for instance, the Archaeological Research Laboratory to maintain memory, provenience, and respect are all repetitive practices that fit into that concept of incorporated bodily memory. By codifying these practices, we make memorializing these people and caring for them part of our institutional ethical guidelines. More than just a vague notion of respect, these practices constitute an active, physical remembrance. Personalized research then constitutes an additional type of remembrance and incorporation by accessing a greater scope of the bodily memory of studied individuals and "listening to" personal experience instead of prioritizing the overt effects of institutional oppression on bodies. Research such as this becomes even more meaningful when we can use that information to reconnect individuals with their identities.

Remembering and Embodiment

This chapter and the previous are also tied together by Connerton's concept of performative memory. This concept is particularly useful for research engaging with life experience because it encompasses a socially constructed yet agency-based conception of the body that is enacted through the intertwining behaviors contained in two contrasting types of bodily practice. The concepts of 'incorporating practices', or messages that a sender imparts through their own bodily activity, and 'inscribing practices' or intentional inscription by cultural actors or institutions (Connerton 1989:72), provide the dichotomy of intention that deepens the context of embodiment research. The concept of bodily practices, when utilized within the context of societal remembering, allow the researcher to situate the observation, description, and continuance of bodily remembrance as an ethical response to modern forgetting (Connerton 2011).

Embodiment as a Framework for Ethical Research

Márquez-Grant and Errickson (2017) discuss the human skeleton as a 'repository of data'; categorizing human remains as a resource that must be accessible for study to understand past and present populations. This project approaches human remains in a different way, instead focusing on individual humanity. This is done by creating a robust, contextualized representation of the experiences and lives of the individuals represented by remains. Such holistic research is well-suited to be grounded in embodiment theory, which gives the researcher greater power to access lived experience, and which also requires that the researcher prioritize the humanity and agency of the individual in question.

Joyce, Crossland, and Csordas all point out the embodied, human nature of skeletal remains, and scholars like Crossland and Hamilakas point to embodiment as useful approach for those who wish to bridge the separation between researcher and remains to see the human that the remains represent. Joyce (2005:154) makes a resonant point about our growing understanding of the embodied human, stating "Today, the body as a site of lived experience, a social body, and site of embodied agency, is replacing prior static conceptions of an archaeology of the body as a public, legible surface." Viewing the body as a site of lived experience opens us up to all the analytical tools and perspectives inherent in such a place- the multiple actors that affected the "site," most importantly the individual to whom the remains belonged, can be examined, and understood in all their complex interactions, rather than once again placing the body as an object- something that was mistreated, something that was excavated, and now something to be studied.

Ethics Conclusions

It is through this lens that ethical practice was built for this project. An emphasis on identity, individuality, and memory was used to build upon extant memorializing practices codified by the MCPFCP, including thorough provenience chains, strict handling policies that include tracking and maintaining even the smallest fragments (<0.01mm), and writing individual names on box labels as soon as an individual is putatively identified. This project established ethical practice by maintaining and expanding these policies.

1. Tracking logs (*Appendix A*)
2. Thorough provenience checklist for scanning (*Appendix B*)
3. Strict file naming conventions and provenience (*Appendix C*)
4. All files associated with individuals stored on a secure server.
5. Gait analyses conducted with strict provenience and file structure.
6. Strict policies regarding dissemination of data (*Appendix E*).
7. Use of Open-Source software to avoid the "black box" phenomenon.
8. Individual Data Files by Lot Number (*Appendix F*)
9. Individual Data Reporting (*Appendix G*)

This project can be considered a memory building endeavor with the goal of ameliorating institutional forgetting through the acts of preservation, the study of embodiment, and the building of context. Substantial work is underway to bring the stories and identities of the individuals buried in the MCPFC 'back to life'—through archival research, through the collection, preservation, and interpretation of biological and material culture data. Through continued engagement with these individuals, the MCPFC project and this research holds their reincorporation into this community, albeit a slightly different one than from which they came, at heart.

Chapter 4 : Methods

Individuals Included in the Study

The Milwaukee County Poor Farm Cemetery excavations recovered the remains of 1368 adults and 870 juveniles. Of the currently assessed adults for whom sex could be determined (*n=895*), 80.12% (*n=717*) are males, 13.29% (*n=119*) are females, and 6.59% (*n=59*) are indeterminate adults (Table 4.1). With such a large group of individuals, identifications can be facilitated by Drew's (Drew 2018) keystone identification approach combined with personalized holistic analysis that includes skeletal assessment according to Richards et al. (2016), material culture analysis, personalized musculoskeletal (MSK) modeling (Modenese et al. 2018; Modenese and Renault 2021), and hospital records assessment. Identifications of these individuals have the potential to foster additional identifications through spatial analysis and assessment of the Register of Burial.

Table 4.1. Distribution of Adult Age at Death for all currently assessed individuals.

Sex/Age Group		*Number*
Adult Females (n=119/13.29%)		
	Young Adult (18-34.9 years)	29
	Middle Adult (35-49.9 years)	48
	Old Adult (50+ years)	22
	Indeterminate Age	20
Adult Males (n=717/80.12%)		
	Young Adult (18-34.9 years)	125
	Middle Adult (35-49.9 years)	329
	Old Adult (50+ years)	207
	Indeterminate Age	56
Adult Indt. Sex (n=59/6.59%)		
	Young Adult (18-34.9 years)	4
	Middle Adult (35-49.9 years)	17
	Old Adult (50+ years)	7
	Indeterminate Age	31
Total		**895**

Where many current osteological studies aim to grasp population data and as such require large sample sizes (Palmer 2019, Mountrakis and Manolis 2015), the focus of this research requires a substantial amount of time spent with each individual. In consideration of one goal of this research and of the Milwaukee County Poor Farm Cemetery Project as a whole, individuals for whom preliminary identifications can be strengthened were included in this study. Richards et al. (2016) and Drew (2018) note that the identification of keystone individuals facilitates further identifications within the cemetery, contributing to the complementary objectives of connecting individuals with possible descendants and centering the voices of individuals that were stripped of self through the erasure of their identities, as addressed by Richards (1997), Freire (2017), and Drew (2018). To maintain ethical practice and full recognition of personhood for each individual included in the study, only ten individuals were "worked with and for" in this project (Meloche et al. 2020). Each individual was selected based on the potential for their own identification and the potential for contributing to the future identification of other individuals (Table 4.2).

Table 4.2. Composition of age and sex of individuals.

Female Adult Age Categories (n=5)			Male Adult Age Categories (n=5)		
Young	Middle	Old	Young	Middle	Old
1	2	2	0	2	3

By working with an equal group of females and males, this project seeks to complement and challenge our current understanding of the cultural meanings behind the demographics of the cemetery, which as discussed above, are greatly weighted towards males. There is a wealth of knowledge to be gained about the cemetery and institutions through working to better understand differential experiences at the MCPFC. Working with an evenly distributed group of individuals instead of selecting based on cemetery demographic distribution enables us to center previously marginal individuals within the narrative. While exploring specific lifeways that led folks into the poor farm cemetery it becomes obvious that not every person arrived there the same way and not every experience was not the oft-depicted one-dimensional struggle through poverty, but rather a collection of experiences mediated by personal agency as well as circumstance, each making its mark on the individual.

Table 4.3 outlines the data collection timetable, customizable to each selected individual. Data collection and analysis averaged 3-4 weeks per individual.

Table 4.3. Research Process per Individual.

Research Process Per Individual (3-4 Weeks Per Individual)					
Scanning	**Osteological Assessment**	**Personalized MSK Assessment**	**Digital Osteological Assessment**	**Document Analysis**	**Material Culture Analysis**
Check paperwork and prepare individual for scanning.	While preparing individual for scanning, compare findings in paperwork with visual evidence. Note areas of concern. (See appendix F)	Prepare geometries using the STAPLE Toolbox in Matlab.	After Personalized MSK Assessment, evaluate articulated remains in NMSBuilder	Scan hospital intake records from the MCHS according to narrowed date ranges (See historical document analysis)	Read assessment from PBR Dissertation
Complete provenience paperwork and cards. Ensure that protocol (Appendix C) is followed, and provenience preserved.	Note areas where systemic analysis may be possible: periostitis, arthritis, and joint change are possible areas.	Articulate and evaluate joint parameters in NMSBuilder.	In NMSBuilder, demarcate locations affected by pathology or trauma and look for connections	Conduct medical record and newspaper database search for individual, using Google Cloud AI and newspaper database.	Examine and photograph MC when needed.
Scan elements according to protocol.	Note elements that may pose a biomechanical issue.	Load models into OpenSim. Adjust baseline data according to estimated sex, height, and age.	Assess correlations between skeletal changes and gait data.	Compile and assess present data	Assess MC in relation to MC categories for potential social context
	Note general preservation and condition of the remains as well as any interfering taphonomic issues.	Assess how gait correlates to overall osteological health and any available material culture or documents.		Assess how document analysis and MC analysis confirm social context.	

The Utility of Digital Gait Simulation and Personalized Musculoskeletal (MSK) Modeling for Archaeologically Recovered Remains

In individuals with serious musculoskeletal conditions, personalized musculoskeletal (MSK) models are not only warranted, but also represent the most efficient assessment available, due to the cascade of biomechanical error introduced when non-conforming anatomical features are ignored in MSK models (Killen et al. 2020; Mantas 2020; Modenese et al. 2018; Modenese and Renault 2021; Montefiori 2019; Saxby et al. 2020).

As illustrated by Montefiore (2019), pathological conditions are more likely to result in additional non-conformity of skeletal features through reactive processes including neoplastic growth, exostoses, osteoclastic pits, and other changes that have a direct impact on locomotion (Killen et al. 2020; Modenese et al. 2018; Modenese and Renault 2021; Saxby et al. 2020). Conditions such as arthroses, periosteal infections, and other immune-involved skeletal changes often affect non-adjacent skeletal elements (McGonagle 2005; McGonagle et al. 1998), so the best path towards a more complete understanding of an individual's locomotion is through personalized models (Modenese et al. 2018; Montefiori et al. 2019; Valente 2019).

For archaeologically recovered individuals, personalized MSK models are useful for gaining insight to locomotion, trauma, treatment experiences, and osteobiographies, since personalized MSK models are one of the only ways to examine skeletal conditions in a dynamic environment. Because archaeologically recovered remains do not include soft tissue or other indicators that contribute to diagnoses, the specificity of a personalized MSK model can narrow down osteologically manifested conditions which can then be cross-referenced in historical medical documents. This method is also a useful tool for understanding life experience and embodiment through movement.

Kinematics and MSK Modeling

A foundational element of MSK models, kinematics describes movement through examining angles, trajectories, and velocities of segments in a MSK system. The analysis focuses on single components within the MSK chain during a motor task such as walking, running, or jumping (Delp et al., 2012). With known geometry, segment orientation can be identified through the trajectories of skin markers on body segments within timeframes (Leardini et al., 2005, Taylor et al., 2005, Capozzo 1991).

Relative movement in digital gait simulation is estimated through inverse kinematics, which assumes rigid bodies in favor of any possibility of tissue deformation. IK arose from Lu and O’Connor’s(1999) proposed global optimization, which strove to minimize the difference between the virtual (on the digital MSK model) and experimental (On the participant) markers (Delp et al. 2007; Lu and O’Connor 1999). This approach enables minimization of global error, which reduces the sensitivity of the system to experimental error, which can arise from incorrect placement or skin movement (Lu and O'connor, 1999) and improves estimates for the direct kinematic model. The global optimization algorithm enables generalized coordinates to describe the position and orientation of segments (representing skeletal elements) with joints that are mechanically constrained by idealized analytical shapes, such as cylinders and spheres. Having accurate joint definition ensures Degrees of Freedom (DoFs) will be limited to anatomically feasible rotations and translations, which will reduce error due to co-penetration or displacement of segments (Klous and Klous 2010; Latash 2018; Lu and O’Connor 1999).

Inverse Dynamics

Dynamic MSK models are “responsive to forces and moments from internal (e.g., musculotendon forces, joint reaction forces, etc.) and external sources (e.g., ground reaction forces, gravitational forces, etc.) (Ding et al. 2019; Dyszkiewicz and Hruby 2020; Inkol et al.

2020; Yamaguchi 2005), and can be used to predict motions that may occur based on several mathematically-based constraints. The dynamic equations that define mathematical relationships between forces, moments, and motions can be used to create predicted motions, through forward dynamic simulations, or internal forces and moments through inverse dynamics (Yamaguchi 2005; Zajac et al. 2002)

Since inertial properties of the multibody system are not accounted for during inverse kinematics, inverse dynamics are required for a robust model. The generalized coordinates of joints in time produced by the inverse kinematics step are integrated to produce generalized velocity and acceleration. This information is combined with external forces acting on the system (Hicks et al. 2015).

External forces include ground reaction force collected by force platforms, gravity, and external topography, which allow estimation of net torque about joints for each moment (Faber et al. 2018; Hatze 2002). The Newton-Euler equation allows us to compute two joint torques- net forces and net moments (Montefiore 2019:48) by "recursively solv[ing] for each body segment, from distal to proximal, to compute the joint torques (i.e. the net forces and net moments)" (Montefiore 2019:48).

$$M(\vec{q})\ddot{\vec{q}} + \vec{C}(\vec{q},\dot{\vec{q}}) + \vec{G}(\vec{q}) + \vec{\vec{E}}(\vec{q},\dot{\vec{q}}) = \vec{\tau}$$

In this case $\vec{q}(t)$,$\dot{\vec{q}}(t)$,and $\ddot{\vec{q}}(t)$ are generalized angle positions, velocities, and accelerations of the joints; $M(\vec{q})$ is the matrix of the masses in the system, $\vec{C}(\vec{q},\dot{\vec{q}})$ represents the centrifugal and Coriolis forces and torques, $\vec{G}(\vec{q})$ is the gravitational component, $\vec{\vec{E}}(\vec{q},\dot{\vec{q}})$ contains the external forces, and $\vec{\tau}$is the unknown vector of forces and moments acting at the generalized coordinates (Montefiore 2019:48).

The forces and moments include the residual forces acting on the proximal segment of the musculoskeletal chain to compensate for the inconsistency between the acceleration computed at the various joints and the external forces measured by force plates. It also accounts for forces and moments that are due to the body segments ignored in the system (i.e. the upper body when studying the lower limb)(Faber et al. 2018; Montefiori et al. 2019; Riemer et al. 2008).

The OpenSim Inverse Dynamics (ID) Tool determines the generalized forces, or net forces and torques, at each joint in a movement. This tool works with the kinematics (states or motions) describing the model, and the kinetics (external loads), to preform ID analysis. The ID tool solves the equations for the mathematical expression of the mass-dependent relationship between force and acceleration, $\boldsymbol{F} = m\boldsymbol{a}$, to produce the net forces and torques at each joint that produces the indicated movement. Inverse Dynamics were calculated for moments and torques illustrated in the following images. Figure 4.1shows the moments measured for the knee: moment arm, knee extension moment, and knee adduction moment.

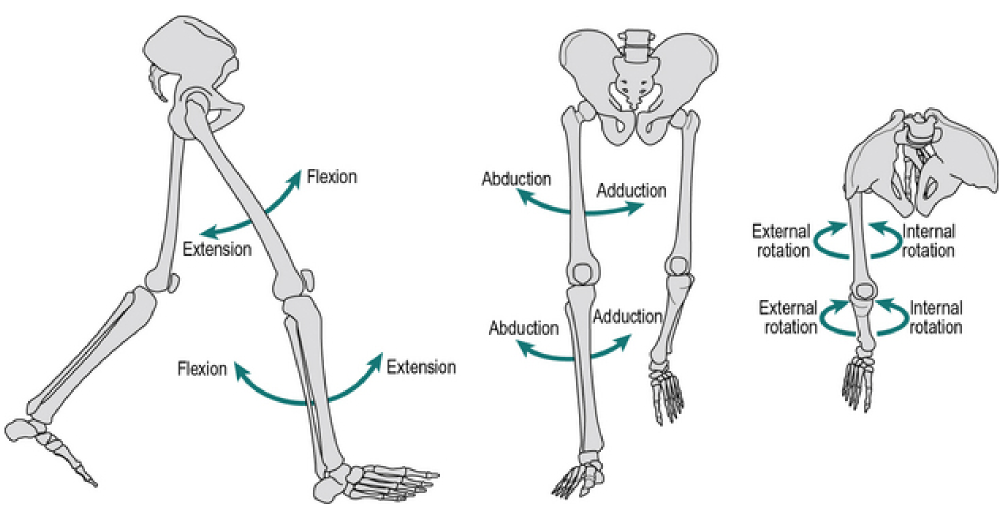


Figure 4.1. Visual summary of hip joint moments observed. Creative Commons non-attributed.

Figure 4.2 provides a visual description of observed knee moments (Nagano et al. 2015).

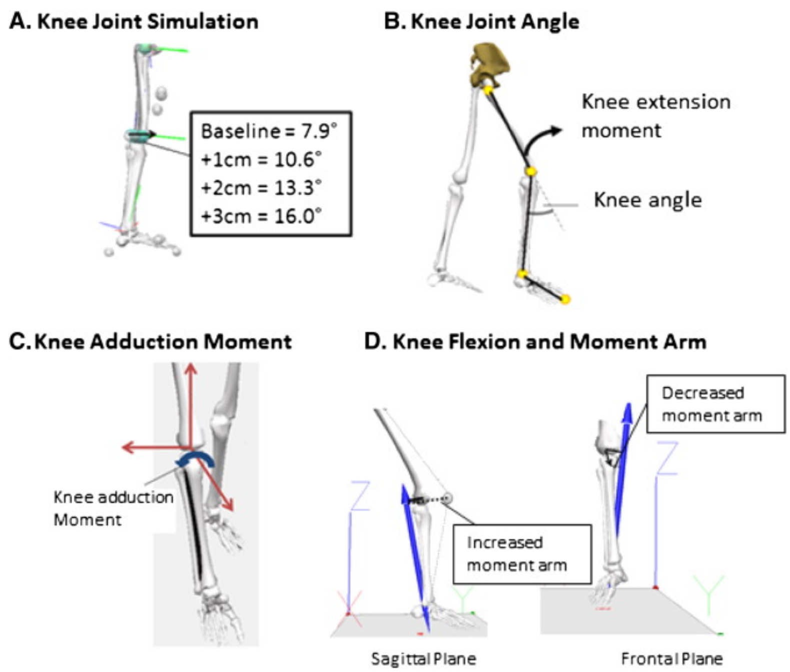


Figure 4.2. Visual description of observed knee moments. Reproduced with permission from Nagano et al. 2015.

Figure 4.3 illustrates the observed (Brockett and Chapman 2016).

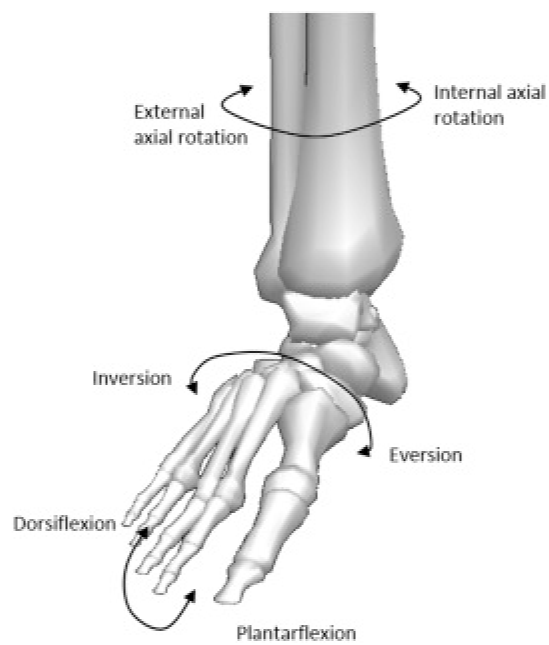


Figure 4.3. Ankle and foot joint moments observed. Reproduced with permission from Brockett and Chapman 2016.

Static Optimization

Since muscle force generates torque at the joints, static optimization can be used to extend the inverse dynamic approach to calculate individual muscle forces as they contribute to total joint moments (Buchanan et al. 2005; Hicks et al. 2015; Modenese et al. 2018; Montefiori et al. 2019). Multiple combinations of muscle forces and actuations are responsible each estimated joint torque, and each represent a possible solution of biomechanical equations (Buchanan et al. 2005; Modenese et al. 2018). To solve this, musculotendon properties need to be considered alongside the activation and contractile dynamics of each unit, which relate to the force- length-contractile velocity of the muscles (Buchanan et al. 2005; Modenese et al. 2018; Montefiori et al. 2019).

Static optimization uses cost functions to minimize performance criterion such as muscle activation, force, and metabolic consumption (Anderson and Pandy, 2001, Crowninshield, 1978, Crowninshield and Brand, 1981, Shourijeh et al., 2017).

This reduces redundancy with a formula that satisfies cost function minimization and relations (Montefiore 2019:47).

$$\vec{\tau} = R(\vec{q})\vec{F}\vec{0} \leq \vec{F} \leq \vec{F}max$$

where $R(\vec{q})$ is the matrix of the moment arms (the perpendicular distances from the line of muscle to the center of rotation of the joints the muscle is crossing), $\vec{F}$ is the vector of muscle forces, and $\vec{F}max$ is the vector of maximal muscle forces according to the musculotendon dynamics relationship.

A common choice for the cost function, also implemented in OpenSim, is the minimization of the sum of the muscle activations squared (Montefiore 2019:49):

$$J(\vec{F}) = \Sigma(\vec{Fi}\ \vec{F}max,i)2ni=1$$

where *n* is the number of muscles in the system.

Joint Reaction Analysis

Steele et al. (2012) proposed the Joint Reaction Analysis Tool to quantify forces acting on the articular surface. This tool allows the estimation of joint contact forces (JCFs), assumed acting at the joint center. Forces are calculated by solving each segment-free body diagram from distal to proximal, including external forces, inertial forces, and muscle forces (Steele et al. 2012). As Montefiore (2019:50) describes: "On the adjacent proximal segment, the distal contact force is equal and opposite to the one previously calculated on the distal segment. In such a way, all the reaction forces can be calculated iteratively, up to the most proximal segment of the chain."

Justification for Use of Shared Tools For Automatic Personalized Lower Extremity (STAPLE) modeling toolbox and the Subject-Specific Modeling Pipeline

The Shared Tools for Automatic Personalized Lower Extremity (STAPLE) modeling toolbox was used as a workflow for stage one of the creation and processing of the personalized models (Modenese and Kahout 2020). STAPLE is a MATLAB toolbox that enables the creation of lower extremity MSK models from individual bone geometries using statistical modeling (Modenese and Renault 2021). Though this toolbox is still in beta testing and has limitations, it provides an excellent starting point for articulating MSK models in NMSBuilder (Modenese 2021, Personal Communication).

In traditional MSK modeling, an idealized sphere is used for the hip and talus, while an idealized cylinder is used for knee and hindfoot, according to Modenese and Kahout. (2020), Modenese et al (2018) and Delp (2012, 2007) as well as International Society of Biomechanics (ISB) recommendations. For this project, personalized joint models were created with the STAPLE toolbox. This toolbox included a least-square algorithm (developed by Modenese and Kahout. (2020), Modenese et al (2018) for Matlab (MathWorks, USA), used to map the joint surface geometry onto these idealized shapes. This algorithm relies on the LSGE Matlab Library (NPL Centre for Mathematics and Scientific Computing, UK).

STAPLE works with 3D bone geometries, with the preferred standard being STL or OBJ files. In STAPLE's primary application, medical research, the geometries are usually surface models from magnetic resonance imaging (MRI) or computed tomography (CT) scans. After these scans are loaded, STAPLE works within the MATLAB environment to statistically analyze the morphology of the bone geometries and defines reference systems to create personalized lower limb MSK models with kinematic and kinetic capabilities (Modenese and Renault 2021). Figure 4.4 illustrates the STAPLE workflow.

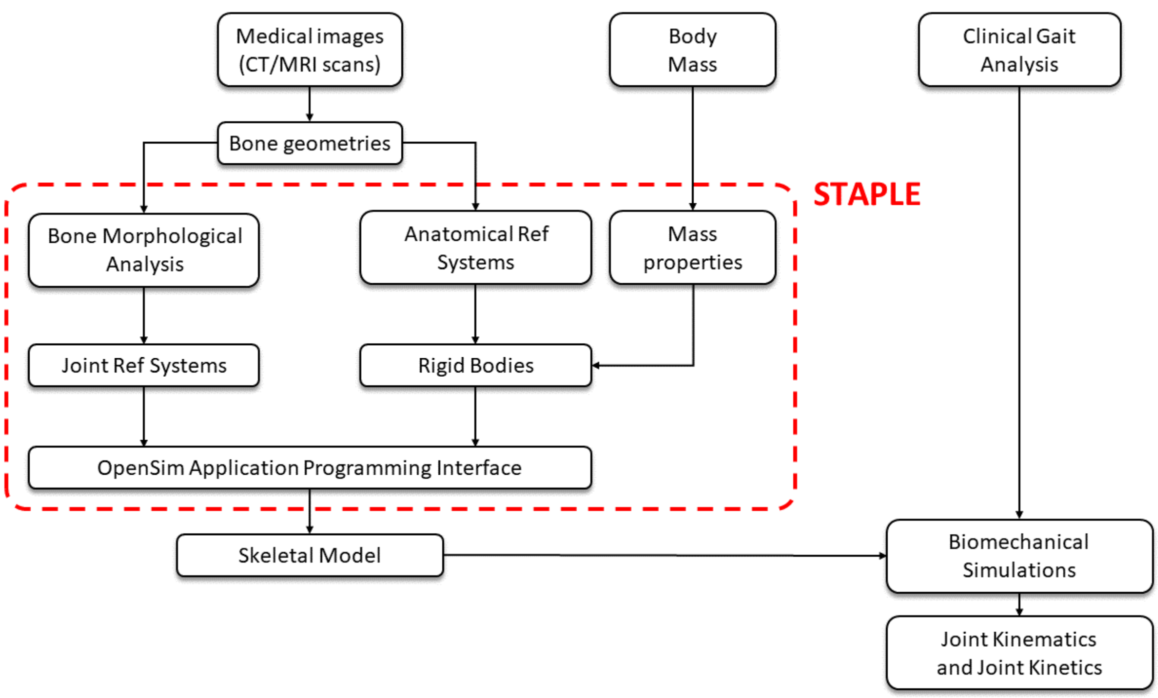


Figure 4.4. STAPLE Workflow. Reproduced with permission from Modenese and Kahout, 2020.

Personalized MSK Modeling: Workflow for Archaeologically Recovered Remains

Working with archaeologically recovered remains requires a slightly different approach to personalized modeling. Additional post-processing is required to digitally refit skeletal fragments and to improve the surface density of the scans for triangulation. These steps are detailed below.

Personalized MSK models were created according to Modenese and colleagues (Modenese et al. 2018; Modenese and Renault 2021). The procedure for developing a personalized model from 3D scans of archaeologically recovered human remains took place in the following steps: (1) bone geometry acquisition (digitization, image processing, digital reconstruction of fragmented remains), (2) scan organization, (3) STAPLE processing, (4) skeletal articulation and joint mapping, (5) joint axis estimation, (6) muscle reconstruction, (7) muscle path specification, and (8) moment arm calculation.

Bone Geometry Acquisition: Three-Dimensional Scanning

Elements scanned include the right and left pelvis, femur, patella, tibia, fibula, talus, hindfoot, and forefoot. Two three-dimensional scanners were used for this project: the NextEngine three-dimensional laser scanner and the LMI Technologies HDI Advance R1X structured light scanner. These two scanners were selected for their high levels of fidelity and efficiency. The NextEngine is currently maintained and used at the University of Wisconsin-Milwaukee Archaeology Research Laboratory. The HDI Advance R1X is currently maintained by Dr. Derek Counts and used in collaboration with the University of Wisconsin-Milwaukee Art History Department. The HDI Advance R1X was the primary scanner used because of its much higher point sampling capabilities as well as its scanning process, which is much less invasive and takes less time, thus reducing potential damage to remains. The application of this technology has several unique advantages. Digitally scanning skeletal elements produces a record that allows greater access for researchers without exposing the bone to damage from transport or excessive handling, allows for replicable analyses through digital tools, and creates the opportunity for collaborative research under proper ethical consideration and guidance.

Post-Processing Scan Files

The first step was to ensure that all STL files were manifold, meaning that there are no gaps between areas of triangulation, or holes, in each model (Hager et al. 2016). Figure 4.5 demonstrates an example of manifold edges.

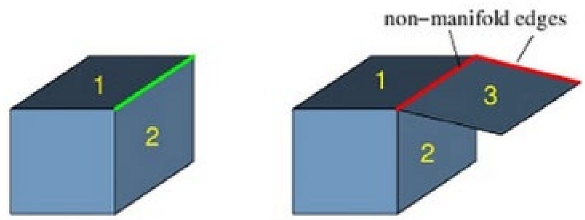


Figure 4.5. Illustration of manifold (green) edges and non-manifold (red) edges of a 3-D model (Adapted from Hager et al. 2016:297)

Even high-density scans can have non-manifolded areas that are not able to be remedied during post-processing in the scanning software (in this case Scan Studio or FlexScan), causing them to be unusable in applications like MatLab or OpenSim. The Autodesk Meshmixer program was used to repair these files. The fill tool within the inspector module was set to Small Threshold (0.02mm) and repaired any remaining holes in the scans so they could be processed in the STAPLE toolbox. Figure 4.6 illustrates this process.

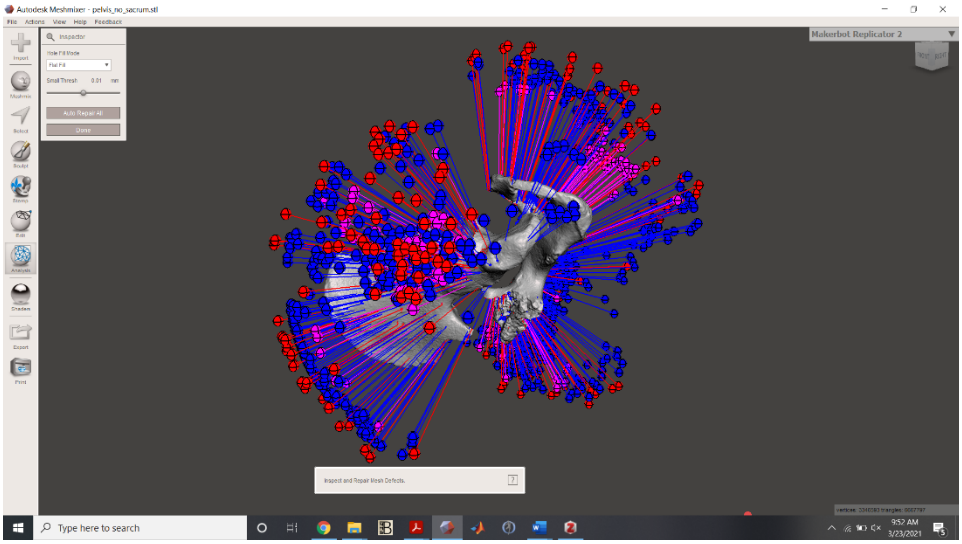


Figure 4.6. Illustration of Autodesk Meshmixer Process. Skinner, 2-16-21, Photo on File at the University of Wisconsin-Milwaukee Archaeological Research Laboratory.

Digital Reconstruction of Fragmentary Remains

Due to the often fragmentary and incomplete nature of archaeologically recovered human remains, digital restoration was used to refit fragments and to extrapolate missing components of skeletal elements. Fragmentary elements were refit using manual methods similar to di Vincenzo et al. (2019), using MeshLab to align the fragments and to save them as a flattened mesh. More advanced programs such as *Fragmento* (Mahfouz et al. 2017) were unable to be used at this time due to access constraints. Figure 4.7 demonstrates the manual

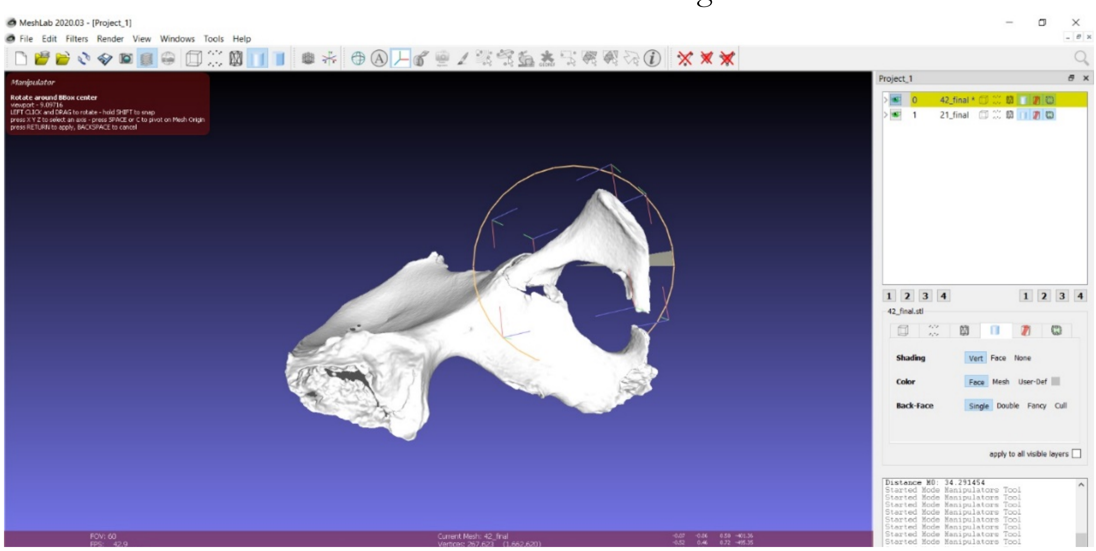


Figure 4.7. MeshLab digital reconstruction process. Skinner 2-16-2021. Image on file at the University of Wisconsin- Milwaukee Archaeological Research Laboratory.

reconstruction process.

Renaming Bone Geometries

To accommodate the STAPLE toolbox while also maintaining provenience for each individual, copies were made of each mesh and stored in pathed folders for the creation of the MSK models. Once a model was complete, all its relevant folders and mesh copies were placed back in the Individual Folder for that lot. Each individual went through the entire model building process separately to prevent digital provenience issues. As part of this process, the copies of the surface meshes were renamed following the names of standard OpenSim models, presented in Table 4.4, below (adapted from (Modenese and Renault 2021)). Individual elements were also grouped at this stage, for instance, surface meshes of pelvic elements were joined using the flatten mesh layers filter in MeshLab.

Table 4.4. Input Names for STAPLE Workflow. Adapted with permission from Modenese and Renault 2021.

STAPLE Input Name	**(Grouped) Segmented Bone Geometries**
pelvis_no_sacrum	right iliacus, left iliacus
femur_r	right femur
femur_l	left femur
tibia_r	right tibia, right fibula
tibia_l	left tibia, left fibula
patella_r	right patella
patella_l	left patella
talus_r	right talus
talus_l	left talus
calcn_r	right calcaneus, right foot bones excluded phalanges
calcn_l	left calcaneus, left foot bones excluded phalanges
toes_r	right foot phalanges
toes_l	left foot phalanges

File Organization

Specialized folder tree systems were used for both the STAPLE toolbox and the personalized MSK pipeline, in each case to support the functions of MATLAB and OpenSim (Modenese et al. 2018; Modenese and Renault 2021). The traditional folder tree setup for the personalized MSK pipeline (Modenese et al. 2018). Figure 4.8 illustrates the traditional folder structure, and a copy of this structure can be obtained at https://simtk.org/frs/?group_id=1618.

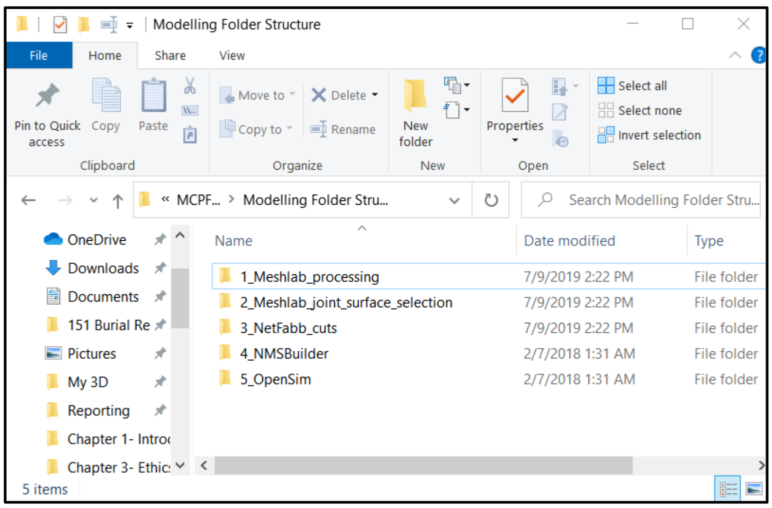


Figure 4.8. Modeling Folder Structure for Subject-Specific Pipeline, adapted from Modenese et al. 2018.

Since meshes can be directly processed in MATLAB using the STAPLE toolbox, the folder structure for this project is slightly different. Figure 4.9 illustrates the adapted folder structure, which is available on request in the supplemental materials folder.

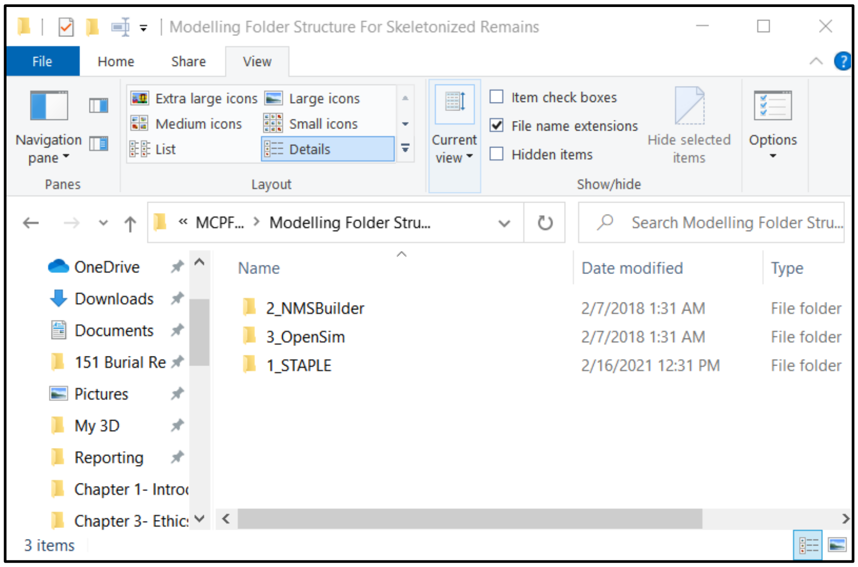


Figure 4.9. Modeling Folder Structure for Skeletonized Remains.

Creating a Model in NMSBuilder

STAPLE cannot create skeletal models from images that have more than one reference system because STAPLE morphological analysis is local to the bone it is performed on and the only information about the relative position of the bones in typical applications of STAPLE comes from the medical scans' resting pose (Modenese and Renault 2021). This limitation was circumvented by manually articulating the elements in NMSBuilder (Valente et al. 2017).

Models that were processed using STAPLE were loaded into NMSBuilder and articulated. For detailed instructions on building a model in NMSBuilder, please see the Step-by-Step Modeling Guide (Modenese et al. 2018). This project used an alteration to the Guide's pipeline for building models- instead of importing the geometries alone, the geometries, mapped joint surfaces, and associated kinematic data were imported to NMSBuilder from STAPLE. To facilitate the creation of a model from incomplete archaeological remains, template skeletal elements were occasionally used. To maintain the individuality and sovereignty of the individuals represented in this project, it was ensured that only mathematical models were used to represent missing elements.

Joint Axis Estimation

Joint centers and axes of rotation (joint parameters) are essential in movement analysis(Schwartz and Rozumalski 2005). In typical applications, the STAPLE toolbox uses the preexisting joint coordinates from MRI or CT data. Due to the lack of preexisting joint parameters resulting from the disarticulated nature of archaeologically recovered remains, this project utilized regression equations (Schwartz and Rozumalski 2005) to estimate joint parameters. Schwartz and Rozumalski (2005) summarize the method as follows:

> (i) the motions of two adjacent segments spanning a single joint are tracked, (ii) the axis of rotation between every pair of observed segment configurations is computed, (iii) the most likely intersection of all axes (effective joint center) and most likely orientation of the axes (effective joint axis) is found (Schwartz and Rozumalski 2005)

The equations determined from this method were deemed best for digital applications where joint parameters cannot be determined since they combine simulation data with clinical data.

Reference System Conventions

The output reference systems of all STAPLE scripts have axes consistent with conventions of the International Society of Biomechanics. However, in many of STAPLE's internal algorithms, technical reference systems altered from GIBOC-core are used. These reference systems are defined according to the following conventions(Modenese and Renault 2021):

> X directed in anterior-posterior direction, pointing posteriorly,
> Y directed in medio-lateral direction, pointing laterally for the right leg,
> Z directed in proximal-distal direction, pointing cranially.

STAPLE Workflow

The STAPLE toolbox was used to define joint surfaces prior to articulation in NMSBuilder. Before using the STAPLE toolbox, the OpenSim API for MATLAB was set up. For more information on setting up the OpenSim API for MATLAB, see https://simtk-confluence.stanford.edu/display/OpenSim/Scripting+with+Matlab.

After preparing geometries for triangulation in MATLAB via the above methods, they were placed in a Study Folder on the MATLAB path according to Modenese and Renault, 2021. Once the files were properly pathed and the API was set up, the following could be evaluated. The following checklist represents the process for setting up a functioning workflow using STAPLE (adapted from Modenese and Renault 2021, accessible at https://github.com/modenaxe/msk-STAPLE#requirements). Steps 2-5 were accomplished more efficiently using wrapping functions created by Lee (2021).

1. Ensure data and environment are prepared as described previously in this chapter.
2. Define the dataset(s) to process.
3. Define a cell array with names of elements to process. The same names will be used for the rigid bodies.
4. Define a body side if not evident from element names.
5. Decide the joint definitions (joint_defs variable in the examples). These determine how incomplete joint reference systems will be completed. Refer to the functions jointDefinitions_auto2020.m and jointDefinitions(Modenese et al 2018).
6. Use createTriGeomSet.m for creating a set of MATLAB triangulation objects (TriGeomSet structure).
7. Use writeModelGeometriesFolder.m to write the visualization geometry files for the model from the TriGeomSet structure.

8. Use initializeOpenSimModel.m to start building the OpenSim model.

9. Use addBodiesFromTriGeomBoneSet to create bodies corresponding to the fields of the TriGeomSet structure. These bodies will be added to the OpenSim model but are not yet connected by joints. At this stage the assigned segment mass properties are calculated from the bone geometries using a bone density of 1.42 g/cm^3 (Dumas et al. 2005). 0If building a kinetic model, use assignMassPropsToSegments.m to update the inertial properties after creating the model joints.

10. Use processTriGeomBoneSet.m to process the bone geometries using the available algorithms to compute joint coordinate systems (JCS), body coordinate systems (CS), and bone landmarks (BL). This step does not rely on the OpenSim API and consists of a morphological analysis of the bone shapes performed using the algorithms available in STAPLE and listed in the Table below.

11. Once these steps are completed, the analysis moves to NMSBuilder to refine joint coordinate systems, since they are lacking in the original model.

Algorithms for Osteological Morphological Analysis

The STAPLE toolbox uses some established algorithms for morphological analysis and others that were created through the STAPLE research team. Table 4.5 links to and describes these algorithms.

Table 4.5. Algorithms for bone morphological analysis (Adapted from Modenese and Renault 2021)

Family of Algorithms	**Bones of interest**	**Reference publication**
Kai2014	• pelvis • femur • tibia	Kai et al. (2014)
GIBOC	• femur	Renault et al. (2018)

Family of Algorithms	Bones of interest	Reference publication
	• tibia • patella	
STAPLE	• pelvis • talus • foot bones	Modenese and Renault (2021)

Range of Motion Calculation

Range of motion (ROM) has a strong statistical correlation with age (Clarke et al. 1975; Macedo and Magee 2009; Roach and Miles 1991; Schmidt et al. 2013), so ROMs for each individual were set according to the average ROM for their age and sex cohort, following Schmidt et al. 2013 for when ROM data is not available.

OpenSim

OpenSim is an open-source software that enables the visualization and analysis of musculoskeletal models while generating dynamic movement simulations (Delp et al. 2007). Models in OpenSim consist of rigid body segments (skeletal elements) connected by joints (often idealized shapes, but in this case skeletal geometry mapped onto idealized shapes). As in the human musculoskeletal system, muscles span the joints and generate force and motion. OpenSim is a tool for creating custom studies that investigate MSK geometry, joint kinematics, musculotendon properties, prosthetic mechanics, and other variables of human movement (Delp et al. 2007).

Methods Conclusions

Interdepartmental and cross-institutional collaboration was essential for the success of these methods. The three-dimensional scanning process was done with the help of the UWM Art History department, which houses the LMI Technologies HDI Advance R1X structured light scanner. Dr. Derek Counts and Dr. Kevin Garstki provided training on the scanner and assisted with troubleshooting. Dr. Luca Modenese, of the biomechanics department at Imperial College London is the creator of the STAPLE and Personalized MSK Modeling pipelines. Dr. Modenese provided extensive feedback and assistance on these pipelines. Once models were built in NMSBuilder and STAPLE, each model was imported to OpenSim, where multiple gait trials were analyzed using the OpenSim Inverse Dynamic (ID) tools. Two types of assessment took place for each of these gait trials: joint force assessment and statistical mapping (Pataky 2012). Dr. Stuart McErlain-Naylor of the Biomechanics and Sports Medicine department at University of Suffolk, UK, provided feedback on the validity of the statistical nonparametric mapping, and suggested avenues for future statistical analysis. Dr. Jennifer Earl-Boehm of the UWM Athletic Training Education Program, provided training and feedback in observational gait analysis (Adams and Cerny 2018). Dr. Kevin Abing, of the Milwaukee County Historical Society, provided access to the Milwaukee County Hospital intake records and facilitated scanning of those documents. Dr. John Richards, of the UWM Department of Anthropology conducted XRF analysis on the medical sutures for individual 10371. Committee members Dr. Bettina Arnold, Dr. Paul Brodwin, and Dr. John Hawks provided extensive discipline-specific review of the dissertation. Dr. Patricia Richards guided and facilitated this project in addition to all others that are part of the Milwaukee County Poor Farm Cemetery Project. The qualitative and quantitative assessments for these trials are discussed in Chapter Five.

Chapter 5 : Results and Analysis

Individuals Included in the Study

As discussed in Chapter 4, only ten individuals were included in this project, to facilitate ethical and thorough holistic practice. Each individual was selected based on the potential for their own identification and the potential for contributing to the future identification of other individuals (Table 5.1).

Table 5.1. Composition of age and sex of individuals.

Female Adult Age Categories (n=5)			Male Adult Age Categories (n=5)		
Young	Middle	Old	Young	Middle	Old
1	2	2	0	2	3

Working with an equal number of females and males complemented our current understanding of the cultural meanings behind the demographics of the cemetery, which as discussed previously, are greatly weighted towards males.

An expanded discussion of all summary data for each individual included in the study can be found in Appendix G. The following summary tables contain identifying information about the 10 individuals included in this study. Table 5.2 provides archaeological context information for all individuals included in the study.

Table 5.2. Archaeological Context information for all individuals included in study.

Lot	**Putative ID Name**	**Ost. Average Age**	**Recorded Age at Death**	**Ost. Sex**	**Stature**	**Coffin Dimensions**	**Coffin Handle Type**	**Material Culture**	**Formal Positioning?**
5099	Carl Mahnke	39.4*	72	M	66.17 ± 2.6	82X23	Type VII	None	P
5128	Mary Henke	51.4	44/41	F	63.27 ± 2.3	74X18	Type VII	Monogrammed Gold Ring, Safety Pins	P
5133	Emma Hall	52.6	52	F	58.80 ± 2.3	70X19	Type VII	None	P
5210	James Hannon	40.15	65	M	65.50 ± 2.5	73X17	Type VII	None	P
8159		53.1		M	67.97 ± 2.8	75X19	Type VIII	None	P
10067		31.25		F	N	75X18	Type II	Shell Button, Safety Pins, head support, melted glass fragment	P
10364		45.65		M	67.09 ± 2.8	71X20.1	Type I/Type VI	2 flat glass, 4 melted glass, 3 INDT Glass	P
10371		43.5		M	66.67 ± 2.5	74.5X21	None	None	P
10372		50.9		F	N	70X18	None	None	P
10805		42		F	63.27 ± 2.3	76X22	2 Indt Handles	1 Rubber Fragment	P

Table 5.3 is a summary table of identification bolstering data for each individual in the study. This includes a combination of osteological data, health record data, and material culture data.

Table 5.3. Summary table of identification bolstering data for each individual in the study.

Lot	Arch. Residence Category	Doc. Residence Category	Dental Health	Dental Intervention?	Medical Trauma?	Ost. Hospital Path/ Trauma?	Documentary Hospital Trauma?	Ost. Medical Intervention?	Intervention Type?	Intervention PM/AM	Documentary Medical Intervention?	Intervention Type?	Place of Death	MKE Death Certificate COD	Coroner's Inquest COD
5099	I	CPR	E	A	P	P	Gangrene Leg/Diabetes M	P	Craniotomy	TBD	P	Infection Addressed	CH	Gangrene Leg/Diabetes M	A
5128	IV	COM	E	A	P	A	Gall Stones	A	A	A	P	Hospitalization/ Medication	CH	Cirrhosis of liver/myocardial insufficiency	perhases of liver (fatty)
5133	I	CPF	C, P, EH, AA	A	P	P	Gall Stones in Common Duct	P	A	A	P	A	CH	Gallstones in Common Duct	A
5210	I	COM	EH, C, P	A	P	P	Lobar Pneumonia	A	A	A	P	A	CH	lobar pneumonia	A
8159	I	A	E, EH, C	A	P	P	NA	A	A	A	A	A	A	A	A
10067	IV	A	E, C	A	P	N	NA	A	A	A	A	A	A	A	A
10364	I	A	E, C	A	P	Y	NA	A	A	A	A	A	A	A	A
10371	I	A	E, C	A	P	Y	TBD	A	A	A	A	A	A	A	A
10372	I	A	E	A	P	Y	NA	A	A	A	A	A	A	A	A
10805	I	A	E, EH, C	A	P	Y	NA	A	A	A	A	A	A	A	A

Musculoskeletal Model Assessment

Models created using the methods outlined in Chapter 4 were validated according to standard methods approved by the ISB (Hicks et al. 2015). Hicks et al (2015: 020905-2) outline a multi-stage verification and validation process, represented in Figure 5.1.

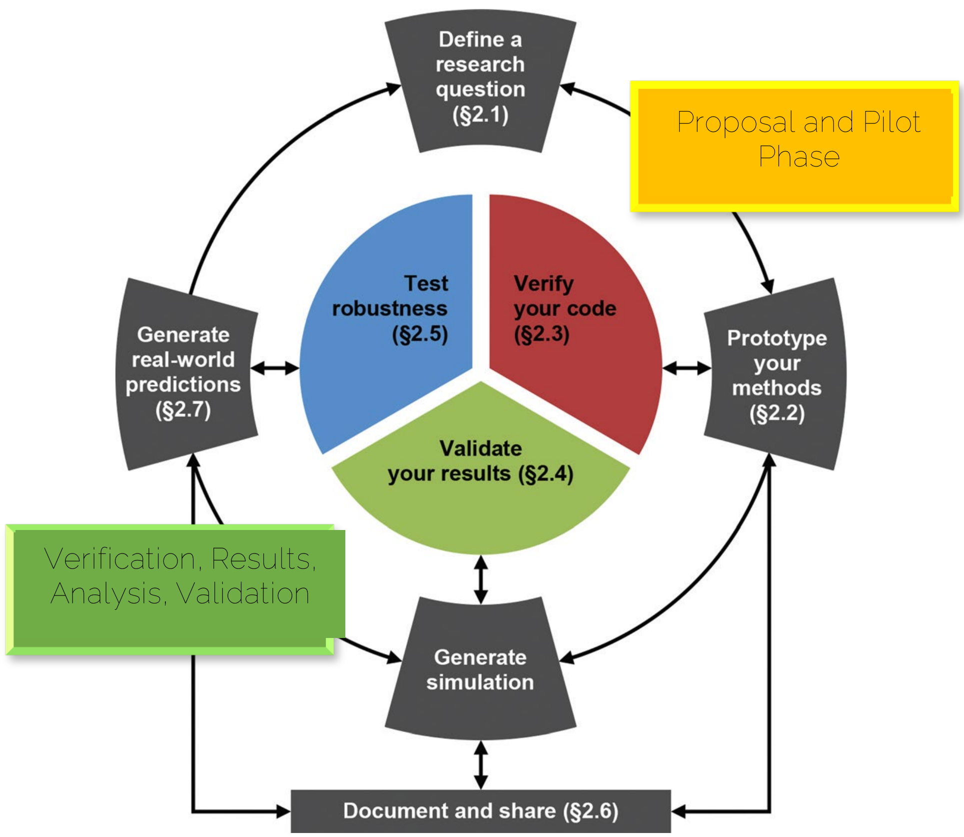


Figure 5.1. Overview of the verification and validation process. Adapted with permission from Hicks et al. 2010.

Due to the unique nature of this population, a priority was to perform simulations and validate the results against independent data to ensure the model and simulation faithfully represent specific physical phenomena of interest, namely skeletal changes. Once the model was validated, real-world predictions could be searched against clinical literature to narrow the field of medical diagnoses that may pertain to each individual. This data was then used to cross-examine the Milwaukee County Hospital intake records to further bolster the putative identities put forth by Richards 1997, Richards et al. 2016, Freire 2017, Drew 2018, and others.

The verification and validation processes within the fields of biomechanics and musculoskeletal healthcare research extends beyond the study due to the benefit of sharing one's models when generalized MSK models are used (Delp et al. 2007; Hicks et al. 2015; Modenese et al. 2011). In personalized musculoskeletal modeling, on the other hand, this process begins with the research question and continues throughout study design and even beyond study completion, as the model may serve to investigate multiple research questions to benefit the individual for whom it was created. The same is true for personalized archaeological MSK models, which can generate additional data as new workflows are released and which need to be assiduously protected and maintained as identifying records of archaeologically recovered individuals.

Software Verification

This step was conducted to determine that the computational model and underlying algorithms were implemented correctly. If an algorithm has been implemented incorrectly, all resulting simulations will be incorrect, and any conclusions drawn will be contaminated. Hicks et al. (2015) underscore the subtle difficulty of this step: "paradoxically, it is not the most substantial errors that are most problematic, since the erroneous results they produce are likely to be immediately apparent- the small errors can be the most pernicious as they can produce results that are plausible and can, therefore, easily go unnoticed."

OpenSim (Delp et al. 2007, Delp et al. 1990), NMSBuilder (Valente et al. 2017), MATLAB (R2021a), AutoDesk MeshMixer, and the STAPLE toolbox (Modenese and

Renault 2021; Saxby et al. 2020) are all verified frequently through algorithm. OpenSim and STAPLE are community-based open source and therefore also debugged frequently. All platforms used are frequently updated.

Model Validation

To mitigate this, the model outputs were compared to independent experiments and other models. A wide range of potential data are available for validation, from motion capture analysis to ground reaction forces and electromyography signals, as well as imaging or cadaver data that helps define musculoskeletal dynamics and geometry. A common workflow uses experimental kinematics and ground reaction force data to generate muscle-driven simulations of observed motions (Delp et al. 2007; Hicks et al. 2015). This is an example of experimental kinematics and ground reaction force data being used to calibrate the simulation. Calibration can also be done with EMG data, ultrasound data, and neuromuscular trials (Hicks et al. 2015). Gait-affecting changes to musculoskeletal geometry were the primary source of calibration and validation in this study.

Evaluating the Robustness of the Study

The range of possible outcomes (e.g., confidence intervals) was determined, and sensitivity analysis was undertaken, to enable validation of the model and comparison with clinical datasets (Delp et al. 2007; Hicks et al. 2015). In traditional MSK research, sensitivities arise from noise created by the interchange between external experimental makers and the simulated internal MSK model. Potential introducers of error or noise include differences in placement of experimental markers, skin movement artifact, variations of musculotendon parameters, differences between model muscle geometry and in vivo muscle geometry, and others(Delp et al. 2007, 1990; Hicks et al. 2015; Modenese et al. 2018; Modenese and Renault 2021; Montefiori 2019; Saxby et al. 2020).

Archaeological MSK models are sensitive to other, still potentially confounding variables, most often arising from a lack of data. These include potential researcher error when defining joint parameters, joint surfaces compromised by taphonomy, and incomplete element sets. These potential sources of noise were mitigated by re-tuning the models after testing and validating them in OpenSim until the parameters were accurate to in vivo studies. One barrier to using existing studies to validate archaeological models is the presence of musculoskeletal conditions that would generally not occur with the benefit of modern medicine. For this reason, it was expected that joint moments may exceed current clinical data, enabling comparison with the understanding that historical instances of conditions like femoroacetabular impingement, displaced fractures, and osteoarthritis lacked the treatment available to individuals generally included in modern clinical trials today. Consequently, the effect on bony surfaces, and therefore joint contact forces, may be exaggerated compared to the literature.

An additional area of complication concerns the motion files and the template individuals (2354, 2392) used as the control for this study. The Gait2392 and Gait2354 models are three-dimensional, 23-degree-of-freedom computer models of the human musculoskeletal system. The models were created by Darryl Thelen (University of Wisconsin-Madison) and Ajay Seth, Frank C. Anderson, and Scott L. Delp (Stanford University). The models feature lower extremity joint definitions adopted from Delp et al. (1990), low back joint and anthropometry adopted from Anderson and Pandy (1999), and a planar knee model adopted from Yamaguchi and Zajac (1989). The bones surface data used in these models for the pelvis and the thigh are obtained by first marking the surfaces of bones with a mesh of polygons, and then determining the coordinates of the vertices with a three-dimensional digitizer. Data describing the shank and foot bones are adopted from Stredney (1982). The joints and skeletal data were all created from idealized shapes, meaning that they were not created from any specific individual nor are they able to represent a specific individual. Prior to Modenese et al. (2018), OpenSim models represented the opposite side of the equation in relation to skeletal and biomechanical data—the models themselves were completely generic (though they could be scaled to a person's size and mass), and the motion input data was generated by the person having their gait assessed- therefore the models contained a great deal of information about the neuromuscular (Joyce 2018) components of a person's gait, but no skeletal data. This project does the opposite- there is a great deal of information about the skeletal factors affecting gait, but unfortunately none of the *in vivo* data. Because the motion for models 2354 and 2392 was captured during experimental trials with living humans (John et al. 2013), the motion files contain artifacts of their gait. Future studies will work to eliminate this confounding factor.

Inverse Dynamics

The OpenSim Inverse Dynamics (ID) Tool determines the generalized forces, or net forces and torques, at each joint in a movement. This tool works with the kinematics (states or motions) describing the model, and the kinetics (external loads), to preform ID analysis. The ID tool solves the equations for the mathematical expression of the mass-dependent relationship between force and acceleration, $\boldsymbol{F} = m\boldsymbol{a}$, to produce the net forces and torques at each joint that produces the indicated movement. The required inputs and outputs for the Inverse Dynamics Tool can be viewed in Figure 5.2.

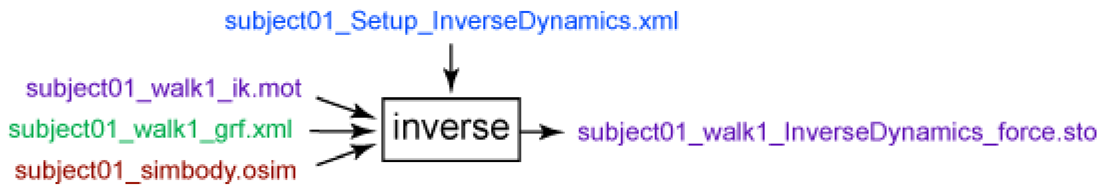


Figure 5.2. Experimental data are shown in green; OpenSim files (.osim) are shown in red; settings files are shown in blue; files generated by the workflow are shown in purple. Adapted with permission from Delp et al. 2007.

Inverse dynamics are particularly well-suited to archaeological populations since the analyses are focused primarily on bone geometry and mass. Specifically, Inverse Dynamics of Personalized MSK models provide useful insight for archaeologically recovered remains due to the ability to estimate the forces resulting from skeletal deformation or changes and then compare these forces to clinical literature to estimate the etiology of the skeletal changes.

In addition to personalized models, semi-personalized mass was calculated by combining stature data with average historical age and sex mass data and confirming that mass was not outside of normal range by examining bodily positioning within the coffin.

Inverse Dynamics analysis was the primary biomechanical tool used in concert with the archaeologically suited tools for this project. Figure 5.3 illustrates the full scope of Musculoskeletal Modeling and the scope of this study.

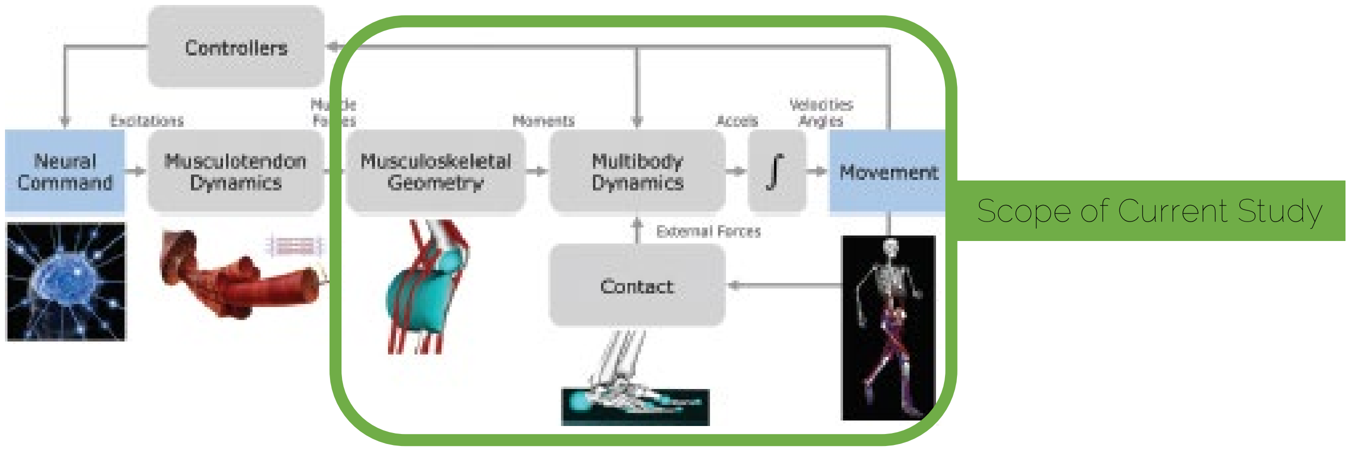


Figure 5.3. Elements of a musculoskeletal simulation. A model of the NMS system can include computational models of muscle–tendon dynamics; geometry of bodies, joints, and muscles; models or estimates of contact; and models or estimates of neural control. A multibody dynamics engine is used to integrate the model's governing dynamic equations forward in time or solve for underlying motion and forces in an inverse analysis. Adapted with permission from Hicks et al. 2015: 020905-6.

The classical equations of motion may be written in the following form:

$$\underbrace{\mathbf{M}(\mathbf{q})\ddot{\mathbf{q}}+\mathbf{C}(\mathbf{q},\dot{\mathbf{q}})+\mathbf{G}(\mathbf{q})}_{\text{knowns}} = \underbrace{\tau}_{\text{unknowns}}$$

where N is the number of degrees of freedom;

$$\boldsymbol{q},\dot{\boldsymbol{q}},\ddot{\boldsymbol{q}}\in\boldsymbol{R}^{N}$$

are the vectors of generalized positions, velocities, and accelerations, respectively;

$$\boldsymbol{M}(\boldsymbol{q})\in\boldsymbol{R}^{N\times N}$$

is the system mass matrix;

$$\boldsymbol{C}(\boldsymbol{q},\dot{\boldsymbol{q}})\in\boldsymbol{R}^{N}$$

is the vector of Coriolis and centrifugal forces;

$$\boldsymbol{G}(\boldsymbol{q})\in\boldsymbol{R}^{N}$$

is the vector of gravitational forces and;

$$\boldsymbol{\tau}\in\boldsymbol{R}^{N}$$

is the vector of generalized forces.

The motion of the model is completely defined by the generalized positions, velocities, and accelerations. Consequently, all of the terms on the left-hand side of the equations of motion are known. The remaining term on the right-hand side of the equations of motion is unknown. The inverse dynamics tool uses the known motion of the model to solve the equations of motion for the unknown generalized forces. Inter-segmental force is the net force acting across a particular joint in a model. This should not be confused with joint bone-on-bone force, which is the force seen across the articulating surfaces of the joint, which includes the effect of active and passive muscle forces (Delp et al. 2007). A flowchart representing the biological equivalent of these equations is illustrated in Figure 5.4. This flowchart represents feedback loops in the musculoskeletal system. The black arrows show the relationship between different biological processes. The red arrows highlight how the inverse method can utilize data about observed moments to compute quantities involved in generating that movement.

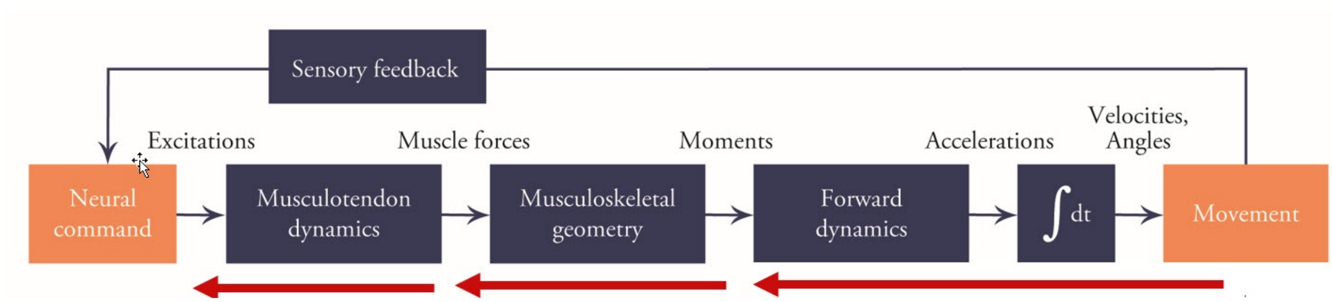


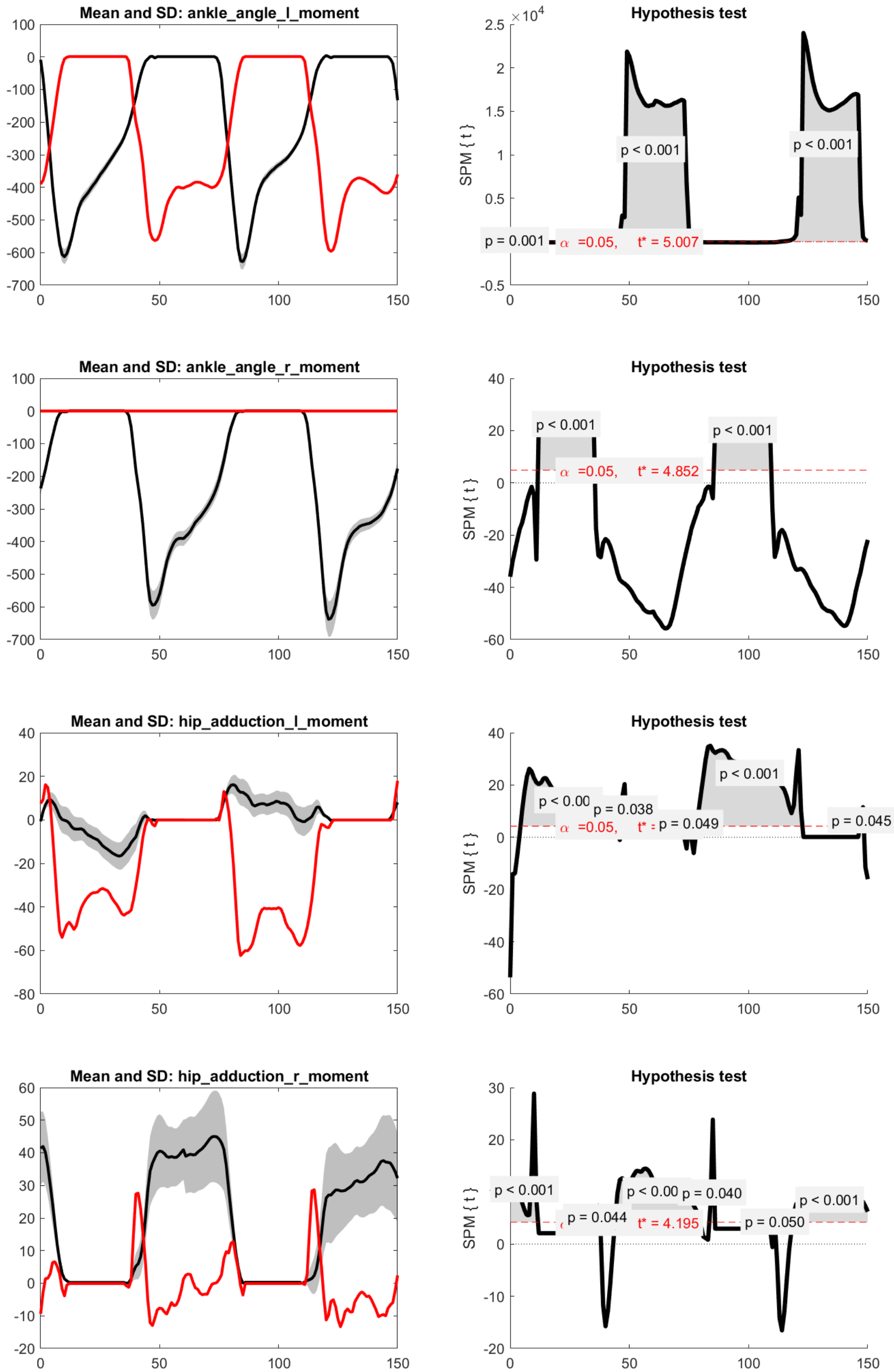
Figure 5.4. This flowchart represents feedback loops in the musculoskeletal system. The black arrows show the relationship between different biological processes. The red arrows highlight how the inverse method can utilize data about observed moments to compute quantities involved in generating that movement.

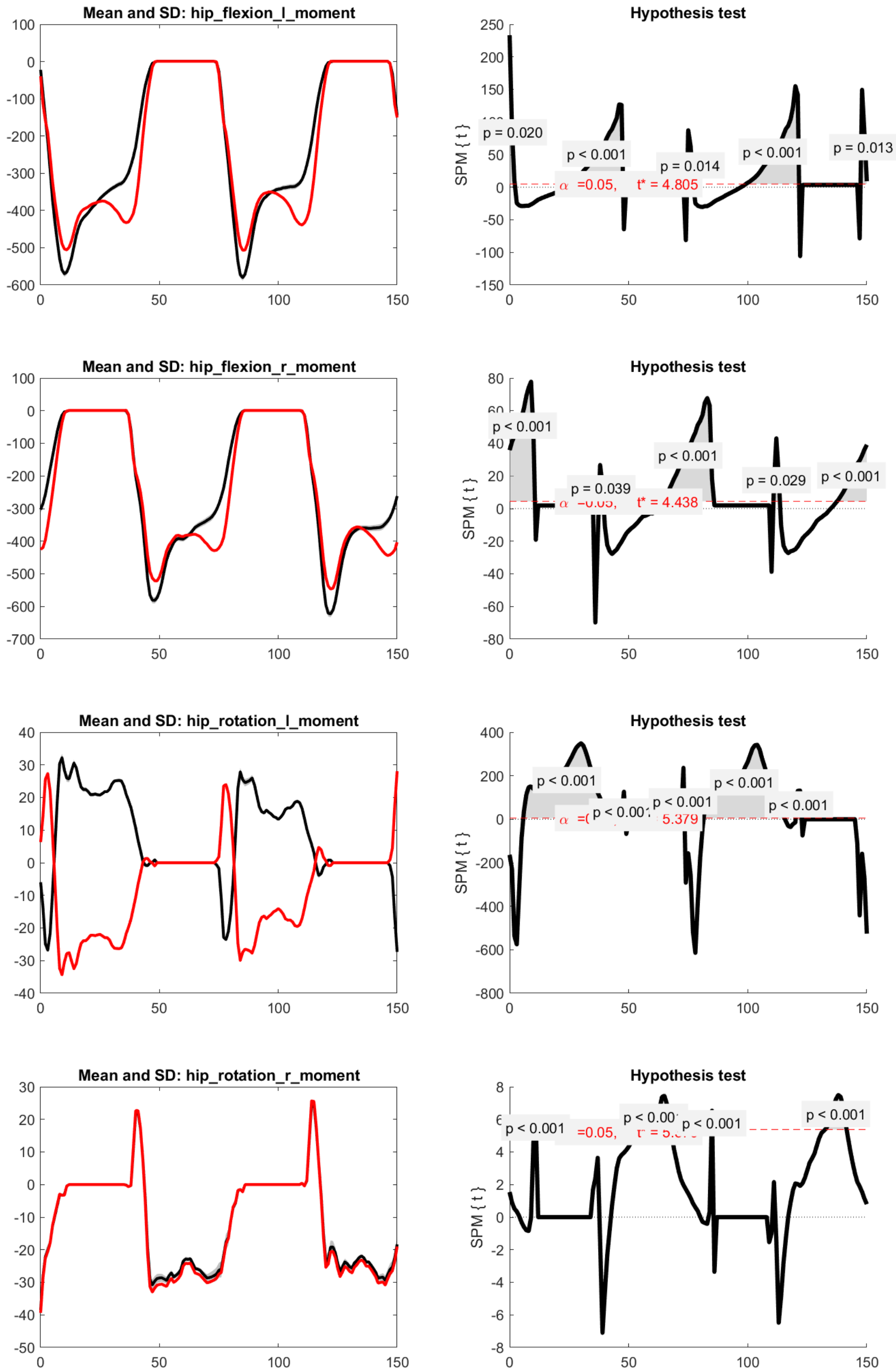
Inverse Dynamics Results

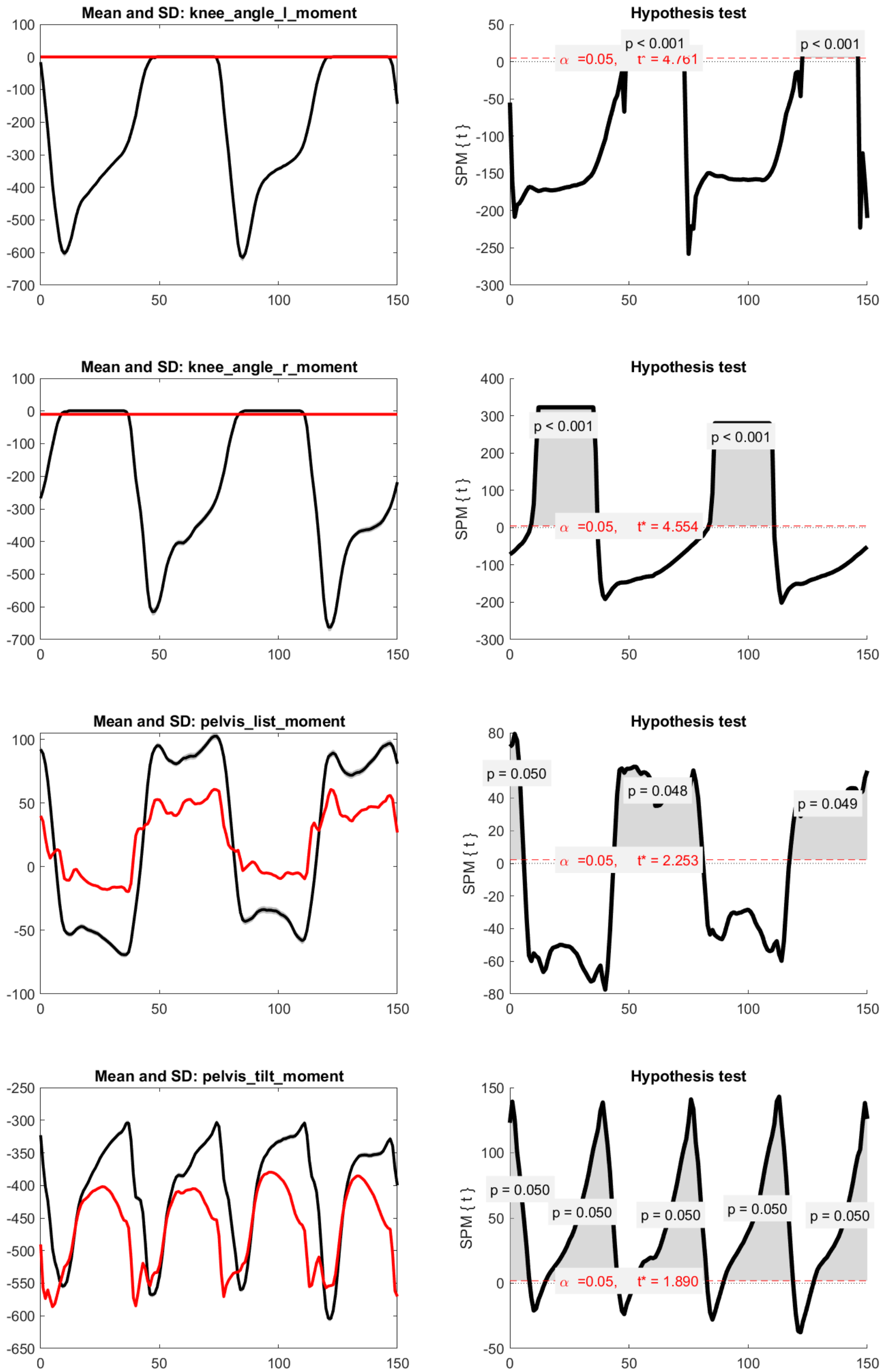
The baseline simulation group and the MCPFC simulation group were compared using Statistical Parametric Mapping (SPM). SPM relies on the Random Vector Field theory to adjust for data variability, which allows for the comparison of group means for time-varying quantities (Modenese et al. 2018). All analyses were done with MATLAB with the spm1d package (Pataky et al., 2013).

The effect of the differential skeletal changes observed for the MCPFC Group on the variability of the joint forces and moments was evaluated with the "SPM equivalent of a one-way ANOVA" (Modenese et al. 2018); the significance of individual differences between the joint moment and force estimates was tested using the SPM equivalent of an unpaired Students' t-test. In all analyses the significance level was set to $\alpha = 0.05$. A Post Hoc test was used to determine statistical differences and correlations.

After model validation, there was still a clear divergence from normal gait pattern for each of the individuals in the MCPFC group. The ID *t* tests between the MCPFC group and Baseline group data showed a significant difference during stance phase and swing phase, despite validity of the models. A more robust statistical analysis was hindered by the low sample size, but the values suggested a clear trend in joint forces and moments between the two groups. Relevant values were grouped to calculate the normalized *z* score used to build the radar plots in Figure 5.5 which summarizes the deviation of the MCPFC group from the baseline group. Statistically significant results suggest an overall increase in peak moments at the pelvis, hip, and knee.


Mean and SD: ankle_angle_l_moment
Hypothesis test
SPM { t }
×10^4
p < 0.001
p < 0.001
p = 0.001
α =0.05, t* = 5.007
Mean and SD: ankle_angle_r_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.001
α =0.05, t* = 4.852
Mean and SD: hip_adduction_l_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.00
p = 0.038
p = 0.049
p = 0.045
α =0.05,
Mean and SD: hip_adduction_r_moment
Hypothesis test
SPM { t }
p < 0.001
p = 0.044
p < 0.00
p = 0.040
p = 0.050
p < 0.001
t* = 4.195


Mean and SD: hip_flexion_l_moment
Hypothesis test
SPM { t }
p = 0.020
p < 0.001
p = 0.014
p < 0.001
p = 0.013
α =0.05, t* = 4.805
Mean and SD: hip_flexion_r_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.001
p = 0.039
p = 0.029
p < 0.001
t* = 4.438
Mean and SD: hip_rotation_l_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.001
p < 0.001
p < 0.001
5.379
Mean and SD: hip_rotation_r_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.001
p < 0.001
=0.05,


Mean and SD: knee_angle_l_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.001
α =0.05,
Mean and SD: knee_angle_r_moment
Hypothesis test
SPM { t }
p < 0.001
p < 0.001
α =0.05, t* = 4.554
Mean and SD: pelvis_list_moment
Hypothesis test
SPM { t }
p = 0.050
p = 0.048
p = 0.049
α =0.05, t* = 2.253
Mean and SD: pelvis_tilt_moment
Hypothesis test
SPM { t }
p = 0.050
p = 0.050
p = 0.050
p = 0.050
p = 0.050
α =0.05, t* = 1.890

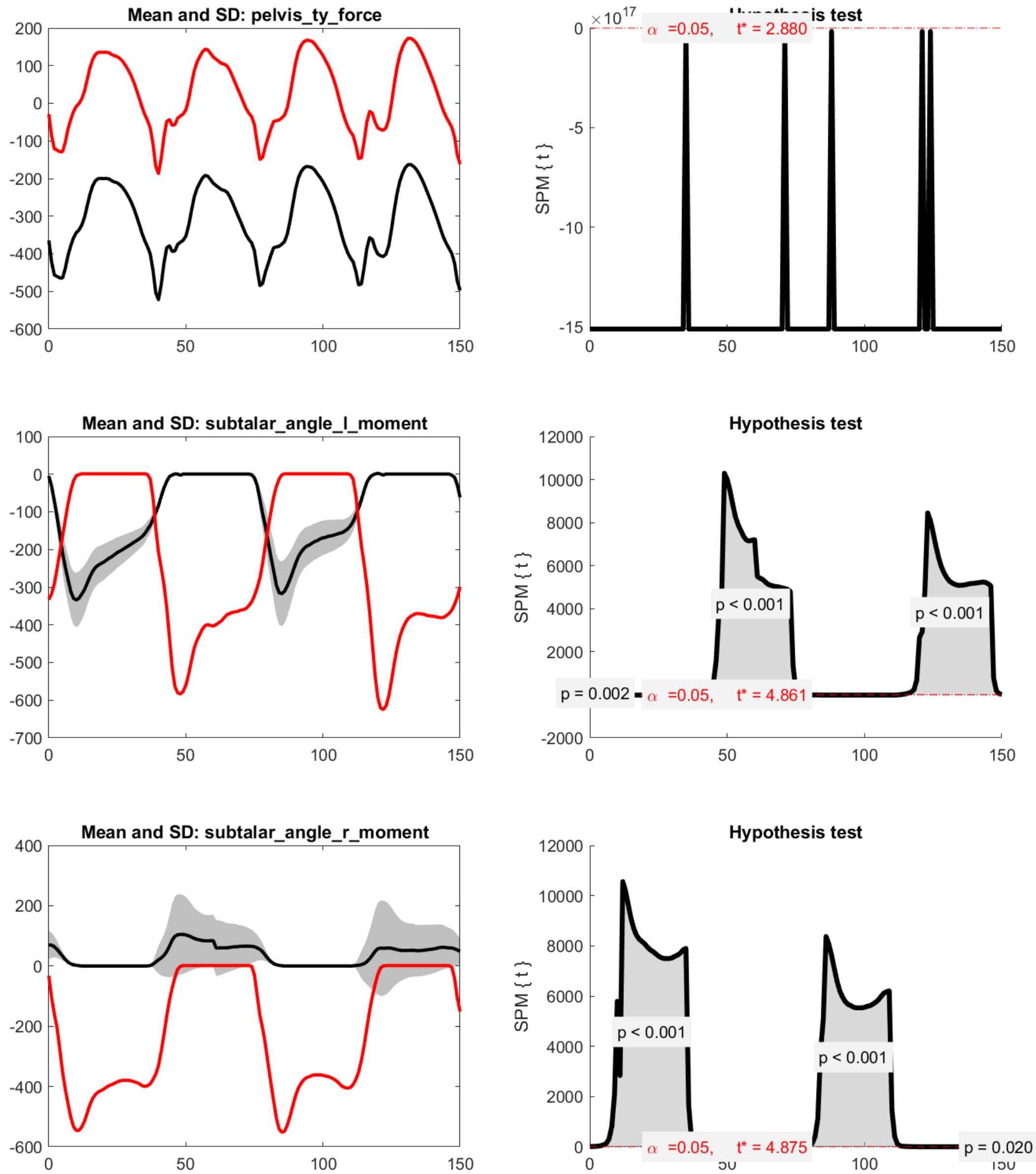


Figure 5.5. Comparison of the MCPFC (Black/Grey) group with the Baseline group (Red) for the standard suite of joint moments and angles. Statistically significant differences were observed for nearly all joint moments and angles.

Figure 5.5 presents biomechanical variables (joint angles and joint moments) estimated for the sagittal plane during walking, between the baseline dataset and the MCPFC group. Average joint angles are presented considering angles equal to zero for the static standing pose. Figure 5.6 outlines the mean and standard deviation for all joint forces.

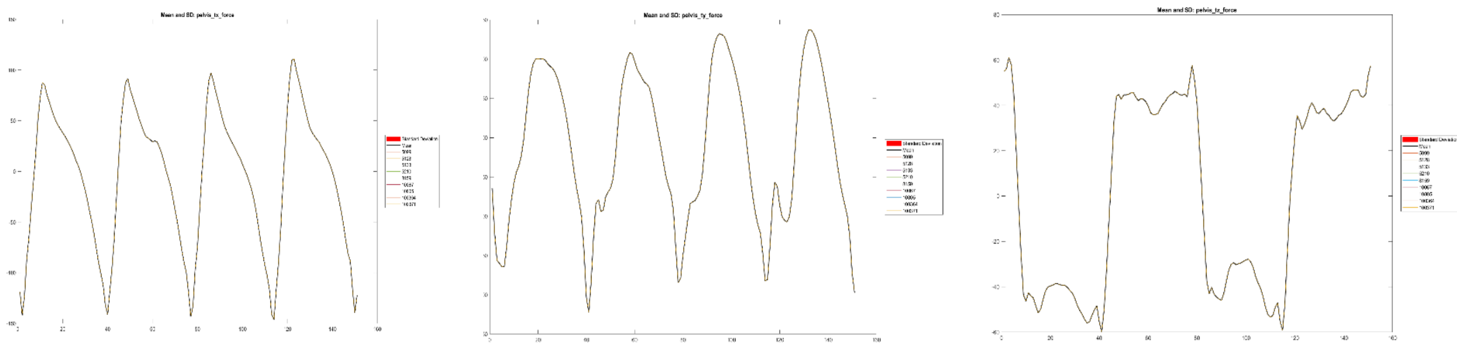
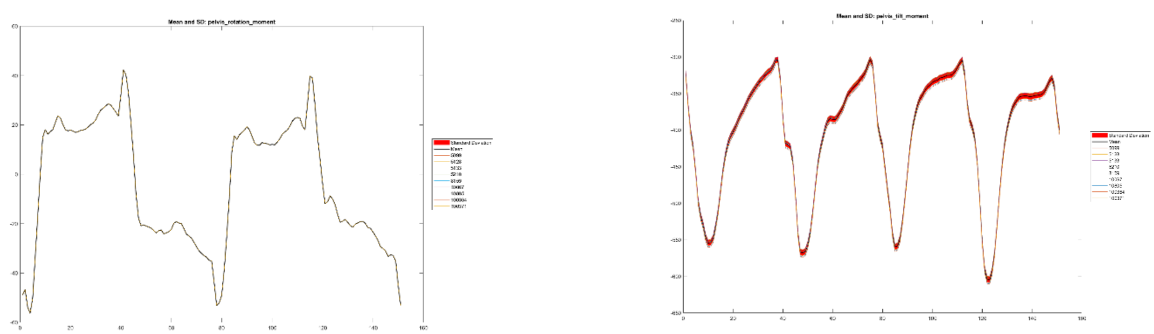
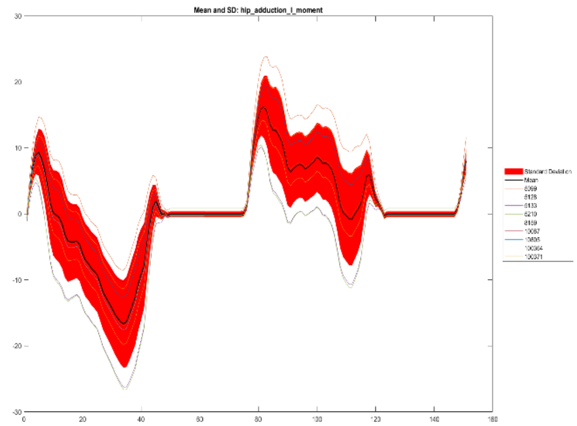
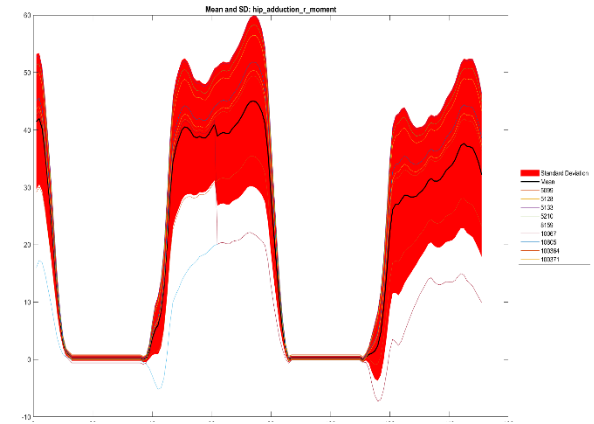


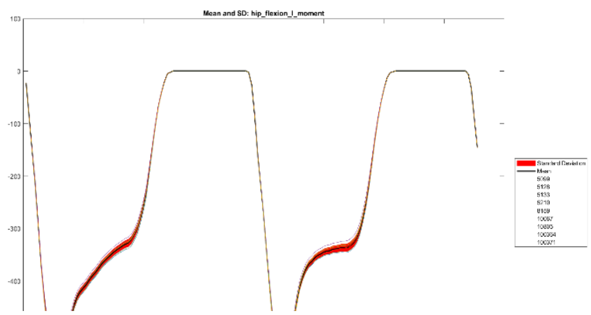
Figure 5.6. Mean and standard deviation for all joint forces.

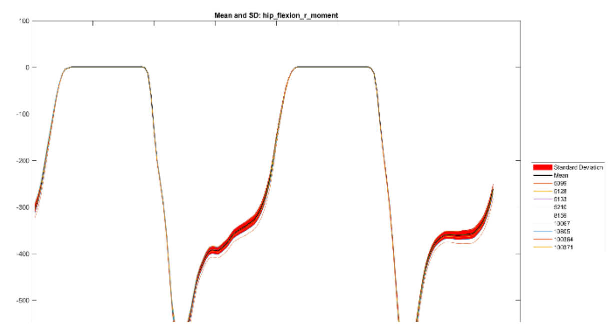
Figure 5.7 outlines the moment distributions for the control dataset and the MCPFC dataset.

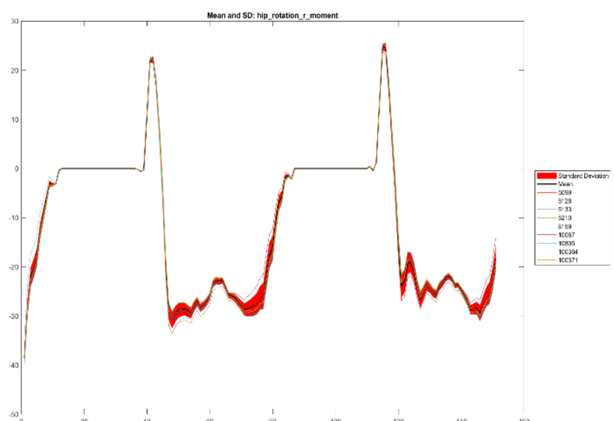



Mean and SD: hip_adduction_l_moment


Mean and SD: hip_adduction_r_moment


Mean and SD: hip_flexion_l_moment


Mean and SD: hip_flexion_r_moment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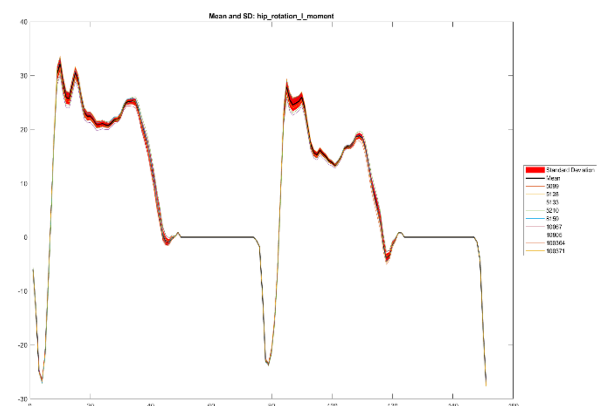
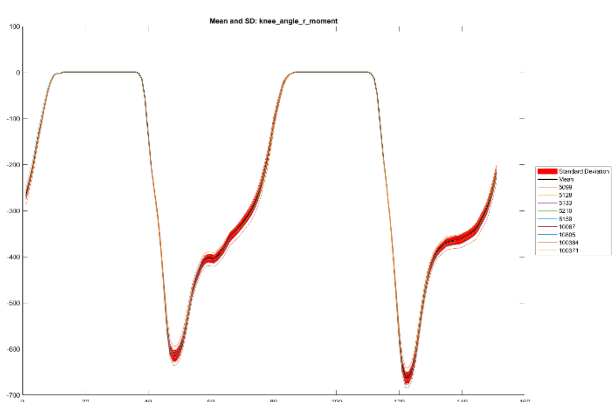
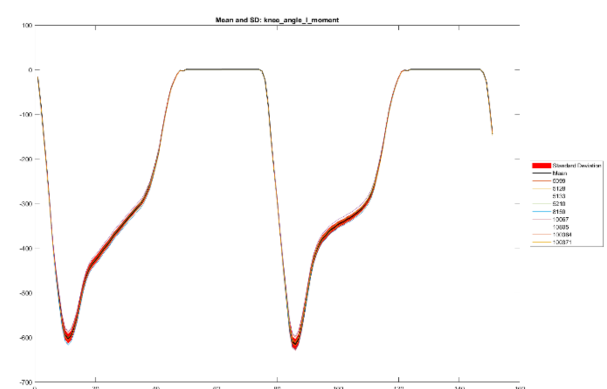

Mean and SD: hip_rotation_l_moment


Mean and SD: knee_angle_r_moment


Mean and SD: knee_angle_l_moment

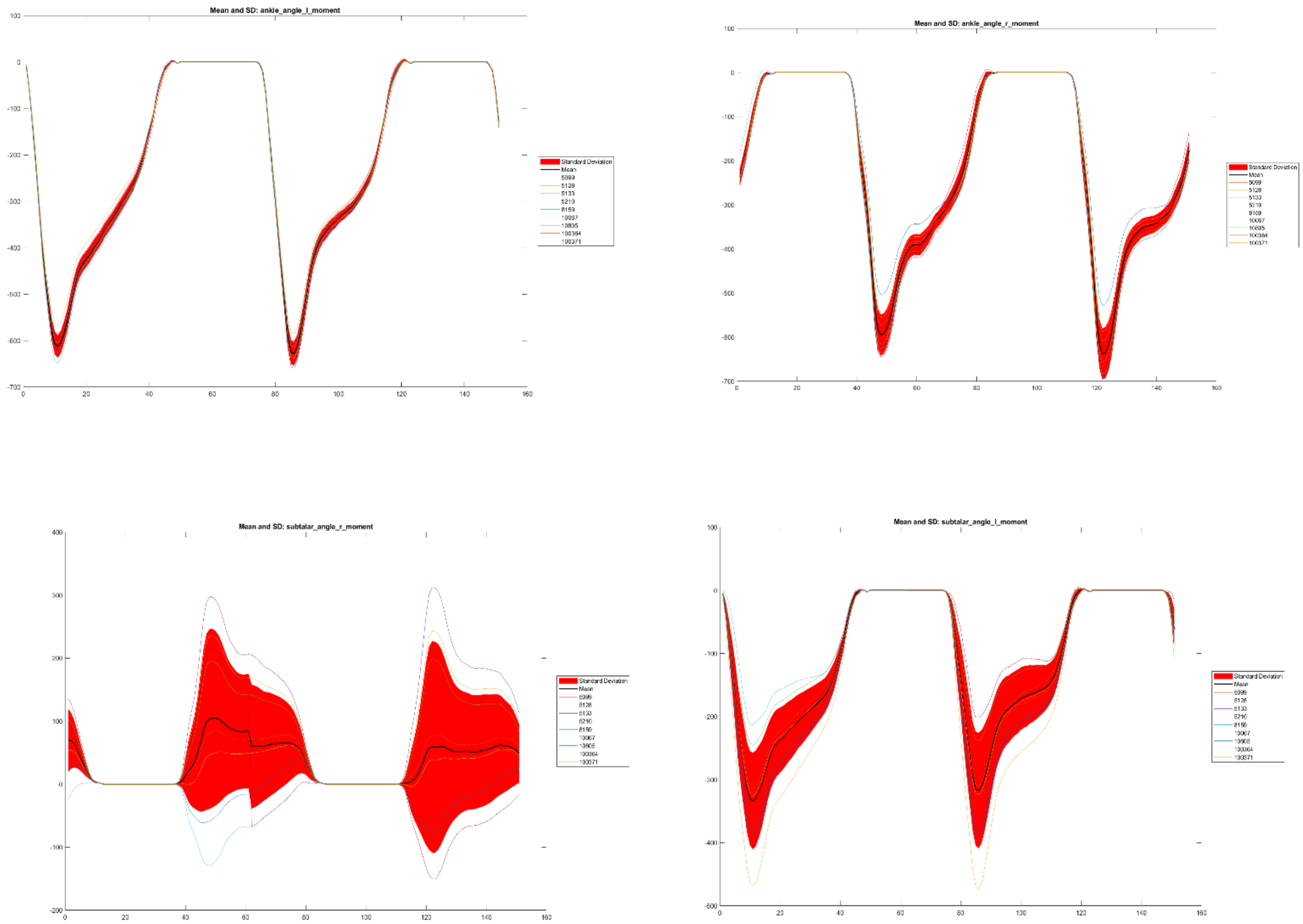


Figure 5.7. Moment distributions for the control dataset and the MCPFC dataset.

Joint moments and joint powers were normalized by body mass. Curves were obtained from walking strides of 9 individuals and 2 generalized OpenSim datasets. Complete results, including pelvis kinematics and non-sagittal degrees of freedom, are available in Appendix C.

Individualized Results

The following sections contain detailed results for each individual in the study. The data are reported in this way to maintain focus on individualized experience and to explicate sample lots associated with existing putative identifications and any additional putative identifications made as a result of this study. Freire (2017:137) discusses putative identifications within the context of the MCPFC Project: "With regard to putative identifications, that is a re-association of an individual skeleton and their associated grave goods with a name." In the same way Freire conceptualizes strontium isotope signatures as one component in a chain of evidence leading to putative identifications, the personalized MSK Models in this project are considered bolstering elements of identification research rather than singular identifiers. In addition, one individual was included in the study, despite fair-to-poor preservation, to test the limits of the personalized MSK method. Though this individual was not able to have gait analyzed in the present study, a skeletal assessment was still conducted, and fragment reconstruction software is improving; further research will be possible with this individual. Table 5.4 summarizes the supporting data for putative identifications or potential putative identifications made during this research.

Table 5.4. Summary of individual profile evidence.

Burial Lot Number	**Name**	**Agreement between MSK Modeling Results and Skeletal Characteristics**	**Agreement between MSK Modeling/ Osteology and Historical Documentation**	**Age**	**Sex**	**Material Culture**	**Archaeological Data**	**Register of Burial**	**Hospital Intake Records**
5099	Carl Mahnke	✓	✓	✓	✓			✓	✓
5128	Mary Henke	✓	✓	✓	✓	✓	✓	✓	✓
5133	Emma Hall	✓	✓	✓	✓			✓	✓
5210	James Hannon	✓	✓	✓	✓			✓	✓
8159		✓							
10067		✓							
10364		✓							
10371		✓	/✓			✓	✓		

10372		✓							
10805		✓							

Burial *Lot: 5099*

Putative ID: Carl Mahnke

The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a probable male of European ancestry. An age range of old adult was estimated for this individual based on cranial suture closure. Stature was estimated to be 66.17 ± 2.5 inches by the left femur and tibia.

An endocranial lesion was observed on the right frontal bone. The C2 and C3 vertebrae were ankylosed. Hyperostosis was observed on the left acetabular rim, and osteophytic lipping was observed on the joint surfaces of the right scapula, humerus, radius, and ulna. Eburnation and degeneration were observed on the joint surfaces of the humerus, radius, and ulna. Periostitis was observed on the sternal end of a rib and the left leg. Two healed rib fractures were observed. A biplanar craniotomy was observed. Hyperostosis on right hip is consistent with femoroacetabular impingement. In some cases, FAI causes impairment significant enough to seek hospital treatment even in exigent circumstances. Support for this can be found in the Milwaukee County Hospital register, where each diagnosis is entered, along with the individual's residence and occupation. Though a statistical analysis of the Milwaukee County Hospital records is a topic for future research, preliminary examination suggests that CH was primarily frequented by individuals that would fit the category of 'community poor' (Richards et al. 2016).

Table 5.5 summarizes the contextual data for individual 5099, and Table 5.6 summarizes the osteological and documentary health data relevant to individual 5099.

Table 5.5. Contextual data for individual 5099.

Lot Number	Name	Age at Death RB	Mean Osteolog-ical Age	Date ofDeath	Causeof Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
5099	Mahnke, Carl	72.00	39.4	12/1/1924	Diabetes Mellitus	CH	IV	P	12/03/1924

Table 5.6. Osteological and documentary health observations for individual 5099

Skeletal	Documentary
Edentulous	Diabetes Mellitus (RBMCPFC 12/3/1924)
C2 C3 Ankylosis	
Endocranial Lesion	
Joint degeneration	
Femoroacetabular impingement	
Craniotomy	

Figure 5.8 includes the gait simulation film for individual 5099 and Figure 5.9 compares the hip sagittal plane moments between individual 5099 and a symptomatic group Samaan et al 2017). Peak forces for individual 5099 are comparable to those of the symptomatic group.

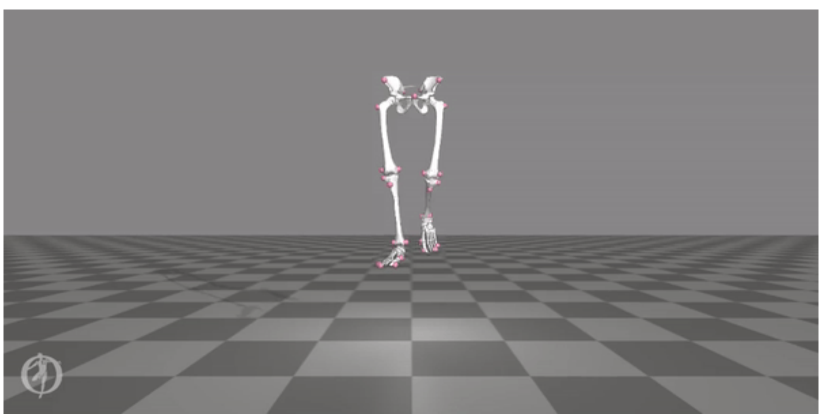


Figure 5.8. Gait simulation film for individual 5099

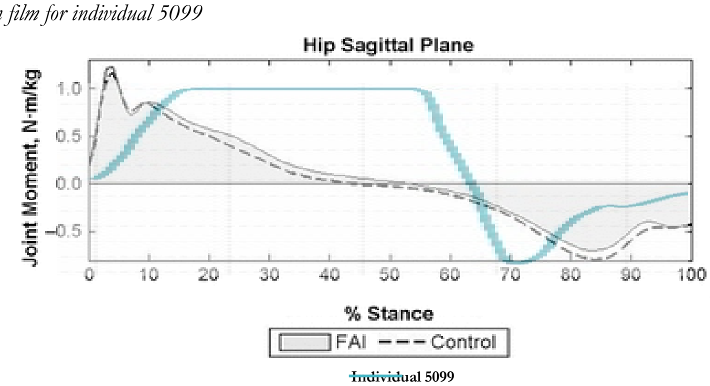


Figure 5.9. Joint moments in the sagittal plane during the stance phase of gait for the femoroacetabular impingement (FAI) and control cohorts,with individual 5099 superimposed adapted with permission from (Samaan et al. 2017).

Gait Observation Results: Joint moments in the sagittal plane during the stance phase of gait for the femoroacetabular impingement (FAI) and control cohorts, with individual 5099 superimposed (adapted with permission from Samaan et al. 2017). Pelvic, knee, and ankle joint contact forces are consistent with FAI. Lower hip contact forces in theanterior (median = 2.7, IQR = 238 2.2–3.9 N/BW), superior (median = 3.7, IQR = 3.5–4.2N/BW), and medial directions (median = 239 0.5, IQR = 0.3–0.6 N/BW) during contralateral foot-strike, resulting in peak force at the anterosuperior aspect of the acetabulum, consistent with the skeletal assessment of FAI. In addition, heel drop was observed, which may be due to decreased power at hip adduction.

Health Assessment: The skeletal and documentary conditions observed for this individual strengthen the RBMCPFC cause of death and therefore the putative ID. These conditions include tooth loss, endocranial lesions, cam-type femoroacetabular impingement, and vertebral ankylosis, which are all comorbidities of diabetes mellitus. Femoroacetabular impingement (FAI) is a condition in which the femoral head and acetabulum have hypertrophic osseous growth which gives the bones an irregular shape. Because they do not fit together perfectly, the bones rub against each other during movement. Over time this friction can damage the joint, causing pain and limiting activity. (Parvizi et al. 2007) The most common side effect of FAI is stiffness, pain, and reduced range of motion, which may have created a limp for this individual, or other externally observable factors (Samaan et al. 2017).

Putative ID Strengthening Characteristics: Individual 5099 exhibited skeletal characteristics consistent with some of the primary comorbidities of Diabetes Mellitus, including premature tooth loss, endocranial lesions, arthropathy, and vertebral ankylosis. In addition, the periostitis observed on the left leg may be consistent with gangrene. These conditions correspond to listed causes of death by County Hospital and on the Milwaukee County Death Certificate. These points of evidence combined with the anthroposcopic, osteological, and spatial data suggest a strong putative identification of individual 5099 as Carl Mahnke.

Burial Lot: 5128

Putative ID: Mary Henke

The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a female of European ancestry. An age range of old adult was estimated for this individual based on the auricular surface and cranial suture closure. Stature was estimated to be 63.27 ± 2.3 inches. Osteophytic lipping was observed on the right and left femora and tibiae, as well as the right and left metacarpals. A button osteoma was observed on the right of the frontal bone. Periostitis was observed on the distal shaft of the right femur. Table 5.7 illustrates the contextual data for individual 5128, including multiple documentary diagnoses.Table 5.8 compares the osteological and documentary health indicators for individual 5128.

Table 5.7. Contextual data for individual 5128.

Lot Number	Name	Age at Death	Mean Ost.Age	Date of Death	Cause of Death Milwaukee County DC	Cause of Death Milwaukee County Coroner	Place of Death	Residence Category (Per Richards et al. 2016)	Date of Burial
5128	Mary Henke	Mean age: 53.1/Recorded Age:	53.1	07/12/1924	Cirrhosis of liver/myocardial insufficiency	Perhases ofliver (fatty)	County Hospital	IV	7/30/1924

Table 5.8. Osteological and documentary health observations for individual 5128.

Skeletal	Documentary
Periostitis	Gall Stones (MCH Register, 7/11/1924)
Osteoarthritis (2nd and 3rd ray hands; knees)	Cirrhosis of the liver (RBMCPFC, 7/14/2-1924)
Premature dental loss (Mean Age: 53.1)	Perhases of liver (fatty) (Coroner's Office)

Gait Observation Results: Figure 5.10 illustrates the walking gait for this individual with increased joint moments for individual 5128 at stance phase (Force curves visible in figures 5.11 and 5.12). These forces are highly associated with knee osteoarthritis**.** Figure 5.12 provides joint moments for individual 5128, illustrating increased forces during stance phase, associated with osteoarthritis. illustrates the increased knee angle moment for individual 5128 over expected arthritic knee moments (Wilson et al. 2017). In addition, a slight increase in Q angle may point to sheer forces responsible for increased OA observed at the lateral margins of the tibia plateau.

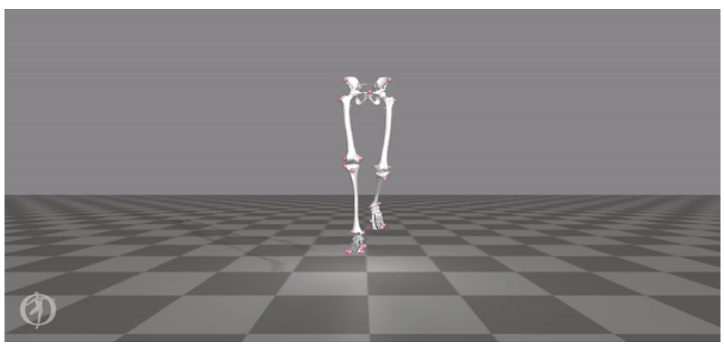


Figure 5.10. Gait simulation film for individual 5128

Figure 5.11 illustrates the increased knee angle moment for individual 5128 which exceeds that of baseline OA patient data (Wilson et al. 2017).

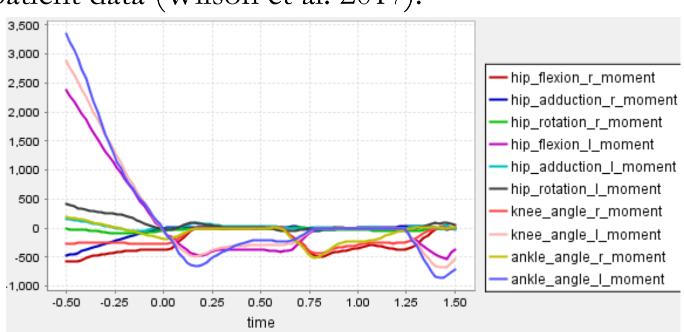


Figure 5.11. Joint moments for individual 5128, illustrating increased forces during stance phase, associated with osteoarthritis.

Health Condition Assessment: The skeletal conditions observed for this individual, including osteoarthritis of the second and third ray of the left and right hand, joint contact forces consistent with knee OA, and premature dental loss are suggestive of untreated hemochromatosis, particularly when paired with the MCH diagnosis of gallstones and the RBMCPF and CI cause of death of cirrhosis of the liver. Figure 5.12 illustrates the increased knee angle moment for individual 5128 over expected arthritic knee moments (Wilson et al. 2017). Osteoarthritis causes pain and limits movement but is a slowly accumulating disorder (Wilson et al. 2017). If associated with an autoimmune disorder the pain from OA may have been attributed to other factors. Though it is likely that OA would have influenced this individual's day to day life, it is less likely that this would be externally observed.

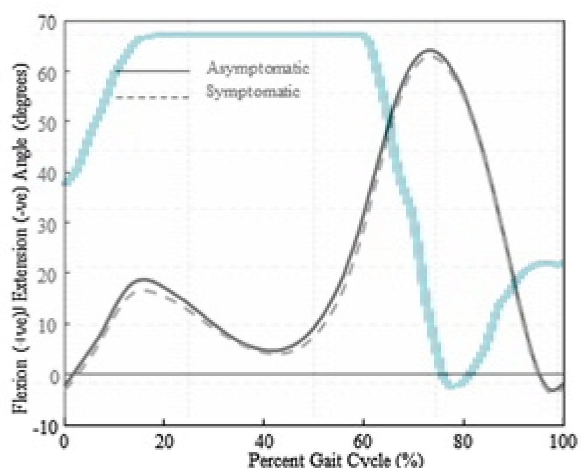


Figure 5.12. Individual 5128 curves of knee flexion angles and three-dimensional knee moments during gait. Mean group waveforms of the asymptomatic (solid lines), symptomatic (dashed lines) groups and Individual 5128 with KL grades of 2 or greater are shown for the knee flexion angle over entire gait cycle. Adapted with permission from Wilson et al. 2017.

Complementing the gait and osteological data is the documentary data about individual Mary Henke, which indicates that she likely had a multietiological condition, hemochromatosis in this case supported by the multiple diagnoses at the hospital and by the coroner near the time of death (Beaton and Adams 2006; Brissot et al. 2011; Grabhorn et al.

2006; Salgia and Brown 2015). In addition, the County Hospital diagnosis of gallstones just prior to a diagnosis of cirrhosis of the liver supports the assessment that Mary Henke may have been suffering from hemochromatosis rather than simple cirrhosis of the liver.

Confirming this mutietiolgoical condition enables us to tie osteological data to documentary data, improving the putative identification made for Mary Henke. Table 5.9 represents the transcribed hospital intake records information for Mary Henke, while a copy of the hospitalintake record can be examined in Figure 5.13.

Table 5.9. Transcribed hospital intake records for Mary Henke.

Admitted	Name	Residence	Age	Diagnosis	Date of discharge	Condition when discharged	Notify
7/11/1924	Henke, Mary	515 Chestnut St.	44	Gallstones	7/12/24	Died	Chas Henke

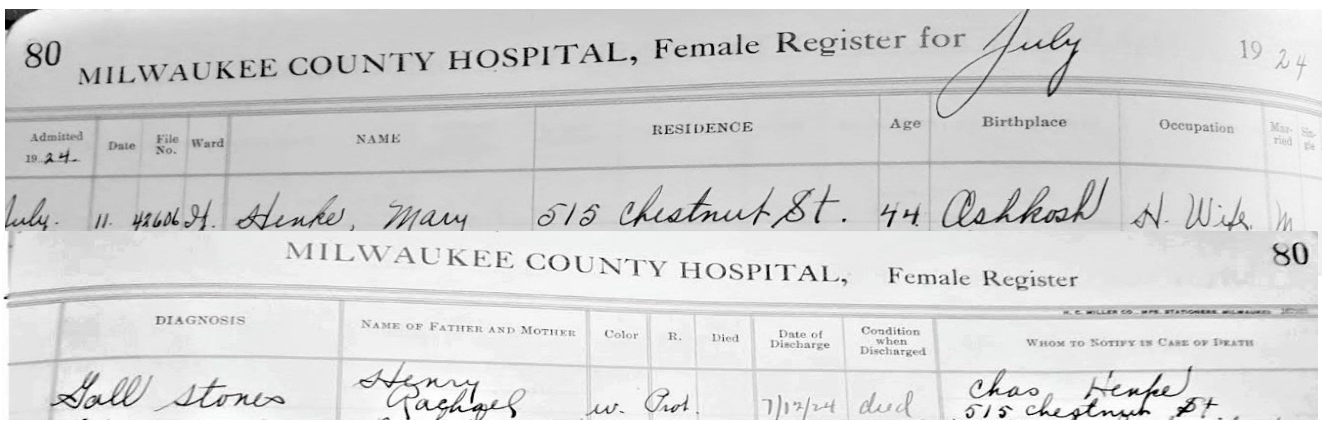


Figure 5.13. Milwaukee County Hospital intake records for Mary Henke, July 11, 1924. Photo, Jessica Skinner, on file at the University of Wisconsin Milwaukee ARL.

Putative ID Strengthening Characteristics: The skeletal characteristics of this individual are indicative of common comorbidities with hemochromatosis and consquently, liver dysfunction. In concert with these health conditions, the MCH diagnosis of gallstones and the RBMCPF and Coroner cause of death of cirrhosis of the liver, as well as the osteological, anthroposcopic, material culture, and spatial data support the assertion that the individual in Lot 5128 represents Mary Henke.

Burial Lot: 5133

Putative ID: Emma Hall

The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a female of European ancestry. An age range of old adult was estimated for this individual based on the pubic symphysis and cranial suture closure. Stature was estimated to be 58.80 ± 2.3 inches. Ankylosis was observed between the right and left sacroiliac joints. Osteophytic lipping was observed on the ribs, right scapula, cervical vertebrae, thoracic vertebrae, right radius, right ulna, and right foot. Exostoses were observed on the right ulna, left os coxae, left femur, left tibia, and calcanei. Healed fractures to two left ribs, the right radius, and left navicular were observed. Table 5.10 illustrates the contextual data for individual 5133. Table 5.11 compares the osteological and documentary health indicators for individual 5133.

Table 5.10. Contextual data for individual 5133.

Lot Number	Name	Age at Death	Mean Ost.Age	Date of Death	Cause of Death Milwaukee County DC	Cause of Death Milwaukee County Coroner	Place of Death	Residence Category (Per Richards et al. 2016)	Date of Burial
5133	Emma Hall	52	52.6	07/12/1924	Gallstones in common duct	NA	County Hospital	IV	7/30/1924

Table 5.11. Osteological and documentary health observations for individual 5133.

Skeletal	Documentary
Healed Fractures	Gall Stones
SI fusion	
Osteoarthritis	

Figures 5.15 and 5.16 represent gait data for individual 5033. Figure 5.15 shows knee moments comparable to current clinical data for osteoarthritis.

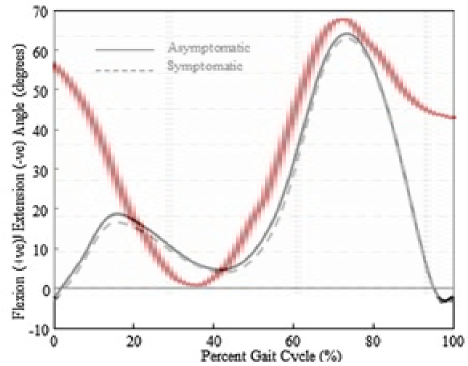


Figure 5.15. Individual 5133 curves of knee flexion angles and three-dimensional knee moments during gait. Mean group waveforms of the asymptomatic (solid lines), symptomatic (dashed lines) groups and Individual 5133 with KL grades of 2 or greater are shown for the knee flexion angle over entire gait cycle. Adaptedwith permission from Wilson et al. 2017.

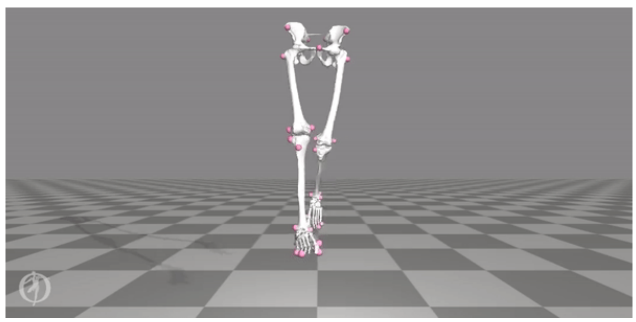


Figure 5.16. Gait simulation film for individual 5133

Putative ID Strengthening Characteristics: Though musculoskeletal changes are not one of the comorbidities associated with gallstones, they are associated with health conditions that are predisposing factors for gallstones, such as Hemochromatosis, Chron's, and IBS (Beaton and Adams 2006; Generini 2004). Individual 5133 exhibited skeletal characteristics consistent with some of the primary comorbidities of gut-affecting autoimmune disorders, including osteoarthritis and fusion of the sacroiliac joint. These points of evidence combined with the anthroposcopic, osteological, and spatial data, including an average osteological age very close to the documented age of Emma Hall, suggest a moderate to strong putative identification of individual 5099 as Emma Hall.

Burial Lot: 5210

Putative ID: James Hannon

The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a male of European ancestry. An age range of middle adult was estimated for this individual based on the pubic symphysis, auricular surface, and cranial suture closure. Stature was estimated to be 65.50 ± 2.5 inches.

Ankylosis of the sacrococcygeal joint was observed. Osteolytic pits were observed onthe right and left proximal humeri. Irregular fusion of the C6 and C7 was observed. A rib neoplasm was observed. Exostoses were observed on the proximal and distal right tibia and the distal left tibia. Periostitis was observed on the proximal right femoral shaft and the proximal left fibula shaft. Tables 5.12 and 5.13 illustrate contextual and health data for individual 5210. Figure 5.17 illustrates the simulated gait for individual 5210.

Table 5.12. Contextual data for individual 5210.

Lot Number	Name	Age at Death	Mean Osteological Age	Date ofDeath	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
5210	James Hannon	65	40.15	04/04/1925	Lobar Pneumonia	CH	IV	MC	04/24/1925

Table 5.13. Osteological and documentary health observations for individual 5210.

Skeletal	Documentary
Exostoses	Pneumonia
Periostitis	

Gait Observation Results: Figure 5.18 contains a comparison of 5210 with baseline gait data for pelvic tilt,pelvic list, and pelvic rotation. Moments for 5210 are slightly elevated but within normal range. Individual 5210 also exhibited varus knee alignment. At present it is not possible to create an association based solely on gait data.

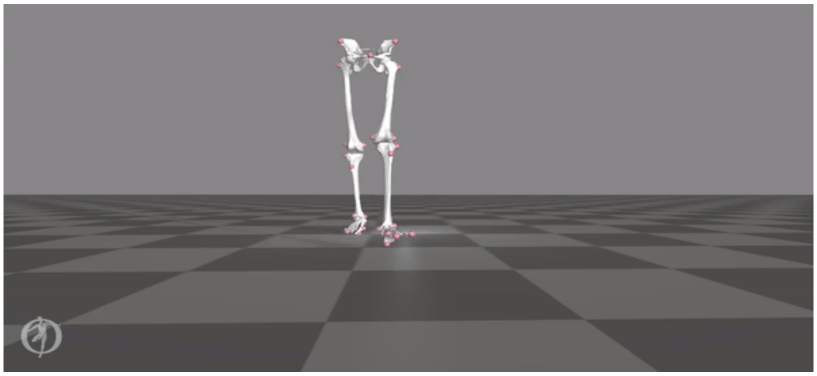


Figure 5.17. Gait simulation film for individual 5210

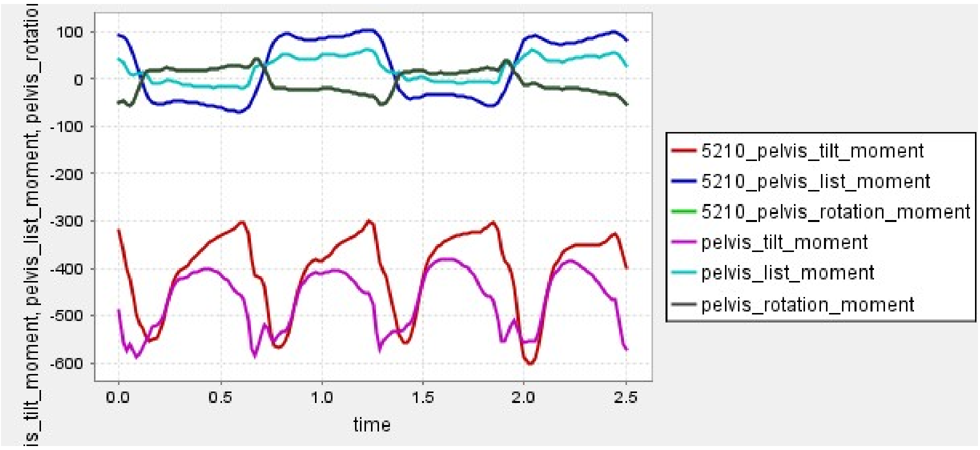


Figure 5.17. Comparison of 5210 with baseline gait data for pelvic tilt, pelvic list, and pelvic rotation. Moments for 5210 are slightly elevated but within normal range.

Possible Health Condition Assessment: Irregular fusion of the C6 and C7 as well as a potential leg infection may point to prior medical treatment. However, it is apparent from the gait analysis and from skeletal data that this individual would not have strikingly altered gait, unless the periosteal infection was causing enough pain to cause a limp, which may have comprised the character of this individual's gait.

Putative ID Strengthening Characteristics: Osteological infections, which can be associated with respiratory infections, coupled with age and sex data, support the putative identification of individual 5210 as James Hannon.

Burial Lot: 8159

Putative ID: In Process

The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a male of European ancestry. An age range of old adult was estimated for this individual based on the auricular surface and cranial suture closure. Stature was estimated to be 67.97 ± 2.8 inches. Endocranial lesions were observed on the frontal and occipital bones. Ankylosis and degeneration was observed on the C3 and C4. Osteophytic lipping was observed on the T5-L5, right and left femora and tibiae, as well as the right and left metacarpals. Periostitis was observed on the distal shafts of the right and left femora. Reactive bone growth was observed on the right hand. Eburnation was observed on theright and left first metatarsal. Schmorl's nodes were observed on the T3-L1 vertebrae. Table 5.14 shows contextual data for individual 8159.

Table 5.14. Contextual data for individual 8159.

Lot Number	Name	Age at Death	Mean Osteological Age	Date of Death	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
8159	-	-	53.1	-	-	-	I	-	-

Possible Health Condition Assessment: Evidence of infection and reactive bone growth may indicate an infection severe enough to cause the individual to seek medical treatment. In addition, MSK analysis indicates this individual may have sought orthotics to correct gait. Table 5.15 shows osteological and documentary health data for individual 8159.

Table 5.15. Osteological and documentary health observations for individual 8159.

Skeletal	Documentary
Infection	Orthotic advertisements from the time period
Reactive Growth	
Irregular gait mechanics	

Figure 5.18 illustrates the gait simulation for individual 8159.

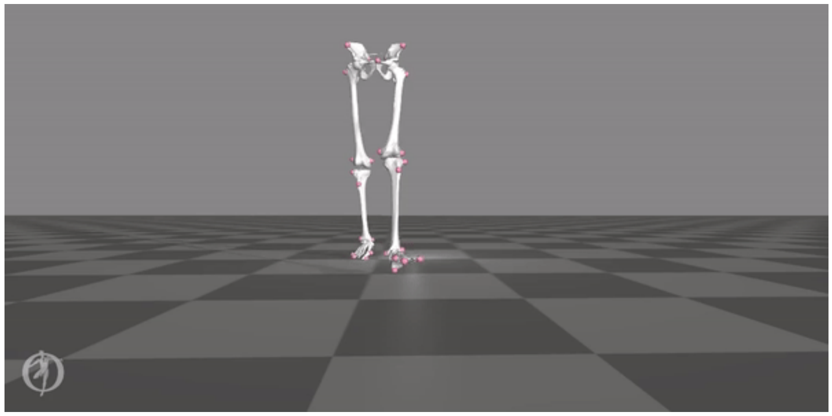


Figure 5.18. Gait simulation film for individual 8159

Gait Observation Results: Individual 8159 exhibits slightly elevated hip rotation moments. There are a number of conditions that may cause this elevation, from femoral torsion, which was observed on a previous project (Brennaman and Skinner 2018), to ankle eversion, two conditions which though they affect gait, may not have required medical intervention. This individual did exhibit a small degree of internal rotation of the hip and knee, which would cause minor difficulty walking and may have been an area suggested by doctors for treatment with orthotics. However, socioeconomic status and the level of rotation existing at this individual's age suggest that this individual did not seek orthotics potentially because they did not have the medical resources for orthotics or because they didn't seem needed. Further investigation is required for this individual. Figure 5.19 illustrates the curve comparison between individual 8159 and the control group.

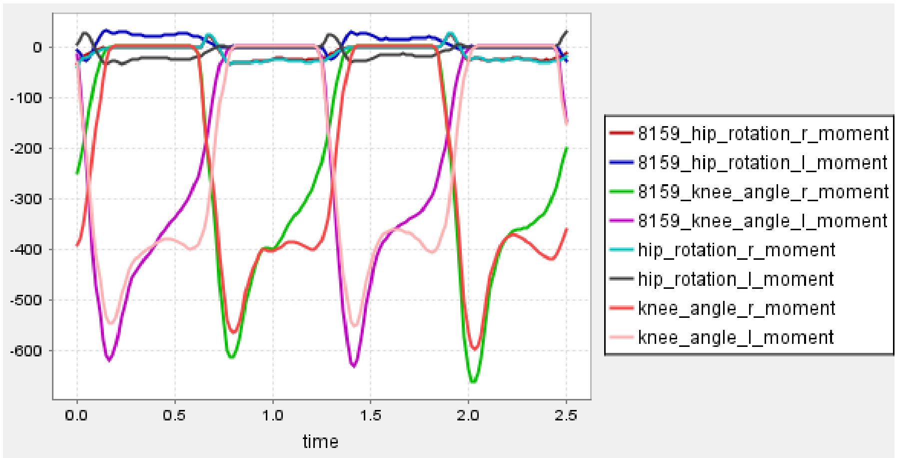


Figure 5.19. Curve comparison of individual 8159 and baseline data. Slightly elevated hip rotational moments observed.

Putative ID Strengthening Characteristics: The skeletal indicators of infection and slightly altered gait, coupled with the spatial data of this burial may contribute to future identification of this individual.

Burial Lot: 10067

Putative ID: In Process

The sexually dimorphic nonmetric and metric characteristics of this individual indicated aprobable female. An age range of young adult was estimated for this individual based on cranial suture closure. Stature was not observable for this individual.

Eburnation was observed on the distal left femur. Schmorl's nodes were observed in the thoracic and lumber vertebrae. Osteophytic lipping was evident in the thoracic and lumbar vertebrae, and on the distal right ulna. Degenerative joint disease was present on left distal femur, left patella, and left proximal tibia. Periostitis was visible on the shafts of the tibiae. Table 5.16 contains contextual data for individual 10067.

Table 5.16. Contextual data for individual 10067.

Lot Number	Name	Age at Death	Mean Osteological Age	Date of Death	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
10067	-		31.25	-	-	-	IV	-	-

Possible Health Condition Assessment: Degeneration of the left knee may have beensevere enough for medical intervention. Periostitis on tibiae suggests infection. Table 5.17 details the health characteristics for individual 10067. Figure 5.20 includes the gait simulation for individual 10067.

Table 5.17. Osteological and documentary health observations for individual 10067.

Skeletal	Documentary
Periostitis	
Osteoarthritis/DJD (knees)	
Schmorl's nodes	

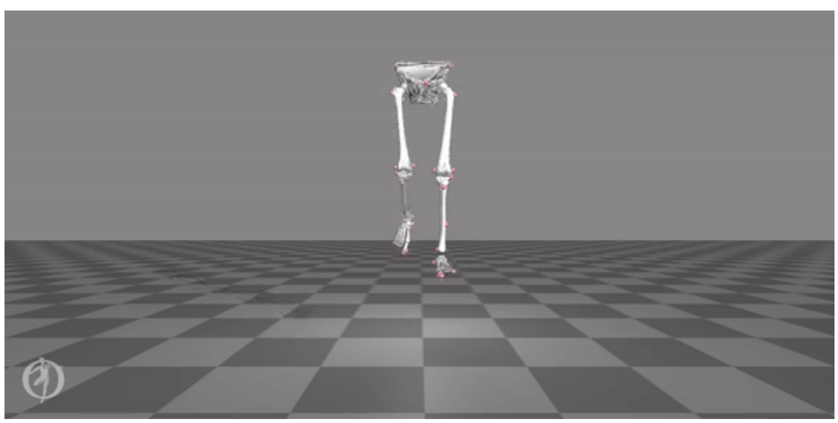


Figure 5.20. Gait simulation film for individual 10067

Gait Observation Results: Figure 5.21 visualizes the fiber-length vs knee angle and muscle moment vs joint angle for individual 10067, illustrating the constraints of the personalized skeletal model on the hill-type muscle model system.

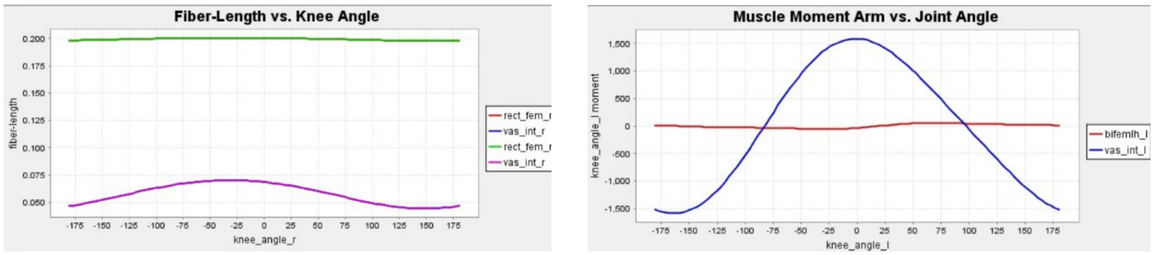


Figure 5.21. Fiber-length vs knee angle and muscle moment vs joint angle for individual 10067, illustrating the constraints of the personalized skeletal model on the hill-type muscle model system.

Figure 5.22 shows joint moments for individual 10067, illustrating increased forces during stance phase, associated with osteoarthritis. The evidence of increased knee angle moment for individual 10067 over expected arthritic knee moments (Wilson et al. 2017). Figure 5.22 illustrates the increased knee angle moment for individual 10067 which exceeds that of baseline OA patient data (Wilson et al. 2017) In addition, this individual exhibited tibial and talar version on the left foot.

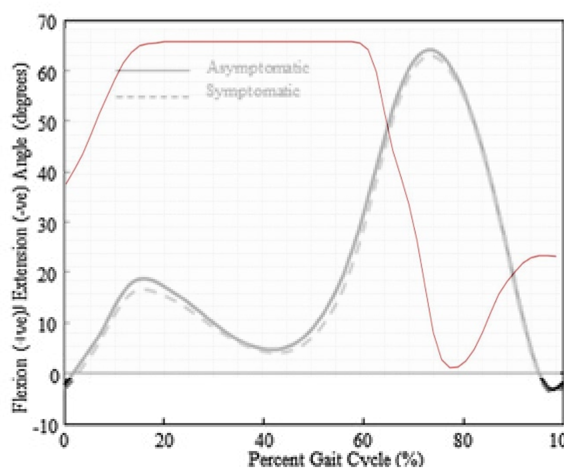


Figure 5.22. Individual 10067 curves of knee flexion angles and three-dimensional knee moments during gait. Mean group waveforms of the asymptomatic (solid lines), symptomatic (dashed lines) groups and Individual 10067 with KL grades of 2 or greater are shown for the knee flexion angle over entire gait cycle. Adapted with permission from Wilson et al. 2017.

Possible Health Condition Assessment: The skeletal conditions observed for this individual, including eburnation of the distal left femur, degenerative joint disease on the leftdistal femur, left patella, left proximal tibia, and periostitis on the shafts of the tibiae, combined with the increased joint moments for this individual illustrate advanced osteoarthritis. This is a progressive condition and may have been attributed to age, occupational degeneration and other life characteristics. It is likely that this individual needed assistance of a cane or other medical device and would have had a distinctive walk within their community.

Burial Lot: 10364

Putative ID: In Process

The sexually dimorphic nonmetric and metric characteristics of this individual indicated a male. An age range of middle adult was estimated for this individual based on the condition of the pubic symphysis, condition of the auricular surface, and cranial suture closure. Staturewas estimated to be 67.09 $\pm$ 2.8 in. from the right tibia.

Hypertrophic osseous growth was observed on the right medial clavicle, left medial clavicle, right superior and inferior innominate, left inferior innominate, left proximal femur, and in the right foot. Lytic lesions were visible cranially on the right parietal and in the cervical vertebrae. Ankylosis was noted between the second medial and proximal phalanges of the right foot. Eburnation was visible between the first metatarsal and first proximal phalanx of the right foot. Schmorl's nodes were visible in the thoracic vertebrae. Osteophytic lipping was observed throughout the vertebrae, as well as on two ribs, the right proximal ulna, the left proximal and distal ulna, the right radial tubercle, in the right hand, the acetabulum of the right innominate, the acetabulum of the left innominate, the right proximal femur, the left proximal femur, the left proximal tibia, and in the right foot.

Degenerative joint disease was noted in the right and left hip joints. Table 5.18 contains contextual data for individual 10364.

Table 5.18. Contextual data for individual 10364.

Lot Number	Name	Age at Death	Mean Osteological Age	Date of Death	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
10364	-	-	45.65	-	-	-	I	-	-

Possible Health Condition Assessment: Widespread hypertrophic growth and degenerative joint disease, osteophytic lipping, and eburnation, as well as schmorl's nodesand systemic arthrosis suggest that this individual may have been dealing with an autoimmune condition. The severity of some OA degeneration may have necessitated treatment or hospitalization. No surgical intervention observed. Table 5.19 outlines skeletal health data for individual 10364. Figure 5.23 includes the gait simulation for individual 10364.

Table 5.19. Osteological and documentary health observations for individual 10364.

Skeletal	Documentary
Hypertrophic Growth	
Lytic Lesions	
Osteophytic Lipping	
Degeneration	
Schmorls	
Eburnation	
Ankylosis	

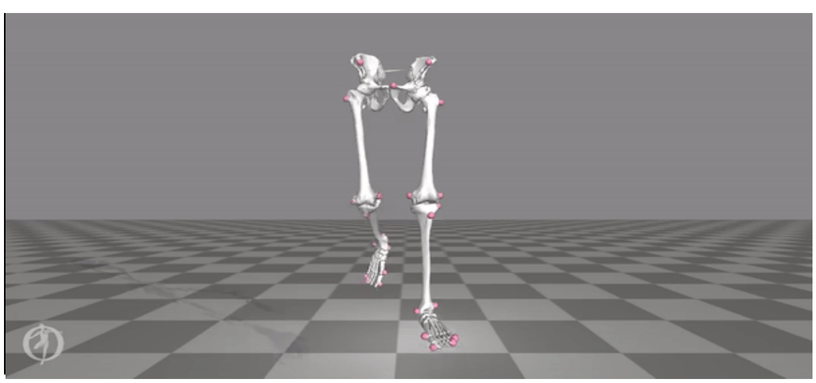


Figure 5.23. Gait simulation film for individual 10364

Gait Observation Results: Figure 5.24 includes a curve comparison of individual 10364 and baseline data for hip rotation, and knee angle moment. Elevated hip rotational moments observed.

Ankylosis and femoroacetabular impingement particularly affected hip kinematics. In addition, gait film reveals stiffness at the hip and decreased hip adduction.

The most common side effect of FAI is stiffness, pain, and reduced range of motion, which may have created a limp for this individual, or other externally observable factors (Samaan et al. 2017)

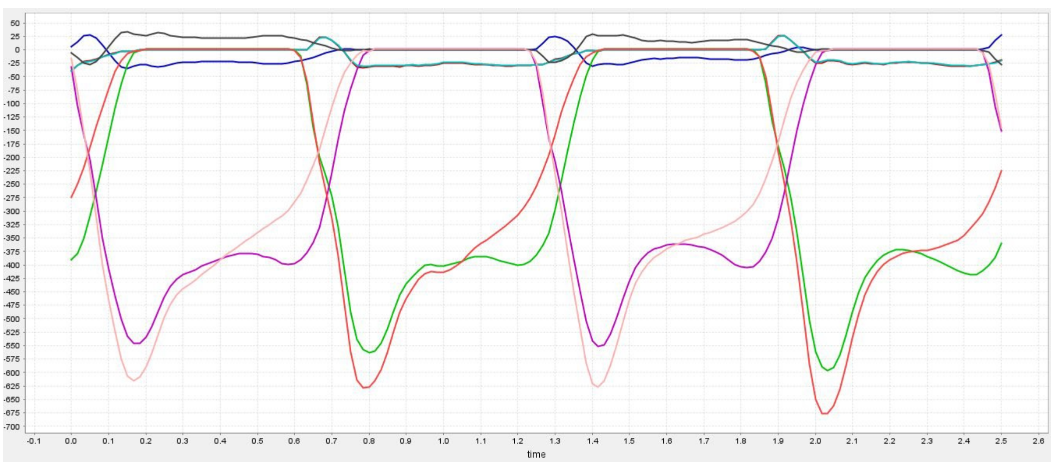


Figure 5.24. Curve comparison of individual 10364 and baseline data for hip rotation, and knee angle moment. Elevated hip rotational moments observed.

Putative ID Strengthening Characteristics: The systemic osteological infection, coupled withspatial data, may help strengthen identification in the future.

Burial Lot: 10371

Putative ID: In Process

The sexually dimorphic nonmetric and metric characteristics of this individual indicated a probable male. An age range of middle adult was estimated for this individual based on the condition of the pubic symphyses, condition of the auricular surface, and cranial suture closure. Stature was estimated to be 66.67 ± 2.5 in. from the right femur and left tibia lengths.

Lytic lesions were observed on the left talus. Irregular fusion of the left maxilla, left zygomatic, and frontal bone was observed cranially. Osteophytic lipping was evident on the glenoid fossae of the right and left scapulae, right proximal humerus, left distal humerus, right proximal ulna, left proximal ulna, left proximal radius, in both hands, in the ribs, and on the left distal femur, the right distal femur, and on both patellae. Heavy wear was observed in the right temporomandibular joint. Healed fractures to the right parietal, right patella, and left distal femoral shaft were observed. Two fractured halves of the right patella were sutured together with pure silver suture wire. Table 5.20 includes contextual data for individual 10371.

Table 5.20. Contextual data for individual 10371.

Lot Number	Name	Age at Death	Mean Osteological Age	Date of Death	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
10371	-	-	43.5	-	-	-	I	-	-

Possible Health Condition Assessment: Evidence of professional surgery represented by patellar sutures. The misaligned displaced fracture of the left femur would have had an extensive healing time.

Historical Health Observations: Medical supply catalogues were used to additionally refine the date through an examination of materials and styles available. As reported in medical literature (Axford 1888; Corner 1898; Lister 1883; Phemister 1915) and supply catalogues, stainless steel-, silver-, and silver-plated wire for suturing was widely available at this time butwere not necessarily inexpensive.

Cemetery spatial data contributes to a date refinement for this individual as well. Lot 10371has a Type I coffin handle (of indeterminate date) but is directly adjacent to coffins with Type II handles that date 1887-1920 (Burant 2020). The three closest coffins with datable material culture (one within the same row and two a row to the east) have earliest dates of burial as 1908 (10746), 1910 (10569), and 1912 (10466) (Burant 2020). A more detailed discussion of these temporal ranges can be found in Chapter 6. Table 5.21 outlines the osteological and documentary health observations for individual 10371. Figure 5.25 contains the gait analysis film for individual 10371.

Table 5.21. Osteological and documentary health observations for individual 10371.

Skeletal	Documentary
Patellar suturing	Patellar fractures were not sutured by wire until 1876. Pure silver wire was almost exclusively used from 1890-1935.
Healed displaced fracture on distal left femoral shaft	Silver wire was available and affordable in the medical supply catalogues most likely used by County Hospital.
Parietal fracture	

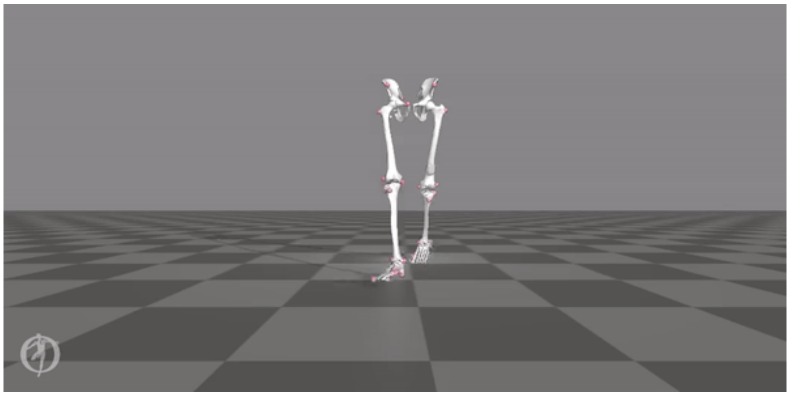


Figure 5.25. Gait simulation film for individual 10371

Gait Observation Results: Figure 5.26 provides a curve comparison of individual 10371 and baseline datafor hip rotation, and knee angle moment. Elevated hip rotational moments observed. Moregait trials will help refine a determination of the impact of patellar suturing on this individual's gait. Visual evidence reveals this person has severe tibial and talar version of the left leg. This would have created a distinctive walking pattern for this individual that likely limited movement and caused day-to-day impairment for this person.

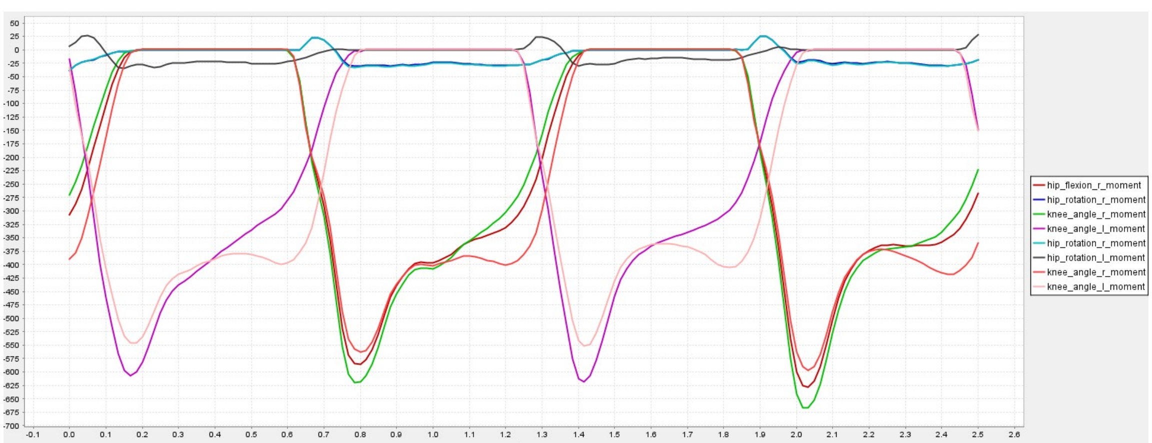


Figure 5.26. Curve comparison of individual 10371 and baseline data for hip rotation, and knee angle moment. Elevated hip rotational moments observed.

Possible Health Condition Assessment: The skeletal conditions observed for this individual, particularly the healed fractures and sutured patella, provide evidence for medical intervention at the hospital level. Expanded discussion of this assessment can be found in Chapter 6.

Putative ID Strengthening Characteristics: Patellar suture enabled refined date range and possible hospital intake record cross-reference. At present there are two candidates for this individual. Table 5.22 contains potential candidates for lot 10371 based on temporal range, hospitalintake records, and medical procedure documents.

Table 5.22. Potential candidates for lot 10371 based on temporal range, hospital intake records, and medical procedure documents.

Name Last	Name First	Diagnosis	Date of Admission	Date of Discharge
Van Hefe	August	Sore Knee	5/31/1913	9/13/1913
Kerom	George	Swollen Knee	5/29/1913	3/9/1914

Burial Lot: 10372

Putative ID: In Process

The sexually dimorphic nonmetric characteristics of this individual indicated a probable female. An age range of old adult was estimated for this individual based on the condition of the pubic symphyses and cranial suture closure. Stature was not observable for this individual.

Hypertrophic osseous growth was observed on the lateral clavicles, proximal right radius, distal femora, both patellae, in both hands, and in the cervical and lumbar vertebrae. Lytic lesions were observed endocranially, as well as exocranially on the right posterior parietal. The L5 vertebrae had collapsed. Eburnation was observed on the right distal ulna and radius, on the right distal femur, in both hands, and in the cervical and lumbar vertebrae. Osteophytic lipping was observed on the scapulae, left proximal ulna, right innominate, in both wrists, and throughout the ribs and vertebrae. Degenerative joint disease was observed in the cervical vertebrae. Osteomyelitis was observed on the left distal radius. Healed fractures to the left proximal humerus, left distal radius and 6 left ribs were observed. Table 5.23 contains contextual data for individual 10372.

Table 5.23. Contextual data for individual 10372.

Lot Number	Name	Age at Death	Mean Osteological Age	Date of Death	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
10372	-	-	50.9	-	-	-	I	-	-

Possible Health Condition Assessment: Cranial lesions, healed fractures, and osteomyelitismay have been severe enough to warrant hospital intervention. Table 5.24 contains osteological and documentary health observations for individual 10372. Figure 5.27 contains a placeholder for future gait assessment for individual 10372.

Table 5.24. Osteological and documentary health observations for individual 10372.

Skeletal	Documentary
Healed fractures	
Osteomyelitis	
Degenerative joint disease	

Figure 5.27. No gait simulation available for individual 10372

Gait Observation Results: This individual was included in the study, despite fair-to-poor preservation, to test the limits of the personalized MSK method. Though this individual was not able to have gait analyzed in the present study, fragment reconstruction software is improving, and further research will be possible with this individual.

Possible Health Condition Assessment: The skeletal conditions observed for this individual, including healed fractures, skeletal infection, and severe joint degeneration, provide strong evidence for potential hospitalization. Difficulty still exists correlating the injuries to the narrative in the hospital intake log.

Putative ID Strengthening Characteristics: Evidence of hospitalization and specificity of injuries will facilitate cross-reference in the hospital intake records. However, limitations still exist correlating the injuries to the narrative in the hospital intake log.

Burial Lot: 10805

Putative ID:

The sexually dimorphic nonmetric and metric characteristics of this individual indicated a female of European ancestry. An age range of middle adult was estimated for this individual based on the condition of the auricular surface and cranial suture closure. Stature was estimated to be 63.27 ± 2.3 inches from right femur and tibia.

Ankylosis was observed within the thoracic vertebrae, in the left sacroiliac joint, andin the right sacroiliac joint. Osteophytic lipping was observed on the left scapular glenoid fossa and the right scapular glenoid fossa. Exostosis was visible on the left distal fibula. Periostitis was evident on the distal left tibia shaft and the distal left fibula shaft. Neoplastic growth was observed on the left distal femur. Table 5.25 contains contextual data for individual 10805.

Table 5.25. Contextual data for individual 10805.

Lot Number	Name	Age at Death	Mean Osteological Age	Date of Death	Cause of Death	Place of Death	Residence Category (Per Richards et al. 2016)	Death Certificate issuer	Date of Burial
10805	-	42		-	-	-	I	-	-

Possible Health Condition Assessment: Neoplastic growth, periostitis, and ankylosis mayhave necessitated medical intervention. Table 5.26 contains osteological data for individual 10805. Figure 5.28 contains the gait film for individual 10805.

Table 5.26. Osteological and documentary health observations for individual 10805.

Skeletal	Documentary
Ankylosis	
Neoplastic growth	

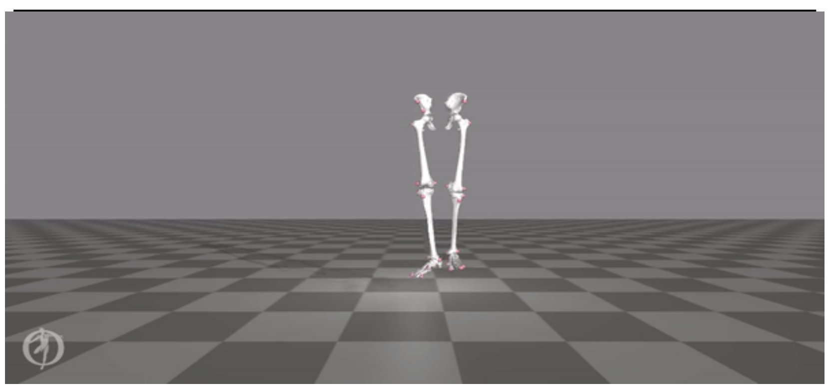


Figure 5.28. Gait simulation film for individual 10805

Gait assessment: Figure 5.29. Curve comparison of individual 10805 and baseline data for hiprotation, and knee angle moment. Elevated hip rotational moments observed. Ankylosis particularly affected hip kinematics. Increased anteversion is observed on the right tibia and talus. This would have resulted in limitations of movement from basic stiffness during walking to inability to sit in one place for long periods of time. This may have affected the individual's choice of employment and many other avenues in daily life. Figure 5.29 contains a curve comparison between individual 10805 and the baseline data.

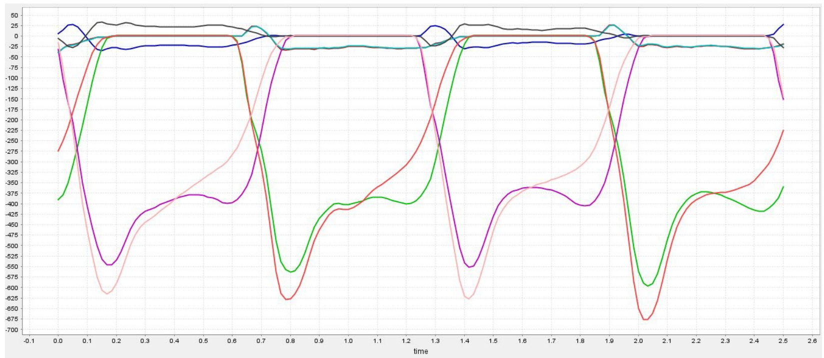


Figure 5.29. Curve comparison of individual 10805 and baseline data for hip rotation, and knee angle moment. Elevated hip rotational moments observed.

Putative ID Strengthening Characteristics: The skeletal characteristics, gait patterning,mortuary context, and spatial data may strengthen a future putative identification for this individual.

Results Summary

These results illustrate both the utility and limitations of this method. As mentioned previously, the method is time-consuming if done right, but several of the more technological components of the method can be automated, making this a potentially useful tool for CRM settings in addition to academic research. One limitation that was noted when conducting the gait assessments was a side-effect of using generic motion files for the individuals in the study. Several distinct generic motion trials were run, and the most neutral was selected for the study, but it was noted that each motion file had a slight but unexpected impact on the virtual gait of the individual. This has shaped the inverse dynamic results but at present this confounding feature is determined to be minimal since it was used for all individuals and still enabled comparison amongst the study cohort and against established datasets (for peak values). Additional research will be conducted to determine a method of simulating motion that does not create a confounding effect on the models. In some cases the gait simulations were exceptionally useful in narrowing potential hospitalization data

(Individuals 5099, 5128, 5133, 5210, 10371), but this component of the method would be strictly considered supporting evidence for individuals 8159,10067,10372, and 10805, rather than a means of opening a new avenue of research. This will enable future research to generate a workflow that narrows candidates for this type of analysis based on factors explored in this dissertation, including availability of hospital data, material culture, death certificates, and spatial data.

Chapter 6 : Discussion and Conclusions

Discussion of Individualized Results

The following sections contain detailed discussions of the results for each individual in the study. The previous chapter outlining the data with a focus on individualized experience requires additional reflection- now that we know these individuals so intimately from a bioarchaeological standpoint- who were they? How did they live and what experiences radiated from the skeletal conditions discussed previously?

Burial Lot: 5099
Putative ID: Carl Mahnke

Carl Mahnke (Individual 5099) exhibited skeletal characteristics consistent with some of the primary comorbidities of Diabetes Mellitus, including premature tooth loss, endocranial lesions, arthropathy, and vertebral ankylosis (McKittrick et al. 1949; Středa et al. 1971). The severe femoroacetabular impingement observed may or may not have been part of this cascade of symptoms. In addition, the periostitis observed on the left leg may be consistent with gangrene, also recorded in the Coroner's Report, and in extreme cases associated with the progression of diabetes(McKittrick et al. 1949). These symptoms and comorbidities likely had a profound impact on the day-to-day quality of life for this individual, with the lower-limb skeletal changes alone often resulting in reported increased pain during walking and standing tasks (Clarke et al. 1975; Westermann et al. 2017). However, this individual shows evidence of having remained active until very near his time of death, as illustrated by the robusticity of muscle attachments and overall bone density, which was visually observed to be within healthy range. In addition, it is possible that the

FAI observed for this individual remained asymptomatic for a time, decreasing the impact of that condition on daily life. It appears that this individual experienced challenging circumstances throughout his life but still engaged with that life fully.

Burial Lot: 5128
Putative ID: Mary Henke

The skeletal conditions observed for Mary Henke (Individual 5128), including osteoarthritis of the second and third ray of the left and right hand, joint contact forces consistent with knee OA, and premature dental loss are suggestive of untreated hemochromatosis, particularly when paired with the MCH diagnosis of gallstones and the RBMCPF and CI cause of death of cirrhosis of the liver. Complementing the gait and osteological data is the documentary data related to Mary Henke, which indicates that Mary likely had a multietiological condition, hemochromatosis in this case supported by the multiple diagnoses at the hospital and by the coroner near the time of her death, which included gallstones, cirrhosis of the liver, and 'perhasses of the liver'(Beaton and Adams 2006; Brissot et al. 2011; Grabhorn et al. 2006; Salgia and Brown 2015). Evidenced in the osteology for Individual 5128, osteoarthritis is a common comorbidity of untreated hemochromatosis, with fatigue and joint pain being two of the most highly reported symptoms of the condition (Brissot et al. 2011). It is likely that before her illness progressed far, Mary Henke's quality of life was not impacted greatly. However, eventually there may have been a gradual accumulation of symptoms followed by the acute abdominal pain which caused Mary Henke to seek hospital treatment.

Burial Lot: 5133

Putative ID: Emma Hall

Though musculoskeletal changes are not one of the comorbidities associated with gallstones, they are associated with health conditions that are predisposing factors for gallstones, such as Hemochromatosis, Chron's, and IBS (Beaton and Adams 2006; Generini 2004). Emma Hall (Individual 5133) exhibited skeletal characteristics consistent with some of the primary comorbidities of gut-affecting autoimmune disorders, including osteoarthritis and fusion of the sacroiliac joint. These diseases are often characterized by slow accumulation of symptoms rather than acute onset, so Emma Hall may have attributed these changes to age or other external issues. It is possible that these symptoms were viewed as natural part of aging to be put up with rather than investigated, resulting in hospital treatment being a last resort.

Burial Lot: 5210

Putative ID: James Hannon

James Hannon (Individual 5210) exhibited irregular fusion of the C6 and C7 as well as a leg infection which may point to prior necessity for medical treatment. Osteological infections of the vertebral column and ribs, which can be associated with respiratory infections, coupled with age and sex data, support the putative identification of individual 5210 as James Hannon. The documentary cause of death for James Hannon was Lobar Pneumonia, also known as non-segmental pneumonia or focal non-segmental pneumonia, which is a radiological pattern associated with homogeneous and fibrinosuppurative consolidation of one or more lobes of a lung in response to bacterial pneumonia (Gharib and Stern 2001; Little et al. 2014; Marston et al. 1997). Complications of lobar pneumonia can include pulmonary abscess, which can affect the ribs (Kumar et al. 2014), and some correlations have been drawn between respiratory symptoms and ankylosing spondylitis (Campbell and MacDonald 1965; Défalque and Hyder 1997; McCool and Benditt 2018). Respiratory conditions can be socially stressful particularly during the nineteenth century when some respiratory symptoms were not well documented and may not have yet had established association with other comorbidities. Further research is required to establish this, but it is possible that James Hannon visited County Hospital multiple times in relation to his respiratory disease. However, bone density and skeletal robusticity illustrate that it was unlikely that he was bedridden for an extended period of time prior to his final hospitalization.

Burial Lot: 8159
Putative ID: In Process

Individual 8159 exhibited potential symptoms of femoral and tibial version that may have contributed to altered gait mechanics (Brennaman and Skinner 2018). The gait analysis for this individual indicated a slight alteration in gait that may be associated with these skeletal characteristics. Due to the lack of footwear in the coffin and the lack of documentary data available at this time, it is difficult to determine if this individual received treatment for this condition, thereby reducing the ability to determine effect on daily life for this individual.

Burial Lot: 10067
Putative ID: In Process

The skeletal conditions observed for this individual, including eburnation of the distal left femur, degenerative joint disease on the left distal femur, left patella, left proximal tibia, and periostitis on the shafts of the tibiae, combined with the increased joint moments for this individual illustrate advanced osteoarthritis. Further research is needed to determine possible comorbidities through documentary analysis as this individual could not yet be correlated to an individual name in the RBMPFC. However, it is possible to hypothesize that this individual suffered from an autoimmune or genetic disorder due to the advanced symptoms exhibited on the remains compared to the relatively young age of the individual.

Burial Lot: 10364
Putative ID: In Process

Widespread hypertrophic growth and degenerative joint disease, osteophytic lipping, and eburnation, as well as Schmorl's nodes and systemic arthrosis suggest that this individual may have been dealing with an autoimmune condition. The severity of some OA degeneration may have necessitated treatment or hospitalization, but no surgical intervention was observed. This individual was relatively young for such an advanced state of degeneration (middle adult), so it is possible that these skeletal conditions represent a lifelong struggle with health. However, the overall condition of skeletal elements seems to indicate that this person was at least ambulatory for the majority of their life.

Burial Lot: 10371
Potential Putative IDs: August Van Hefe, George Kerom

Silver patellar sutures enabled a refined date range and possible hospital intake record cross-reference for this individual. At present there are two candidates for this individual, based on temporal range, hospital intake records, and medical procedure documents. Each of these individuals engaged in a prolonged stay at County Hospital after admission for a knee injury, Van Hefe for three months, George Kerom for nearly a year. Additional research is needed, as perhaps a better match for this individual would be found in a person admitted to county hospital for a broken right knee and broken left leg, though unfortunately at this time we do not have the ability to know definitively if those injuries took place at the same time. Figure 6.1 shows August Van Hefe's entry in the Milwaukee County Hospital Male Register.

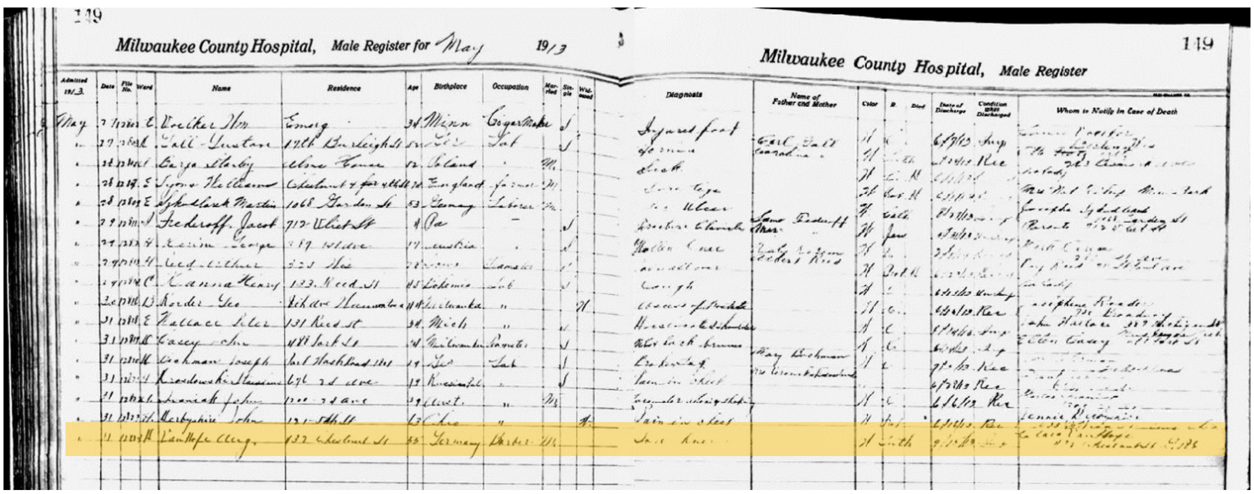


Figure 6.1. August Van Hefe's entry in the Milwaukee County Hospital Male Register, 1913.

Overall, it was clear that this individual remained active despite these injuries, though the heterotrophic ossification of the right patellar ligaments resulting from surgery would have caused pain and changed the knee moment due to the lengthening of the patellar moment arm (Modenese et al. 2018; O'Brien et al. 2012). Table 6.1 illustrates the name candidates for individual 10371.

Table 6.1. Potential candidates for lot 10371 based on temporal range, hospital intake records, and medical procedure documents.

Name Last	Name First	Diagnosis	Date of Admission	Date of Discharge
Van Hefe	August	Sore Knee	5/31/1913	9/13/1913
Kerom	George	Swollen Knee	5/29/1913	3/9/1914

Burial Lot: 10372
Putative ID: In Process

The skeletal conditions observed for this individual, including healed fractures, skeletal infection, and severe joint degeneration, provide strong evidence for potential hospitalization. Difficulty still exists correlating the injuries to the narrative in the hospital intake log. However, it will likely be possible to putatively identify this individual and thereby gain more information about their individual experience once a putative identification of individual 10371 is made.

Burial Lot: 10805
Putative ID: In Process

Individual 10805 exhibited elevated hip rotational moments and elevated knee angle moments. It appears that ankylosis, which was observed within the thoracic vertebrae, in the left sacroiliac joint, and in the right sacroiliac joint, particularly affected hip kinematics. The neoplastic growth, osteoarthritis, and exostoses observed appear to indicate systemic infection or autoimmune disorder. This type of disorder would have a profound impact on the individual's daily life, and from the gait simulation it appears likely that the gait alterations caused by the ankylosis and osteoarthritis would have been visible to outsiders. At present, no documentary evidence exists to expand the scope of our understanding of this individual's experience, but this will likely be possible soon with increased digitization of hospital and cemetery records.

Integration of Archaeological Data and Medical Data

Bioarchaeological databases are often created from studies with archaeological collections used to categorize and represent different types of illness and injury. Larsen

(1997:108) stresses that though there is an abundance of skeletal injury data in the osteological literature, there is a sparseness of population perspective as well as a difficulty ascribing a mechanism of skeletal damage in these cases. This includes specific causes of known injury as well as methods to distinguish trauma from taphonomy (Larsen 1997:109). This approach has created a somewhat flawed database of injury mechanism within bioarchaeology, as several studies (Merbs 1983; Owens 2007; Shermis 1984) used in the compilation of these databases did not fully consider the cascade of physiological effects that occur during musculoskeletal injury.

In addition, within a historical research context, understanding clinical practices of the time also enables a more robust contextualization of these injuries. This dissertation is characterized partially by the methodological framework of pathoetiology (as defined by physical therapy professionals, orthopedic surgeons, and kinesiology professionals) to integrate modern kinesiology, orthopedics, and historical clinical practice with bioarchaeological analysis.

This integration is examined more deeply for two individuals from the selected study cohort to evaluate the efficacy and difficulties of engaging with clinical approaches to bolster the analysis of musculoskeletal injury of individuals buried in the Milwaukee County Poor Farm Cemetery.

Pathoetiology of Musculoskeletal Injury and Bioarchaeological Analysis

Pathoetiology of musculoskeletal injury is the study of the underlying causes of musculoskeletal pathology, including the disordered physiological processes associated with the disease or injury, risk factors, and mechanism of injury. In a modern medical context, this study is most often undertaken by physicians, physical therapists, and surgeons in a clinical setting. The understanding of the presentation and processes associated with musculoskeletal disease and injury is key to diagnoses and treatment plans in these settings. Though not all modern clinical kinesiology studies apply to archaeological contexts (for instance, high-speed vehicular crashes were not common prior to the nineteenth century), there are several analogous conditions for which new techniques in kinesiology can expand understanding of musculoskeletal injury in archaeological remains, particularly during the historic period. These improved analytic techniques will contribute our understanding of conditions manifested skeletally on the body and can in turn aid in creating robust osteobiographies which center on a holistic representation of personhood and life experience.

Many pathophysiological reactions leave permanent markers on human bone, but it is often the case that many different conditions may cause the reactions visible to the osteologist during skeletal analysis. For that reason, understanding and applying the mechanisms of each injury or pathology to analysis of what is visible in a bioarchaeological context. A thorough knowledge of these pathologies will also improve our understanding of the mechanisms behind entheseal change or other skeletal changes, since these are often multietiological.

Healed Fractures: Mechanism of Injury, Healing Processes, and Fracture Non-Union

Examples of medical treatment, or lack thereof, of fractures for individuals from the MCPFC can provide further context for ideas about health and injury management during the late 19th and early 20th centuries. Modern orthopaedic literature can help demystify these practices as well as the underlying biological processes that create visible skeletal change and how these injuries may have been experienced by the individual that sustained them, while historical literature contextualizes the treatments and experiences of individuals going through treatment.

An example from an MCPFC individual not included in this study bears this out: One middle adult male (Lot 5014) had sustained several fractures to the left arm during life. These include the distal humerus, proximal radius, proximal and medial ulna, the scaphoid, and the first metacarpal. The medial ulna fracture sustained non-union, and the two halves of the bone created a pseudoarthrosis, or "false joint". Several complications of these fractures are also skeletally observable: osteophytic lipping, irregular bone remodeling, and exostoses are some of the examples (MCPFC Human Remains Analysis Paperwork: Skinner 2016).

Analysis within the context of the individual as whole and articulated (to the extent possible) soon provided a mechanism of injury: the cascade of fractures from the proximal hand all the way to the distal humerus is characteristic of a fall onto an outstretched hand. This is well-represented in clinical literature; Whiting and Zernicke (2008) cite outstretched hand falls as one of the leading causes of first metatarsal, scaphoid, and medial ulnar fractures, with the proximal radius and distal humerus often involved.

The non-union of the ulnar fracture and pseudoarthrosis raise the question of medical treatment. There are modern studies concerned with correcting non-union, which results from improperly aligned fractures, poor vascularity, and pressure on the fracture site (Whiting and Zernicke 2008). However, modern fractures rarely reach the point that the one sustained by this individual did, and this is where modern clinical research fails to assist with creating more complete profiles of injury and treatment during the historic period. Technology and treatment strategies have clearly improved to the point where some things are no longer analogous or available in the literature.

Historical literature gives some insight into the cause of this presentation: it is not a lack of technology or available treatment: advanced techniques for proper fixation and healing of fractures were well accepted even as early as 1868 (Callender 1868:144). "The non-union of fractures has been attributed to a great variety of causes, constitutional and local. Mr. Amesbury, however, remarks, "by far the most frequent cause of non-union that I have noticed is want of rest, in consequence of the inadequacy of the plans of treatment which have been employed. I consider this to have been the primary cause in almost all the cases I have examined" (Callender 1868:144). This and other studies (Marcy 1876; Senn 1893) illustrate that a possible cause of non-union for this individual was the inability to stop work to let a fracture heal. During the late 1800s, this was common, often leading to infection and early death (Poland 1870).

Medical Intervention: Current and Historical Practices

Current orthopedic literature is also useful in better understanding medical treatment visible in the archaeological record, as past practices have informed current ones. In addition, surgical adaptations over time evolved in response to the physiological reactions to treatment that may explain osteological conditions observed archaeologically. As discussed previously, individual 10371 (Figure 6.2) has the remains of metal sutures embedded in the right patella. Modern clinical research used in tandem with historical documentation or

Figure 6.2. Medical wiring visible in the patella of the individual from Lot 10371. Ossified tendon and reactive osseous growth are also visible. Adapted with permission from Richards et al. 2016:189.

surgical techniques assisted in creating a robust explanation of both the intervention and the osteological response to this intervention. In addition, analysis of the metal sutures provided a refined temporal range for this individual and contributed to refining temporality in the NW quadrant of the area of Cemetery 2. Figure 6.3 illustrates the distribution of temporally diagnostic burials and their dates relevant to individual 10371, according to Burant (2020).

The combined data from the medical history assessment and a temporal range established by Burant (2020) enabled a more concentrated search area within the intake register for individual 10371.

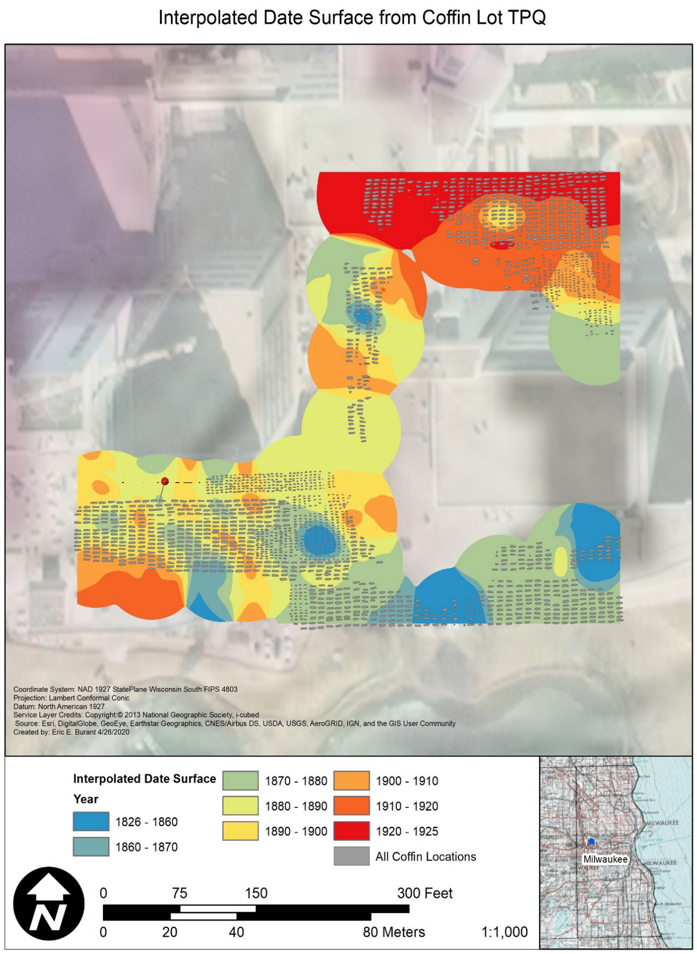
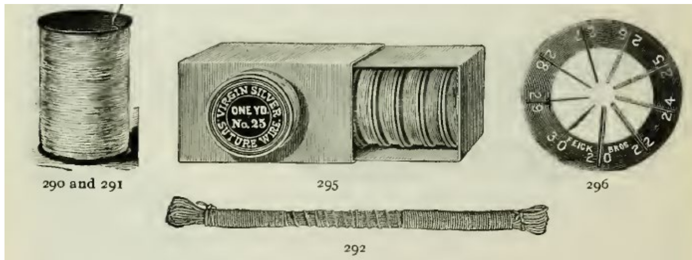


Figure 6.3. Interpolated date surface from coffin lot TPQ placing Burial 10371 within the context of a temporally diagnostic area of Cemetery 2 that corresponds to the interpolated date range of 1900-1910. Adapted with permission from Burant 2020

A portable X-Ray fluorescence analyzer was used to determine the composition of the metal used in the sutures with the assistance of Dr. John Richards and Dr. Patricia Richards. The sutures were found to be made of pure, unalloyed silver wire, which allowed refinement of the date via medical literature, since silver suturing was considered the only line of defense against transverse patellar fractures after 1910, all other methods having been discarded as too inflammatory or easily rejected by the body (Phemister 1915). Figure 6.4 illustrates the prevalence of pure silver wire in medical supply catalogues.



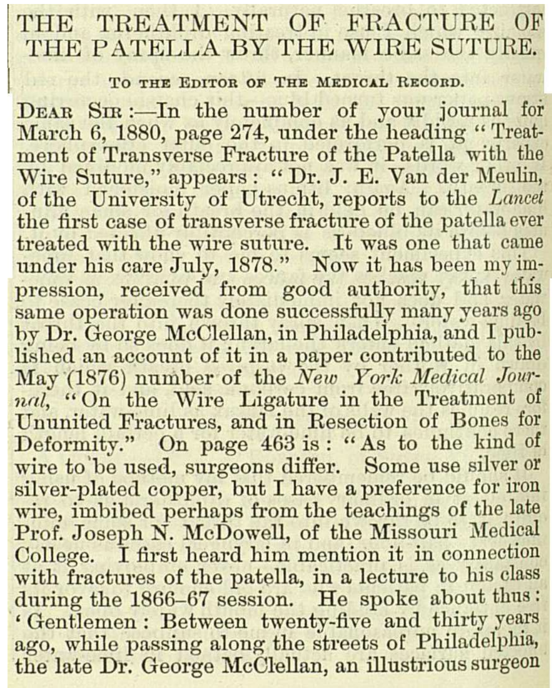
280.*	Silk, Twisted, White or Iron dyed, on reel, 14 sizes, per doz., 80c.; 3 for 25c.	each	$0 10
282.*	" " " " " 4 sizes on a tablet in slip case .	"	30
283.	" " " " " 3 sizes on glass spools in solution .	"	65
284.	" " " " " 1 size in Tank package with solution	"	75
286.*	" Braided " " " on reel, 14 sizes, per doz., $1 75 ;	"	18
287.*	" " " " " 4 sizes on a tablet in slip case	"	45
288.	" " " " " 3 sizes on glass spools in solution .	"	65
289.	" " " " " 1 size in Tank package with solution	"	75
290.*	" " " " " 14 sizes on half oz. spools . .	per ounce	2 50
291.*	" Twisted " " " 14 sizes on half oz. spools	"	1 50
292.*	" Cable Twist, White, 7 sizes, in skeins per doz., $1 75 ;	each	20
294.*	" Tait's genuine hand-made, White, 3 sizes, in skeins " 3 50 ;	"	35
295.*	Pure Silver Wire, for Suture, six 1-yard spools in box, assorted sizes . .	"	75
296.*	" " " " " all sizes, from 14 to 30 .	per ounce	2 25
	" " " " " per yard, No. 14, $2 25 ; No. 16, $1 50 ; No. 18		1 00
	" " " " " per 2-yard coils, No. 20, $1 20; No. 22, 70c.; No. 24		45
	" " " " " per 2-yard coils, No. 25, 40c.; No. 26, 30c.; No. 27		25
	" " " " " per 2-yard coils, No. 28, 25c.; No. 29, 20c.; No. 30		20
298.	Pure Gum Elastic Ligature, Nos. 3, 4, 5, 6 and 7, American scale . .	per yard	15

*All instruments illustrated are designated by a *.*

Figure 6.4. "Pure Silver Wire, for Suture, six 1-yard spools in box, assorted sizes." From the Whitehall Tatum 1904 Medical Supply Catalogue.

Medical supply catalogues were used to additionally refine the date through an examination of materials and styles available. As reported in medical literature (Axford 1888; Corner 1898; Lister 1883; Phemister 1915) and supply catalogues, silver and silver plated wire for suturing were widely available at this time but were not necessarily inexpensive, low cost generally being a prerequisite for use at County Hospital, according to County Hospital budgets (Proceedings of the Milwaukee County Board of Supervisors, 1922). Figure 6.5 outlines the earliest treatment with wire suture., which was used to establish a range for the procedure.

Historical medical publications also assisted in determining when the procedure may have taken place: surgeons were using heavy silk and fascial grafts to fixate fractured patellae



THE TREATMENT OF FRACTURE OF THE PATELLA BY THE WIRE SUTURE.

TO THE EDITOR OF THE MEDICAL RECORD.

DEAR SIR :—In the number of your journal for March 6, 1880, page 274, under the heading "Treatment of Transverse Fracture of the Patella with the Wire Suture," appears : "Dr. J. E. Van der Meulin, of the University of Utrecht, reports to the *Lancet* the first case of transverse fracture of the patella ever treated with the wire suture. It was one that came under his care July, 1878." Now it has been my impression, received from good authority, that this same operation was done successfully many years ago by Dr. George McClellan, in Philadelphia, and I published an account of it in a paper contributed to the May (1876) number of the *New York Medical Journal*, "On the Wire Ligature in the Treatment of Ununited Fractures, and in Resection of Bones for Deformity." On page 463 is : "As to the kind of wire to be used, surgeons differ. Some use silver or silver-plated copper, but I have a preference for iron wire, imbibed perhaps from the teachings of the late Prof. Joseph N. McDowell, of the Missouri Medical College. I first heard him mention it in connection with fractures of the patella, in a lecture to his class during the 1866–67 session. He spoke about thus : 'Gentlemen : Between twenty-five and thirty years ago, while passing along the streets of Philadelphia, the late Dr. George McClellan, an illustrious surgeon

Figure 6.5. Editorial note in the fall 1880 Medical Record attesting the earliest date of wire sutures used to treat transverse patellar fractures. Reproduced with permission from The Lancet.

as early as 1885 (Phemister 1915:4). Poland's 1870 treatise on patellar fractures outlines instances of internal fixation used but does not specify methods. Fowler's 1885 account of patella repair, as well as several others from 1880-1900 (Axford 1888; Hinton 1885; Lister 1883) pair well with Henry Marcy's 1876 account of a new method of patellar fracture treatment using wire, giving a range of approximately 1900-1920 for this particular intervention.

In other cases, where it is clearer how long the individual lived after treatment, this may even be a helpful method of refining temporal spans in different areas of the MCPFC. The lack of damage or reactive growth in the femoral and tibial condyles reported in the burial description for this individual could be misconstrued to mean that the individual did not survive long after treatment. However, the type of patellar injury suggested by the intervention (superficial, not disrupting the joint capsule: during this time fractures that disrupted the joint capsule often resulted in amputation) and the extent of tendon ossification suggest that gait forces were applied to the joint for some time after surgery.

Fowler (1885) describes the prevailing surgical treatment for a fractured patella in the early period of surgical intervention: "It was only after patient scraping and lifting away of the tissue, by means of the scalpel, that a clean bony surface was obtained for approximation to the lower fragments. I then drilled and wired together the two lower fragments; these were in their turn each wired to the large upper fragment" (Fowler 1885:246-247). This account not only explains the metal wiring in the patella, but also partially clarifies the reactive bone growth and heterotopic mineralization, or tendon ossification, visible for this individual. In fact, recent studies (McBryde 2009; O'Brien et al. 2012) illustrate that surgical tendon trauma is a significant motivator (up to 62% of Achilles tendon surgical intervention results in heterotopic mineralization) of heterotopic mineralization. "Increased levels of bone morphogenetic proteins (BMPs) have been identified in experimental models of tendon injury and in patients with rotator cuff tears" (O'Brien et al. 2012:3). This happens post-injury, as part of the physiologic cascade that occurs when cytokines, or members of the transforming growth factor beta family, are activated during the trauma process (O'Brien et al. 2012).

Discussion Summary

Integrating modern clinical studies and practices with bioarchaeological analysis is not a fool-proof process. In fact, the process of writing this dissertation made abundantly clear that while integrating data from modern clinical studies is useful, it cannot be properly done without the process of contextualizing this information using historical medical reports and clarifying archaeological data. In addition, modern clinical data is helpful for providing biomechanical and physiological information that can be applied to further our understanding of injuries, while historic documentation is most useful for determining likely treatments used as well as temporal contextualization. Future studies should also incorporate comparisons of contemporary population data collected by physicians, further discussion of access to medical care, and a biosocial examination of attitudes about health, injury, and the body during the late 19th and early 20th centuries.

Limitations of this Research

This method is time-consuming, but several of the more technological components of the method can be automated, making this a potentially useful tool for CRM settings in addition to academic research. One limitation that was noted when conducting the gait assessments was a side-effect of using generic motion files for the individuals in the study. Additional research will be conducted to determine a method of simulating motion that does not create a confounding effect on the models. This is not to say that archaeological gait simulations are useless or invalid-the gait simulations were exceptionally useful in narrowing potential hospitalization data (Individuals 5099, 5128, 5133, 5210, 10371), but this component of the method would be strictly considered supporting evidence for individuals 8159,10067,10372, and 10805. Future research will generate a workflow that narrows candidates for this type of analysis based on factors explored in this dissertation, including availability of hospital data, material culture, death certificates, and spatial data.

Benefits and Challenges of Holistic Analysis

The broader impact of this research extends beyond osteological education and the field of anthropology. In concert with the current push in modern medicine to consider multiple facets of an individual's life while conducting research and planning treatment (Campbell and Dave 2018; Houben-Wilke et al. 2017), this project argues not for the elimination of specialization, but for the enrichment of it, through models that integrate lived experience with biological realities.

As Kretchmar (2008) argues that "silos and bunkers" of specialized and general knowledge enrich the discipline of orthopedics, with the caveat that "Silos present practical problems related to fractionation, poor communication, and a lack of mutual respect," the emphasis on a holistic understanding of musculoskeletal movement in this dissertation serves additionally to underscore the necessity of interdisciplinary collaboration and "mutual respect". This mutual respect goes hand in hand with creating a tangible practice of respect for the individuals we research with and for.

This project encourages cross-disciplinary discussion and collaboration, as well as contributing to the current advances in both bioarchaeology and forensics, with potential benefits to modern medicine. In striving towards well-rounded research that encompasses personal experience and the impacts of health *beyond* the body, this project sheds light on the importance of holistic, personalized care, revealing what is lacking when an illness is treated or researched, instead of a whole person.

Beyond these benefits is the contribution to the growing discussion of bioethics, both pertaining to new technology and digital methods, as well as the discussion of public access and education in the sciences. Finally, with this research, we hope to facilitate the reclamation of humanity for those who were denied it, while offering up the "rite of incorporation" (Richards et al. 2016) that enables their transcendence of the subject-object barrier in scientific research, engaging with their agency both as the living and the "slightly alive" (Arnold 2014).

As mentioned previously, the time-consumptive nature of holistic analysis makes it a difficult choice for use in cultural resource management or other time-contingent applications, though the semi-automated nature of personalized MSK models makes the possibility of using that tool much greater in instances where biomechanical studies would benefit the analysis or identification of recovered individuals. From an academic or restorative standpoint, holistic research is an ideal complement to other analytical techniques. The research time is manageable when paired with other assessments and this time will only reduce with improved technology. In addition, the use of open-source software makes this research style an accessible and easily adopted practice.

Ethics Grounded in Past and Present

Examining embodied relationships and experiences to better contextualize osteological analysis provides desperately needed grounding in this and other bioarchaeological studies. The changed relationship between the researcher and the archaeologically recovered individuals brought about by a method that seeks to find the life in each individual instead of their death was transformative from a methodological standpoint and an emotional one. With the opportunity and capacity to understand others in the world this well, projects of social welfare and justice could be undertaken more effectively and with more compassion than previously thought possible. This step towards epistemological and emotional connection is increasingly more important in the face of pressure to situate these individuals as 'other' in an effort to obtain scientific objectivism, and, when grounded in embodied practices, provides a tangible connection to the past individuals we steward.

Ethics in Practice

When using an emphasis on identity, individuality, and memory to build upon extant memorializing practices codified by the MCPFCP, this project found that other activities enabled the building of memory, as well. The following are recommended as a first line of active memory research in archaeological or historical studies, especially when those studies use new technology:

1. Tracking logs (*Appendix A*)
2. Thorough provenience checklist for scanning (*Appendix B*)
3. Strict file naming conventions and provenience (*Appendix C*)
4. All files associated with individuals stored on a secure server.
5. Gait analyses conducted with strict provenience and file structure.
6. Strict policies regarding dissemination of data (*Appendix E*).
7. Use of Open-Source software to avoid the "black box" phenomenon.
8. Individual Data Files by Lot Number (*Appendix F*)
9. Individual Data Reporting (*Appendix G*)

Through these methods, this project can be considered a memory building work that seeks to heal acts of institutional forgetting through acts of preservation.

Clinical and Bioarchaeological Integration

Integrating modern clinical studies and practices with bioarchaeological analysis is far from simple. Modern clinical data is helpful for providing biomechanical and physiological information that can be applied to further our understanding of injuries, while historic documentation is most useful for determining likely treatments used as well as temporal contextualization, but neither can be used alone if an accurate understanding of the condition is to be reached. Future studies should also incorporate comparisons of contemporary population data collected by physicians, further discussion of access to medical care, and a biosocial examination of attitudes about health, injury, and the body during the late 19th and early 20th centuries.

Future Research and Collaborations

- *Personal MSK modeling for forensic cases without other ID information:*

  Personalized MSK modeling could be exceptionally useful for forensic cases that lack other identifying information. If there is video of the missing person that may be connected to the remains, a gait analysis could be an identifying factor even if the individual does not have a stark gait abnormality, since the visual representation of gait provided by OpenSim could be statistically compared with video footage via programs like ImageJ.

- *Digital modeling for paleopathology and prehistoric contexts:*

  As widely recognized, particularly since the recovery of *H. naledi*, three-dimensional scanning and research can greatly benefit the study of hominids (Berger et al. 2015; Bolter et al. 2020; Holloway et al. 2018). Once the problem of digital restoration is solved, development of personalized MSK models for hominids can provide new insights to the evolution of hominin locomotion.

- *Non-Impact Document Scanning and Handwriting AI:*

  Non-Impact scanning, such as the CamScanner app that was used for this project will be integral to digitizing and preserving important historic documents. The continued development and use of handwriting AI programs like the Google Handwriting API will prove exceptionally useful in the investigation and curation of historical records, such as the Milwaukee County Hospital Intake Records.

Habitus and Embodiment as Mechanisms of Postmortem Agency

Nystrom (2011:164) argues that there is a distinct and observable difference in the manifestations of self-ascribed identity and external social inscription of identity. These inscriptions of identity tend to overlap and merge in ways that make them difficult to distinguish within the burial context, even in the case of items or skeletal changes that are highly personal. While our choices and experiences are certainly mediated by cultural context, we still have a role in shaping the context itself and our place in it.

For this reason, it is crucial to remind ourselves that the durable dispositions explored by Bourdieu (1977) do not lead to strictly bounded cultural identities, but rather represent a fluid and changing way of navigating various cultural contexts. Jones (1999:226) reminds us that habitus plays a role in archaeological engagements with post-mortem agency acting not as a system of normative rules which exist outside the individual history, but as simultaneous "structuring structures" and "structured structures" that mold and are shaped by social practice (Bourdieu, 1977).

Jones also posits that habitus plays a role in the subjective class distinctions that arise in institutions where inequality of power is part of daily life as well as in how these distinctions are grounded in dynamic social conditions. Social identification of class, ethnicity, and social status are not passive reflections of similarities and differences in the "cultural practices and structural conditions in which agents are socialized" (Jones, 1999:226).

Instead, it can be argued that the construction of identity in these contexts is grounded in the shared dispositions of habitus which shape and are shaped by commonalities of practice (Jones, 1991: 226-227). These conditions and commonalities make their mark on individuals in organic, yet durable ways that enable glimpses into personal choices that are part of everyday life. These are sometimes small choices, but many of them have ramifications that echo through the archaeological record.

The research methods undertaken in this work open the door to finding small expressions of personal antemortem agency and retention of individuality at MCPFC, particularly in response to the physical body and its status as a vehicle for thought and action. It is evident in the ways that individuals retained fragments of independence and identity while moving through these large institutions, that dynamics when encountering the Milwaukee County Institutions were anything but static, and the lives lived in the intersection of these community members and the institutions were mediated by personal choice even while constrained by circumstance.

Conclusions

Though the remains of Mary Henke were recovered from an unmarked burial in the MCPFC, her time at the UWM ARL has revealed quite a bit about her life. Mary Henke was born in Oshkosh, WI, in 1880. At present, little is known about what took her from Oshkosh to Milwaukee, though newspaper clippings reveal she may have returned to the area at least once, in 1916 to attend the funeral of a close friend or relation (The Neenah Daily Times [NDT], March 28th, 1916, Figure 6.6).

—Those from out-of-town who attended the funeral of Mrs. O. E. Bullis were Mr. and Mrs. Chas. Henke, J. W. Henke, Mrs. Chas. Lorenzen, the Misses Ida and Mary Henke, of Milwaukee, all brothers and sisters, also Mrs. Muttart, Mrs. Keyes, Mrs. Farrow, Mrs. McCoy, Mrs. Unmuth, of Winnebago, and A. H. Spencer, of Sheboygan.

Figure 6.6. A possible mention of Mary Henke, included in a list of out-of-town funeral attendees memorializing Mrs. O. E. Bullis, in Neenah, WI. (The Neenah Daily Times [NDT], March 28th, 1916)

We do know that Mary Henke lived in Milwaukee for a substantial portion of her life and was buried there on July 18th, 1924 (Drew 2018: 501), six days after dying of "cirrhosis of liver" and "myocardial insufficiency" at the Milwaukee County Hospital at the age of 44 (Richards 1997: 582). Mary Henke's death certificate denotes the fact that she was married and names some of her closest relatives: Rachel Senet and Henry Elwer (Figure 6.7).

TRANSCRIBED MILWAUKEE COUNTY DEATH CERTIFICATE

Certificate Vol./Page# 499/176

Vital Statistics					
Name of Deceased	Henke, Mary			Sex	F
Date of Birth		Place of Birth	Oshkosh		
Mother or Wife	Rachel Senet				
Father or Husband	Henry Elwer				
Occupation	Housewife				
Mortality					
Date of Death	12-Jul-1924	Age at Death	44		
Cause of Death	cirrhosis of liver, myyocardial insufficiency				
Place of Death	County Hospital				
Date of Burial	18-Jul-1924	Grave#	20-14	Excavated Lot#	5128

Figure 6.7. *Transcribed Death Certificate for Mary Henke, including her closest relatives, cause of death, and age at death. The Excavated Lot # refers to an individual recovered from the MCPFC who matches Mary's description and was buried with an insignia ring bearing the letters "M H", seen below.*

The individual excavated from the MCPFC and identified as Mary Henke through Richards' 1997 spatial and mortuary analysis is represented by Burial Lot 5128. Richards notes:

The skeletal remains were in poor condition but suggest a female burial. One gold

> ring was present on the left hand. A specific finger could not be identified. The insignia ring with the initials "MH" is 1.70 cm in diameter. Safety- pins were found also. Lot No. 5128 (burial 20-24) is identified according to the cemetery arrangement as Mary Henke. Ms. Henke died at the age of 44 of liver cirrhosis at the County Hospital. (Richards 1997:131)

The 1991 field designation of female was corroborated through a biological profile conducted during the start of comprehensive osteological analysis efforts piloted by the MCPFC Project and supported by the University of Wisconsin-Milwaukee Archaeology Research Laboratory, and several osteological conditions were noted during this time (MCPFC Analysis Paperwork, 2015). Further bolstering the designation of the individual from Lot 5128 as Mary Henke is of course the insignia ring recovered from the burial bearing the letters "M H" (Figure 6.8).

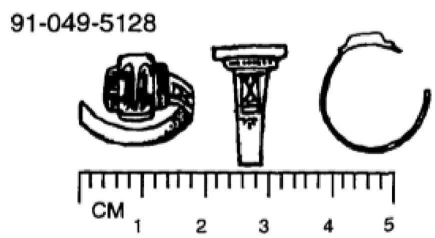


Figure 6.8. Gold insignia ring recovered from burial 5128, bearing the letters "M H".

An additional detail noted in the death certificate that further bolsters this identification is the presence of gallstones, liver failure, and myocardial failure. Hemochromatosis is a metabolic disease which results in concurrent disruption of several tissue types, due to the high buildup of iron in the body due to ineffective metabolism. Though there are a few possible comorbidities of hemochromatosis, there are three that more often occur together: arthropathy (joint disease), liver cirrhosis, and myocardial failure (Pauwels et al 2018). The systemic three-dimensional analysis undertaken concerning the osteology of the individual from Lot 5128 revealed arthropathic patterning consistent with that of hemochromatosis. This not only allowed us to further confirm Mary Henke's identity, but also to shed new light on her condition and the experiences she lived through.

Substantial work is underway to bring the stories and identities of the individuals buried in the MCPFC "back to life"—through archival research, through the collection, preservation, and interpretation of biological and material culture data, and through continued engagement with these individuals with their reincorporation into this community, albeit a slightly different one than from which they came, at heart. It is our imperative to contribute to this endeavor, to the painstaking work undertaken to "reindividualize those whose individuality was taken from them as a result of poverty, medical procedure, or accident" (Richards 2017 et al.) as a work not just of respect, but of compassion.

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Appendix A: Provenience Tracking Log

Lot Number	Age Category	Sex Category	Reason For Inclusion	Date Moved to Lab	Moved to Lab Initials	Date Scanning Data Collection Complete	Analyst Initials	Date Moved to G65	Moved to G65 Initials
3041	Old Adult	Ambiguous	Possible Pelvic Gait Assessment						
3060	Middle Adult	Male	Reactive BG						
5099	Old Adult	Probable Male	Ankylosis Assessment						
5107	Middle Adult	Male	Historical Research re: Muirdale						
5128	Old Adult	Female	Hemochromatosis Assessment						
5133	Old Adult	Female	Trauma Gait Assessment						
5145	Young Adult	Ambiguous	Irregular Fusion Assessment						
5146	Middle Adult	Male	OA Movement Assessment						
5208	Old Adult	Female	Possible Pelvic Gait Assessment						
5209	Old Adult	Male	DJD Gait Assessment						
5210	Middle Adult	Probable Male	Possible Systemic Gait Assessment						
5212	Old Adult	Male	Pelvic OA Gait Assessment						
5213	Middle Adult	Ambiguous	Gait Assessment						
9286	Old Adult	Male	Systemic Infection Gait Assessment						
9289	Young Adult	Male	Baseline Gait						
10067	Young Adult	Female	Knee OA						
10364	Middle Adult	Male	Femoroacetabular Impingement						
10371	Middle Adult	Male	Patellar Staples						
10372	Middle Adult	Female	Trauma Gait Assessment						
10805	Middle Adult	Female	Femoral Movement Assessment						
10671	Middle Adult	Male	Misaligned Fracture						

Appendix B: Three-Dimensional Scanning Provenience Protocol

UWM ARL Three-Dimensional Scanning Protocol

These scanning protocols were developed in the University of Wisconsin-Milwaukee Archaeological Research Laboratory to serve as an overview of effective scanning methods using the LMI Technologies Structured Light Scanner or NextEngine Ultra HD 3D Scanner, with adapted strategies from additional cited works. For more information on the use and care of the scanners, please contact Dr. Patricia Richards at pbrownr@uwm.edu.

Pre-Scan

- Materials Preparation
  - Start a check-out sheet. (Attached at the end of this document)
  - Arrange to transport the artifacts, flora, fauna, individuals, or individual skeletal elements selected for the scan session. The number of items transported from Artifact Curation or other locales is dependent on how many scanning sessions are planned for the day.
  - Determine how many scanning sessions are needed. (Researchers may conduct multiple scanning sessions in a day without signing out)
    - If working with more than one individual or skeletal elements from more than one individual, all researchers must conduct separate scanning sessions for each.
    - If working with more than one site or archaeological context, researchers must conduct separate scanning sessions for each.
    - If working with only one individual or artifacts from one provenience context, researchers do not have to conduct separate scanning sessions.
    - ***These rules are context-dependent and each researcher should work with a supervisor to determine the best course of action.***
  - Create provenience cards for each item that will be scanned. **Always maintain provenience.**
    - **The format for the cards will follow the format for curation bags.**
    - **Example:**
      - MCPFC
      - 47BMI0076
      - 91-049
      - Lot #__________
      - Date of excavation and excavator initials.
      - Inventory date and inventory initials.
      - Artifact or element description
      - For skeletal elements be sure to include left and right in the description.
  - Materials transport
    - Each set of items and corresponding cards should have an individual tray.
    - Cards should be placed by each item.
    - Due to lack of space and concern for provenience, please do not unpack multiple sets of items in the scan lab at one time.

- Preparation of materials for scanning
    - Unless told otherwise by a supervisor, researchers may not mark or place foreign materials on the items for scanning
    - Thread is recommended as a marking tool.
    - Putty is available for marking but should only be used if a researcher's supervisor approves it.
    - Researchers may gently brush materials for a good scan. This can also be determined by supervisor.
    - Researchers should carefully determine whether the material they are working with is strong enough to be held in place with the NextEngine tools. There are other options available if not.
    - Researchers should carefully determine whether the LMI turntable can be used.
- Scan Environment: Errickson et al. (2015) provide excellent advice on the environment conducive to the best scan possible. "The authors also suggest the use of a black background in a [correctly] lit environment to reduce noise and post processing when using a laser line scanning due to the difficulties in recording this type of surface. Further, for recording osteological material, although knowledge of anatomy is not necessary, it may be important to ensure that pathological features are recorded correctly and not over-looked. An experienced non-contact surface scanner user is suggested to ensure the bone is fully recorded and archival [quality] is achieved in accordance with Guides to Good Practice" (Errickson et al. 2015. Digital Publication).

- **Save Scan**
    - **Selecting Output:** NextEngine and LMI output 3D geometry files for working on in CAD programs or indeed eventually for 3D printing.
        - Click 'output' on the main toolbar.
        - Click STL or OBJ to save to those file types respectively. STL is the more common, however OBJ contains connected phototexture
        - There will be a save dialog to choose a name and location for the exported file. Check the box to export only the green attached mesh (make sure the fused mesh is the only attached mesh before exporting).
    - **Save** the original scan file (.scn) before closing. All the scans are referenced from that one file.
    - **Make sure to save the scan with all of the provenience information on the provenience card.** Similar to ARC GIS, Scan Studio generates a lot of files. You may want to zip these and place them on the scanner or a remote hard drive (*depending on supervisor permissions*) to manipulate later. There are also different programs in which to work with the data, such as MeshLab.
- **Finishing Up**
    - Once finished, return the element and provenience card to the tray.

- Use the brushes available to sweep the scanner, tables, and general area for any material that may have adhered to the item, such as soil from the site. Return this to the tray with the item.
- Check the floor for site soil, fragments, or any other important items.
- **Return the items to their original location, maintaining all provenience with the cards and trays.**
- Finish the check-out sheet.

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Appendix C: Three-Dimensional Scanning Checklist

UWM ARL Three-Dimensional Scanning Checklist

Analyst Name: ______________________________
Date: ______________________________
Project: ______________________________
Lot #/Artifact #: ____________________
Supervisor: ______________________________
Pre-Scan

- ☐ Materials Preparation
  - List of items selected for this scan session. This includes provenience information.
    - ______________________________
    - ______________________________
    - ______________________________
    - ______________________________
    - ______________________________
  - Set aside trays for items.
  - Create cards for each item that will be scanned. **Always maintain provenience.**
    - **The format for the cards will follow the format for the curation bags.**
    - **Example:**
      - MCPFC
      - 47BMI0076
      - 91-049
      - Lot #__________
      - Date of excavation and excavator initials.
      - Inventory date, number, and inventory initials.
      - Artifact or skeletal element description
      - For skeletal elements be sure to include left and right in the description.
  - Materials transport
    - Each set of items and corresponding cards should have an individual tray.
    - Provenience Cards have been placed by each item.
    - Reminder: *Due to a strong concern for provenience as well as a lack of space, please do not bring multiple sets of items into the scan lab at one time.*
  - Preparation of materials for scanning
    - Reminder: *Unless told otherwise by a supervisor, do not mark or place foreign materials on the items that will be scanned.*
    - Are all needed materials present?
      - Thread or String
      - Brushes

- Putty if recommended by a supervisor.

- ☐ **Scanning**
  - o Scans have been saved with all provenience information:
  - o File naming protocol: ____

- ☐ **Finishing Up**
  - o Item and provenience card have been returned to the tray.
  - o Swept the scanner, tables, and general area for any material that may have adhered to the item, such as soil from the site. Returned this to tray with item.
  - o Checked the floor for site soil, fragments, or any other important items.
  - o **Returned all items to their original location, maintaining all provenience with the cards and trays.**
  - o **Returned items to original boxes and original curational facility.**

- ☐ **Supervisor Signature: ____ Date:_________**

Human Remains Provenience Card Example:

MCPFC
47BMI0076
91-049
Lot #: __________
Excavated: ____________________________________
Inventoried: __________________________________
Elements: ________, __________, __________, _______
Circle L or R **(L|R) (L|R) (L|R) (L|R)**

Appendix D: Three-Dimensional Scan Editing Checklist

UWM-ARL Human Remains Scan Editing Checklist

Analyst Name: ______________________
Date: ______________________
Site Number: ______________________
Project Number: ______________________
Lot Number: ______________________
Supervisor: ______________________
Pre-Scan

- ☐ A supervisor has assigned a lot to be edited
- ☐ Editing Preparation
  - o Listed elements selected for this editing session. A new session and paperwork will be issued for every lot number.
    - ▪ The list of elements for this editing session includes provenience information. Be sure to note P for present elements or A for absent elements. If an element was not selected for this section, place a dash. Write NE if the scans were present but not edited.

Site Number	Site Name	Project Number	Lot Number	Element and Side (Presence/Absence)	

- ☐ **Scan Editing**
  - o Checked the editing protocol before starting to edit a scan.
  - o Ensured OBJ Files have been saved with all provenience information:
  - o File naming protocol example:
    - ▪ **MCPFC_91-049_Lot####_UWMScan_ElementSide_ElementName**
- ☐ **Finishing up a Lot:**
  - o **Entered information in the Scanning Tracker and the Checklist Log.**
  - o **Informed a supervisor that this individual's scans are fully processed.**

☐ **Supervisor Signature:** ______________________________ **Date:** __________

Appendix E: Burial Descriptions

Burial Lot: 5099
Coffin Lot: 5099
Putative ID: Carl Mahnke
Associated Lot: None

Burial Description
The burial was located through mechanical stripping. No grave shaft was visible. The east end of the burial was disturbed by rain during the excavation. The coffin was poorly preserved with no coffin lid and moderate sections of the walls and base intact. The individual was supine and extended with head to the west and hands crossed at the pelvis. Elements were recovered in situ.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 82 inches long and 23 inches wide.

Coffin Hardware
Four Type VII coffin handles and 16 coffin handle screws were recovered.

Grave Goods
There was no note of recovered grave goods.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in poor condition with heavy fragmentation. The sternum was not present in this burial. The cranium was complete but exhibited moderate fragmentation, craniotomy, and fracture. The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a probable male of European ancestry. An age range of old adult was estimated for this individual based on cranial suture closure.

Stature was estimated to be 66.17 ± 2.5 inches by the left femur and tibia.

No maxillary or mandibular teeth were present. The entire mandibular and maxillary alveolar surface was remodeled.

An endocranial lesion was observed on the right frontal. The C2 and C3 vertebrae were ankylosed. Wormian bones were observed on the lambdoid suture. Hyperostosis was observed on the left acetabular rim. Osteophytic lipping was observed on the joint surfaces of the right scapula, humerus, radius, and ulna. Eburnation and degeneration were observed on the joint surfaces of the humerus, radius, and ulna. Periostitis was observed on the sternal end of a rib. Two healed rib fractures were observed. A biplanar craniotomy was observed.

Burial Lot: 5128
Coffin Lot: 5128
Putative ID: Mary Henke
Associated Lot: None

Burial Description
The burial was located through mechanical stripping. The grave shaft was marked by a dark soil stain. The west end of the burial was disturbed by heavy rain during the excavation. The coffin was fairly preserved with a collapsed coffin lid and small sections of the walls and base intact. The individual was supine and extended with head to the west and hands crossed at the chest. Elements were recovered in situ.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 74 inches long and 18 inches wide.

Coffin Hardware
Two Type VII coffin handles and coffin handle screws were recovered.

Grave Goods
One engraved monogrammed gold ring and copper safety pin fragments were recovered.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in good condition with light fragmentation. All elements were recovered. The cranium was complete but exhibited moderate fragmentation. The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a female of European ancestry. An age range of old adult was estimated for this individual based on the auricular surface and cranial suture closure.

Stature was estimated to be 63.27 ± 2.3 inches.

Loose maxillary teeth were recovered. No maxillary teeth were recovered in situ. The right mandibular M_2 was present. Enamel hypoplasia was observed on the loose right and left central maxillary incisors. Caries were observed on two loose maxillary molars. The entire mandibular alveolar surface was remodeled except the right mandibular M_2.
Osteophytic lipping was observed on the right and left femora and tibiae, as well as the right and left metacarpals. A button osteoma was observed on the right of the frontal bone. Periostitis was observed on the distal shaft of the right femur.

Burial Lot: 5133
Coffin Lot: 5133
Putative ID: Emma Hall
Associated Lot: None

Burial Description
The burial was located through mechanical stripping. No grave shaft was visible. Standing water was present in the coffin. The individual was supine and extended with head to the west. Elements were recovered by hand from below water level.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 70 inches long and 19 inches wide.

Coffin Hardware
Two Type VII coffin handles and coffin handle screws were recovered.

Grave Goods
None.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in good condition with light fragmentation. All elements were recovered. The cranium was complete. The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a female of European ancestry. An age range of old adult was estimated for this individual based on the pubic symphysis and cranial suture closure. Stature was estimated to be 58.80 ± 2.3 inches.

The right maxillary PM^2 was present. Loose maxillary teeth were recovered. No mandibular teeth were present in situ. Loose mandibular teeth were recovered. Calculus, carious lesions, periodontitis, and enamel hypoplasia were observed. An artificial abrasion was noted on the left maxillary C.

Ankylosis was observed between the right and left sacroiliac joints.
Osteophytic lipping was observed on the ribs, right scapula, cervical vertebrae, thoracic vertebrae, right radius, right ulna, and right foot. Exostoses were observed on the right ulna, left os coxae, left femur, left tibia, and calcanei. Healed fractures to two left ribs, the right radius, and left navicular were observed.

Burial Lot: 5210
Coffin Lot: 5210
Putative ID: James Hannon
Associated Lot: None

Burial Description
The burial was located through mechanical stripping. The grave shaft was indeterminate. The west end of the burial was disturbed by water inclusion. The coffin was poorly preserved with no coffin lid and small sections of the walls and base intact. The individual was supine and extended with head to the west and arms extended. Elements were recovered in situ.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 73 inches long and 17 inches wide.

Coffin Hardware
Four Type VII coffin handles and coffin handle screws were recovered.

Grave Goods
None.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in good condition with light fragmentation. All elements were recovered. The cranium was complete and exhibited light fragmentation. The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a male of European ancestry. An age range of middle adult was estimated for this individual based on the pubic symphysis, auricular surface, and cranial suture closure.

Stature was estimated to be 65.50 ± 2.5 inches.

The right maxillary C, PM^1, PM^2, M^1, M^2, and left maxillary PM^1, PM^2, M^1, M^2, M^3 were recovered. Five loose maxillary teeth were recovered. The right mandibular C, PM_1, PM_2, M_1, M_2, M_3, and left mandibular C, PM_1, PM_2, M_1, M_2, M_3 were recovered. Four loose mandibular teeth were recovered.

Enamel hypoplasia was observed on the right maxillary canine and the left mandibular canine. Calculus was observed on the right mandibular PM_2, M_1, M_2, and M_3 and the left mandibular PM_2, and M_1. Periodontitis was observed at the left mandibular M_1, M_2, and M_3.

Ankylosis of the sacrococcygeal joint was observed. Osteolytic pits were observed on the right and left proximal humeri. Irregular fusion of the C6 and C7 was observed. A rib neoplasm was observed. Exostoses were observed on the proximal and distal right tibia and the distal left tibia. Periostitis was observed on the proximal right femoral shaft and the proximal left fibula shaft.

Burial Lot: 8159
Coffin Lot: 8159
Putative ID:
Associated Lot: None

Burial Description
The burial was located through mechanical stripping. The grave shaft was indistinct. The coffin was poorly preserved with an absent coffin lid and no sections of the walls and base intact. The individual was supine and extended with head to the west and arms crossed at the torso. Elements were recovered in situ.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 75 inches long and 19 inches wide.

Coffin Hardware
Four Type III coffin handles, five wire nails, and sixteen coffin handle screws were recovered.

Grave Goods
None.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in fair condition with moderate fragmentation. All elements were recovered. The cranium was complete but exhibited moderate fragmentation. The sexually dimorphic anthroposcopic and osteometric characteristics of this individual indicated a male of European ancestry. An age range of old adult was estimated for this individual based on the auricular surface and cranial suture closure.

Stature was estimated to be 67.97 ± 2.8 inches.

The right maxillary PM^1, PM^2, M^1, M^2, and left maxillary I^1, M^1, M^2, M^3 were recovered. eight loose maxillary teeth were recovered. The right mandibular I_1, I_2, C, PM_1, PM_2, M_1, M_2, M_3, and left mandibular I_1, I_2, and M_3 were recovered. Three loose mandibular teeth were recovered.
Enamel hypoplasia was observed on the loose right and left central maxillary incisors. Caries were observed on two loose maxillary molars. The entire mandibular alveolar surface was

resorbed except the right mandibular M_2.

Endocranial lesions were observed on the frontal and occipital bones. Ankylosis was observed on the C3 and C4. Osteophytic lipping was observed on the T5-L5, right and left femora and tibiae, as well as the right and left metacarpals. Periostitis was observed on the distal shafts of the right and left femora.

Burial Lot: 10067
Coffin Lot: 10067
Putative ID:
Associated Lot: None

Burial Description
This burial was defined by the stain of the grave shaft. The coffin was minimally preserved with only small fragments of the walls and base remaining. The individual was supine and extended with head to the west; the right arm was to the side, the left arm was crossed over the stomach, and the left leg was bent toward the north wall. Elements were recovered in situ. Water damage was evident on the left arm, femora, tibiae, and fibulae. Shell buttons were recovered from the area above the sternum. Safety pin fragments were recovered from the right ribs below the sternum. A small piece of melted glass was recovered near the left femur. A wedge-shaped pillow, measuring 6 in. deep was recovered at the west end of the coffin.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 75 inches long and 18 inches wide.

Coffin Hardware
Four Type II coffin handles and coffin handle screws were recovered.

Grave Goods
One fragmentary shell button and one fragmentary large safety pin were recovered during excavation.

Other Associated Material Culture
One intact head support with one associated melted glass fragment was recovered during excavation.

Osteological Description
Adult. The remains were in fair condition with moderate fragmentation; all elements were recovered for this individual. The cranium was complete and in good condition. The sexually dimorphic nonmetric and metric characteristics of this individual indicated a probable female. An age range of young adult was estimated for this individual based on cranial suture closure. Stature was not observable for this individual.

All maxillary teeth were present except for the right I1-2, PM1-2, M3, and the left I2, M3; each was marked by calculus on the labial, lingual, and buccal surfaces. The left maxillary PM2 has a carie on the occlusal surface. Remodeled alveolus was observed in the area of the right maxillary I1 and right PM1-2. All mandibular teeth are present except for the right PM2, M1-3, and the left PM1, M1-3; each was marked by calculus on the labial, lingual, and buccal surfaces. Remodeled alveolus was observed in the area of the right mandibular PM2, M1-3 and on the left M1-3.

Eburnation was observed on the distal left femur. Schmorl's nodes were observed in the thoracic and lumber vertebrae. Osteophytic lipping was evident in the thoracic and lumbar vertebrae, and on the distal right ulna. Degenerative joint disease was present on left distal femur, left patella, and left proximal tibia. Periostitis was visible on the shafts of the tibiae.

Burial Lot: 10364
Coffin Lot: 10364
Putative ID:
Associated Lot: None

Burial Description
This burial was defined by the stain of the grave shaft. The coffin was partially preserved with sections of the walls and base remaining; portions of the south wall were removed during excavation. The coffin lid had collapsed inward. Burnt wood was recovered from the fill above the coffin. The individual was supine and extended with head to the west and arms crossed over the pelvis; the remains appeared to have shifted due to taphonomic processes. Elements were recovered in situ. An unknown adherent material was noted cranially on the right parietal. Desiccated brain tissue was recovered.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 71 inches long and 20.1 inches wide.

Coffin Hardware
Two Type I coffin handles, two Type VI coffin handles, and 12 wire nail fragments were recovered.

Grave Goods
None.

Other Associated Material Culture
2 clear flat glass fragments, 4 melted glass fragments, and 3 unidentified glass fragments were recovered during excavation.

Osteological Description
Adult. The remains were in good condition with light fragmentation. All elements were

recovered for this individual. The cranium was in fair condition and fragmented through the maxillae, zygomatics, and nasals. The sexually dimorphic nonmetric and metric characteristics of this individual indicated a male. An age range of middle adult was estimated for this individual based on the condition of the pubic symphysis, condition of the auricular surface, and cranial suture closure.

Stature was estimated to be 67.09 ± 2.8 in. from the right tibia.

All maxillary teeth were present except the right M2-3 and left M1-3. Calculus was visible on the labial, buccal, and lingual surfaces of all maxillary teeth. A carie was noted on the buccal surface of the left maxillary PM2. Remodeled alveoli were evident in the area of the rght maxillary M2 and the left maxillary M1. All mandibular teeth were present except the right M1-3 and the left M1-3. Calculus was visible on the labial, buccal, and occlusal surfaces of each mandibular tooth. A carie was noted on the mesial surface of the right mandibular PM2. Remodeled alveoli were evident in the area of the right mandibular M1-3 and the left mandibular M1-3. Two loose teeth were recovered. A carie was noted on one loose tooth.

Hypertrophic osseous growth was observed on the right medial clavicle, left medial clavicle, right superior and inferior innominate, left inferior innominate, left proximal femur, and in the right foot. Lytic lesions were visible cranially on the right parietal and in the cervical vertebrae. Ankylosis was noted between the second medial and proximal phalanges of the right foot. Eburnation was visible between the first metatarsal and first proximal phalanx of the right foot. Schmorl's nodes were visible in the thoracic vertebrae. Osteophytic lipping was observed throughout the vertebrae, as well as on two ribs, the right proximal ulna, the left proximal and distal ulna, the right radial tubercle, in the right hand, the acetabulum of the right innominate, the acetabulum of the left innominate, the right proximal femur, the left proximal femur, the left proximal tibia, and in the right foot. Degenerative joint disease was noted in the right and left hip joints.

Burial Lot: 10371
Coffin Lot: 10371
Putative ID: In Process
Associated Lot: None

Burial Description
This burial was defined by the stain of the grave shaft. The coffin was partially preserved with small sections of the walls and base remaining; the east wall and portions of the north and south walls were removed during excavation. Water was present in the coffin. The individual was supine and extended with head to the west, right arm to the side, and left arm over the pelvis; the remains appeared to have shifted slightly due to taphonomic processes. Elements were recovered in situ. Water damage was evident on the cranium, scapulae, left distal humerus, left ribs, right radius, and right ulna. An unknown adherent material was noted on the right scapula and a rib. Desiccated brain tissue was recovered. A grooved piece

of lumbar measuring 7 x ¾ x 84 in. was located lying at a southwest to northeast slant below the coffin floor.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 74.5 inches long and 21 inches wide.

Coffin Hardware
None.
Grave Goods
None.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in good condition with light fragmentation; the sternum was not recovered. The cranium was complete and in good condition. The sexually dimorphic nonmetric and metric characteristics of this individual indicated a probable male. An age range of middle adult was estimated for this individual based on the condition of the pubic symphyses, condition of the auricular surface, and cranial suture closure.

Stature was estimated to be 66.67 ± 2.5 in. from the right femur and left tibia lengths.

All maxillary teeth were present except the right I1, PM2, M3, and the left I1, PM1-2, and M1-3. Calculus was observed on the labial surface of the left maxillary C1. Caries were observed in the right maxillary C1, PM1, M1-2, and the left maxillary I2, C1, and M2. Remodeled alveolus was evident in the area of the right maxillary PM2 and the left maxillary M1. All mandibular teeth were present except the right PM2 and M2-3. Calculus was observed on the labial, buccal, and lingual surfaces of all mandibular teeth. Caries were noted in the left mandibular M2 and on the mesial surface of the left mandibular PM2. An abscess was observed just inferior to the left mandibular M2. Remodeled alveolus was evident in the area of the right mandibular PM2.

Lytic lesions were observed on the left talus. Irregular fusion of the left maxilla, left zygomatic, and frontal bone was observed cranially. Osteophytic lipping was evident on the glenoid fossae of the right and left scapulae, right proximal humerus, left distal humerus, right proximal ulna, left proximal ulna, left proximal radius, in both hands, in the ribs, and on the left distal femur, the right distal femur, and on both patellae. Heavy wear was observed in the right temporomandibular joint. Healed fractures to the right parietal, right patella, and left distal femoral shaft were observed. The right patella was sutured together with silver or silver-alloy wire.

Burial Lot: 10372
Coffin Lot: 10372
Putative ID: In Process
Associated Lot: None

Burial Description
This burial was defined by the visible coffin outline at the surface. The coffin was partially preserved with large sections of the walls and base remaining; portions of the decayed south wall were removed during excavation. Water was present in the coffin. The individual was supine and extended with head to the west, right arm over the pelvis, and left arm to the side; the remains appeared to have shifted due to taphonomic processes. Elements were recovered in situ. Desiccated brain tissue was recovered. Water damage was evident on the right femur.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 70 inches long and 18 inches wide.

Coffin Hardware
One coffin handle of unknown type was recovered during excavation.

Grave Goods
None.

Other Associated Material Culture
None.

Osteological Description
Adult. The remains were in fair condition with moderate fragmentation. All elements were recovered for this individual. The cranium was partially complete and fragmented through the maxillae, zygomatics, and nasals. The sexually dimorphic nonmetric characteristics of this individual indicated a probable female. An age range of old adult was estimated for this individual based on the condition of the pubic symphyses and cranial suture closure.

Stature was not observable for this individual.

No maxillary teeth were recovered for this individual. No mandibular teeth were recovered for this individual. Remodeled alveoli were observed in the area of the right mandibular I1-2, M1-3, and the left mandibular I1-2 and M1-3. 1 loose tooth was recovered.

Hypertrophic osseous growth was observed on the lateral clavicles, proximal right radius, distal femora, both patellae, in both hands, and in the cervical and lumbar vertebrae. Lytic lesions were observed endocranially, as well as exocranially on the right posterior parietal. The L5 vertebrae had collapsed. Eburnation was observed on the right distal ulna and radius, on the right distal femur, in both hands, and in the cervical and lumbar vertebrae.

Osteophytic lipping was observed on the scapulae, left proximal ulna, right innominate, in both wrists, and throughout the ribs and vertebrae. Degenerative joint disease was observed in the cervical vertebrae. Osteomyelitis was observed on the left distal radius. Healed fractures to the left proximal humerus, left distal radius and 6 left ribs were observed.

Burial Lot: 10805
Coffin Lot: 10805
Putative ID: In Process
Associated Lot: None

Burial Description
The burial was identified when the east end of the coffin was disturbed during mechanical stripping. No coffin wood remained but the stain of the decayed wood was visible. The individual was supine and extended with head to the west, right arm over the torso, and left arm bent toward the shoulder; the remains appeared to have shifted slightly due to disturbance and taphonomic processes. Elements were recovered in situ. Excavations were made into the north wall to reveal the left arm and left innominate and into the south wall to reveal the right arm, right innominate, and right femur. Water damage was observed throughout the remains.

Coffin Shape and Dimensions
The coffin was hexagonal in shape and measured 76 inches long and 22 inches wide.

Coffin Hardware
Two indeterminate coffin handles and two wire nail fragments were recovered.

Grave Goods
None.

Other Associated Material Culture
One rubber fragment was recovered during analysis.

Osteological Description
Adult. The remains were in fair condition and moderately fragmented; the sternum was not recovered. The cranium was complete and fragmented through the maxillae, zygomatics, and nasals. The sexually dimorphic nonmetric and metric characteristics of this individual indicated a female of European ancestry. An age range of middle adult was estimated for this individual based on the condition of the auricular surface and cranial suture closure.

Stature was estimated to be 63.27 ± 2.3 inches from right femur and tibia.

No maxillary teeth were recovered for this individual. No mandibular teeth were recovered for this individual. Remodeled alveolus was observed in the area of the left mandibular I1-2, M3, and right mandibular I1-2 and M1-3. 8 loose teeth were recovered. Enamel hypoplasia and calculus were observed among the loose teeth.

Ankylosis was observed within the thoracic vertebrae, in the left sacroiliac joint, and in the right sacroiliac joint. Osteophytic lipping was observed on the left scapular glenoid fossa and the right scapular glenoid fossa. Exostosis was visible on the left distal fibula. Periostitis was evident on the distal left tibia shaft and the distal left fibula shaft. Neoplastic growth was observed on the left distal femur.

JESSICA SKINNER

CURRICULUM VITAE

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EDUCATION

2021 University of Wisconsin-Milwaukee
PhD, Anthropology | Dr. Patricia Richards, Supervisor
Concentration: Bioarchaeology, Historic Cemeteries

2015 University of Wisconsin-Milwaukee
MS, Anthropology | Dr. Fred Anapol, Supervisor
Thesis: *Entheses and Activities: The Multivariate Mechanisms of Entheseal Change for Individuals Represented By the 2013 Excavations of the Milwaukee County Institution Grounds Cemetery*
Concentration: Biological Anthropology

2011 University of Wisconsin-Milwaukee
BA, Journalism
Certificate: Medicolegal Death Investigation

2016 Irish Archaeological Field School: Blackfriary, Trim, Ireland
Field Excavation and Post-Excavation Stabilization
Burial Excavation and Post-Excavation Stabilization

ACADEMIC APPOINTMENTS

2020-Current — Instructor: McHenry County College, Department of Anthropology
Courses Taught (In-Person and Online):
Introduction to Anthropology

2018- Current — Instructor: College of Lake County, Department of Anthropology
Courses Taught (In-Person and Online):
Introduction to Anthropology
Cultural Anthropology

2016-Current — Graduate Teaching Assistant: University of Wisconsin-Milwaukee, Department of Anthropology
Lab and Discussion Sections Taught (In-Person and Online):
Introduction to Anthropology: Human Origins
Human Evolution and Variation (Upper Level Lab)
Dead Men Do Tell Tales

2013-2016 — Graduate Teaching Assistant: University of Wisconsin-Milwaukee, Department of Biological Sciences
Lab Sections Taught:
Anatomy and Physiology I
Human Structure and Function

FIELD AND LABORATORY APPOINTMENTS

2020-Current	Bioarchaeology Field Supervisor: Blackfriary Archaeology Field School, Trim, Ireland
2020-Current	In-Field Skeletal Analysis Supervisor: Cultural Research Management **Selected Projects:** Lakeshore Avenue Street Construction Project: 2020
2013- Current	Skeletal Analyst: UWM Cultural Resource Management **Selected Projects:** Lakeshore Avenue Street Construction Project: 2020 Milwaukee County Poor Farm Cemetery Project: 2013- Current Oshkosh Golf Course Project: 2018-2019 Second Ward Cemetery Project: 2016-2017
2017-Current	Burial Archaeologist UWM-Cultural Resource Management **Selected Projects:** Lakeshore Avenue Street Construction Project: 2020 St. Patrick's Cemetery Project: 2020 St. John's Church Project 2019 Markesan Unlocateables Project: 2018 Wisconsin Ave/Michigan St. Project: 2018 Old Catholic Cemetery Project: 2017- 2018
2017-2018	Research Assistant: Milwaukee County Poor Farm Cemetery Research Growth Initiative Project Primary Investigator: Dr. Patricia B Richards
2013-2014	Skeletal Stabilization Technician-UWM-Cultural Resource Management
2012-2015	Research Assistant: UWM Center for Forensic Science Lab Primary Investigator: Fred Anapol
2012-2013	Research Assistant: Muscle Fiber Architecture: Arboreal Primates: Primary Investigator: Fred Anapol

PUBLICATIONS

2020 "Like Pulling Teeth: Relationships Between Material Culture and Osteology at the Milwaukee County Poor Farm Cemetery, Wisconsin, USA" *Archaeologies*, Springer Journals, Heidelberg.

2020 "Manual for Ethical Post-Processing and Personalized MSK Modelling of Archaeologically Recovered Human Remains" Open-Source Publication. (Embargoed Until Publication of Dissertation)

2019 "Chapter 4: Skeletal Analysis." In: Report of Investigations 506: Archaeological Investigations at 47WN 0049 (BWN-0210) Golf Course, Winnebago Co, WI. 2019. Chapter authored by Jessica Skinner, Report Co-Authored by Katherine Sterner, Jessica Skinner, and Jennifer Haas.

2018 "Person-Centered Research and Digital Bioarchaeology: The Future of Uncovering the Past at the Milwaukee County Poor Farm Cemetery." The Artifact: A Publication of the Archaeological Institute of America - Milwaukee Society. 24:1:06. Milwaukee, WI.

2017 "The Application of NextEngine Scanning Technology to Commingled Analysis at the Milwaukee County Poor Farm Cemetery: A Replicable Method for Restoring Individuality." Field Notes, A Journal of Collegiate Anthropology. 9:70-81. Milwaukee, WI.

2015 *Entheses and Activities: The Multivariate Mechanisms of Entheseal Change for Individuals Represented By the 2013 Excavations of the Milwaukee County Institution Grounds Cemetery.* Master's Thesis. Available at UWM Digital Commons, Theses and Dissertations. 1083. http://dc.uwm.edu/etd/1083

MANUSCRIPTS IN PREPARATION

2020 "Personalized Musculoskeletal Modelling of Recovered Remains."

2020 *A Last Claim on Public Notice: A Personalized Assessment for Individuals Recovered from the Milwaukee County Poor Farm Cemetery.* (In Progress Title) Doctoral Dissertation. Will be Made Available at UWM Digital Commons, Theses and Dissertations.

GRANTS, FELLOWSHIPS, AND AWARDS

2020 UWM Graduate Student Excellence Fellowship
2020 Laura Bassi Editorial Scholarship
2019 UWM Distinguished Dissertation Fellowship
2018 Three-Minute Thesis Award
2017 UWM Distinguished Graduate Student Fellowship
2017 UWM Anthropology Student Union Travel Grant
2017 UWM Graduate School Travel Grant
2017 UWM Graduate School Travel Grant
2015 UWM Anthropology Student Union Travel Grant
2015 UWM Graduate School Travel Grant
2013 UWM Anthropology Student Union Travel Grant
2013 UWM Graduate School Travel Grant
Lifetime: Lambda Alpha Anthropology Honors Society Member

CONFERENCE PARTICIPATION

2018 Society for American Archaeology Annual Meeting.
Poster Title: Three-Dimensional Musculoskeletal Modeling in Commingled Analysis: A Preliminary Study at the Milwaukee County Poor Farm Cemetery

2018 Coauthor, American Association of Physical Anthropologists Annual Meeting.
Poster Title: Toeing the line: Morphology and biomechanics of metatarsus varus in three dimensions: a case study from the Milwaukee County Poor Farm Cemetery
Coauthor: Ashley L. Brennaman

2018 Society for Historical Archaeology Annual Meeting.
Paper Title: Like Pulling Teeth: Relationships Between Material Culture and Osteology at The Milwaukee County Poor Farm Cemetery
Symposium Title: The Red Shoes: Toward a Materialized Relationship Between the Living and the Dead

2017 Society for Historical Archaeology Annual Meeting
Paper Title: Living Tactically: Postmortem Agency and Individual Identity in Institutional Burials at the Milwaukee County Poor Farm Cemetery
Symposium Title: Bookends: What We've Learned in the Twenty-two Years Separating Archaeological Excavations of the Milwaukee County Poor Farm Cemetery

2017 Midwest Archaeological Conference Annual Meeting
Paper Title: The Application of NextEngine Scanning Technology to Commingled Analysis at the Milwaukee County Poor Farm Cemetery: A Replicable Method for Restoring Individuality
Symposium Title: Updates from the Milwaukee County Poor Farm Cemetery Project

2016 University of Wisconsin Milwaukee Anthropology Student Union Colloquium
Paper Title: *Postmortem Agency: Human Actors and Institutional Cemeteries*

2015 Society for American Archaeology Meetings
Paper Title: *Entheses and Activities: The Effects of Entheseal Change for Individuals from the Milwaukee County Institution Grounds Population*
Symposium Title: People That No One Had Use For, Had Nothing To Give To, No Place to Offer: The Milwaukee County Institution Grounds Cemetery

2015 Human Anatomy and Physiology Society Meetings
Workshop Title: *Not Just "Dem Dry Bones": An Integrative Approach to Teaching Osteology to Anatomy Students*

2014 University of Wisconsin Milwaukee Anthropology Student Union Colloquium
Paper Title: *What Individuals from The Milwaukee County Institution Grounds Cemetery Can Teach Us About Skeletal Change*

2014 Central States Anthropological Meetings:
Paper Title: *Biocultural Applications of the Structural Violence Concept*

INVITED TALKS
2019- Current: Hartford Union HS Body Systems, Hartford, WI

2018 Beloit College Anthropology: Advanced Selected Topics in Anthropology, Beloit WI
2017 Shorewood High School Anthropology, Shorewood, WI

CAMPUS TALKS

2020 UWM Anthropology: Dead Men Do Tell Tales
2019 UWM Anthropology: Human Evolution and Variation
2019 UWM Anthropology: Dead Men Do Tell Tales
2017 UWM Biological Sciences: Anatomy and Physiology I
2017 UWM Biological Sciences: Anatomy and Physiology I
2017 UWM Biological Sciences: Guest Training for Anatomy & Physiology TAs

PROFESSIONAL SERVICE

2019-Current: Field Notes: A Journal of Collegiate Anthropology: Editor
2018-Current: Lambda Alpha Beta of Wisconsin: President
2018 Oral Presentation Judge: UWM Undergraduate Research Symposium
2017-Current: UWM-ARL 3D Scan Use Instructor
2017 Executive Committee: Midwest Bioarchaeology and Forensic Anthropology 24th Annual Meeting
2016-2017 International Archaeology Day Volunteer
2016 Anthropology Student Union Vice President
2016 Executive Committee Chair: UWM Anthropology Student Union Colloquium Conference
2016 Scientific Olympiad Forensic Anthropology Volunteer
2015 Wauwatosa High School Issue Fair Judge

PROFESSIONAL DEVELOPMENT

2020 Dissertation Writing Clinics UWM
2020 Overview of Online Instruction: Illinois Online Network
2020 Dissertation Boot Camp, Dr. Jason Puskar and Susan Wade
2019 What You Don't Know About Publishing (And how to fix it) Dr. Karen Kelsky
2019 Lambda Alpha Grant Workshop- Coordinator
2018 Building a Toolkit for the Heart-Centered Archaeologist Dr. Natasha Lyons, Ursus Heritage Consulting; Dr. Kisha Supernant, University of Alberta; and Dr. John R. Welch, RPA, Simon Fraser University
2018 3D Morphometrics for Archaeologists, Society for American Archaeology
2017 Practical Aspects of Bioarchaeology and Human Skeletal Analysis Workshop, Society for Historical Archaeology

PROFESSIONAL QUALIFICATIONS

Wisconsin State Qualified Burial Archaeologist
Wisconsin State Qualified Skeletal Analyst
Medicolegal Death Investigation Certificate
Meets the Secretary of the Interior's Professional Qualification Standards for Archaeology
Society for Historical Archaeology Bioarchaeology Workshop Certificate
Society for Historical Archaeology Mortuary Archaeology Workshop Certificate

SKILLS AND PROFICIENCIES

Adult Osteological Analysis
Burial Excavation
Juvenile Osteological Analysis
NextEngine 3D Scanner Data Collection
Microscribe 3D Digitizer Data Collection
LMI Technologies Structured Light Scanning
FlexScan Postprocessing
OpenSim Musculoskeletal Modeling
MATLAB and Simulink
NMS Builder
Meshlab
ImageJ
Geometric Morphometric Analysis GeoMorph® Statistical Analysis
R Statistical Analysis
Multivariate Statistics
Histological Analysis
Histological Preparation
Tissue Sampling and Preservation Chemical Preparation
Viewbox 4
Netfab Basic
Microsoft Office Suite
Photoshop
InDesign
Publisher

PROFESSIONAL AFFILIATIONS

American Association of University Professors
Society for American Archaeology
Archaeological Institute of America
Society for Historical Archaeology
American Association of Physical Anthropologists
World Archaeological Survey
Midwest Archaeological Conference
Wisconsin Archaeological Survey

RESEARCH INTERESTS

bioarchaeology, skeletal analysis, commingled analysis, osteological and periosteal development, biomechanics, entheseal change, personalized musculoskeletal modeling, geometric morphometrics

ethics in anthropology, critical and socially active anthropology, digital method adaptation, postmortem agency, embodiment, history of clinical research, archaeology of institutions, historic cemetery preservation.

REFERENCES

References made available upon request.