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Inferences of Subsistence Activities Using Musculoskeletal Stress Markers of Humerii from Two Louisiana Archaeological Populations

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INFERENCES OF SUBSISTENCE ACTIVITIES USING
MUSCULOSKELETAL STRESS MARKERS OF HUMERII FROM TWO
LOUISIANA ARCHAEOLOGICAL POPULATIONS

A Thesis

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ABSTRACT

Wolff's Law states that bone is laid down where it is needed; therefore, mechanical factors, including subsistence-based activity patterns, play a role in bone biology. One of bone's responses to strain is the development of musculoskeletal stress markers (MSMs) at entheses, or the sites in which soft tissues, including tendons and ligaments, attach to bone. MSMs have been used by bioarchaeologists to make inferences about past population's activity patterns and subsistence behaviors. The following study scores eight MSMs of the proximal humerii from the Tchefuncte (16ST1) and Greenhouse (16AV2) sites in Louisiana. The MSMs were segregated into muscle groups and tested statistically for bilateral asymmetry, sexual dimorphism, and inter-populational variation to make inferences about handedness, the division of labor, and diachronic changes associated with subsistence activities. The MSMs were also tested for a correlation to body size. The results of this analysis indicate MSM scores are not bilaterally asymmetric, with the exception of a few muscle groups. Also, Tchefuncte males have significantly higher MSM scores than females that are not a result of body size, as all the correlation tests for body size and MSM development were insignificant. The results of the tests for inter-populational variation suggest that some activities may have altered with changing socio-political structures; yet, few changes occurred through time in the general workload of these two populations.

CHAPTER 1: INTRODUCTION

Anthropologists are interested in many facets of both modern and past human existence, ranging from biological to cultural. One specialty in particular, bioarchaeology, examines human skeletal remains recovered from archaeological contexts to suggest diachronic changes of bio-logical variation, activity patterns and behavior (i.e., subsistence strategies), diet and nutrition, and population health and demography (Larsen 1997). Research from modern populations has shown that there is a relationship between workload (i.e. activity patterns) and the development of musculoskeletal stress markers (MSMs) (Cardoso and Henderson 2010; Niinimaki 2011, 2012; Villotte et al. 2011). Therefore, in bioarchaeological research, inferences about prehistoric lifestyles and/or subsistence activities can be drawn from inter- and intra-populational variation in MSM patterns. Indeed, numerous studies have examined the relationship between MSMs and activity patterns (Chapman 1997; Churchill and Morris 1998; Eshed et al. 2004; Hawkey and Merbs 1995; Lieverse et al. 2011; Molnar 2006; Molnar et al. 2011; Niinimaki 2012; Steen and Lane 1998; Weiss 2007); however, none have focused on the cultures of the Lower Mississippi Valley.

In this study, the development of MSMs as indicators of activity patterns and subsistence behaviors of two skeletal populations from the Louisiana archaeological record is addressed. The Tchefuncte people (1,000 B.C. – A.D. 1), represented by the remains from the Tchefuncte site (16ST1), are characterized as riverine-environment-adapted hunter-gatherers (Ford and Quimby 1945; Hays and Weinstein 2010; Neuman 1984; Saunders 2010). The Coles Creek people (A.D. 700 – 1,200), represented by the human skeletal remains from the Greenhouse site (16AV2), also are characterized as hunter-gatherers; yet, they practiced horticulture, as evidenced by the presence of wild grasses from northern sites (Brown 1984; Ford 1951; Roe and

Schilling 2010). Following Wolff's Law, this study operated under the assumption that the varying subsistence activities practiced by these two cultures would be reflected in the development of the MSMs of the proximal humerii. I hypothesized that variation in humeral MSM scores would be evident between these two skeletal populations, thus, allowing for inferences to be drawn about these peoples' subsistence activities, sexual division of labor, and handedness.

To test my hypothesis, I scored eight entheses of the proximal humerus and ran statistical analyses to test for variation among the samples. First, the right and left humeral MSM scores of each sex from both populations were tested for bilateral asymmetry. If variation between left and right humerii were statistically significant, then inferences about the populations' subsistence activities and handedness were made. Second, the male and female MSM scores within each population were tested for sexual dimorphism. Ethnohistoric data indicates that native populations practiced a sexual division of labor during subsistence activities; therefore, the tests should provide results that are indicative of this trend. Also, males are larger than females and MSMs have been shown to have a correlation to body size. Calculating the Spearman correlation provided insight into the relationship between MSMs and body size among these populations. Finally, the inter-populational variation of sex-specific MSM scores was tested to make inferences about diachronic changes in subsistence activities. The Coles Creek culture was more socio-politically organized than the Tchefuncte and utilized different environmental niches; therefore, variation in humeral MSM scores between the populations was expected to reflect these differences. Regardless of the outcome, these analyses contribute to anthropologists' understanding of the subsistence-based activity patterns of these two archaeological populations from the Lower Mississippi Valley.

CHAPTER 2: LITERATURE REVIEW

2.1: Musculoskeletal Stress Markers

Anthropologists have long recognized the relationship of bone biomechanics and musculoskeletal stress markers (MSMs) to activity patterns of past populations; however, assigning specific activities to MSM formation generally is avoided as their development is dependent on a number of different factors (Hawkey and Merbs 1995; Molnar 2006; Niinimaki 2012; Steen and Lane 1998; Stirland 1998; Weiss 2007; Wilczak 1998). Nevertheless, it is clear that mechanical factors play a strong role in bone biology (Chapman 1997; Lieverse et al. 2009; Martin 2007; Niinimaki 2012; Ruff et al. 2006; Steen and Lane 1998). An increase in activity and the habitual use of a specific area increases the amount of blood brought to this particular region of the bone. The increased blood flow stimulates the osteoblastic activity of bone cells, thereby adding bone mass to that region (Lieverse et al. 2009; Molnar 2006; Parfitt 2004; Steen and Lane 1998). Indeed, the number of capillaries that supply the periosteum is much higher at the entheses, or sites at which soft tissue attaches to the bone, than along the periosteum of the diaphyses (Hawkey and Merbs 1995; Steen and Lane 1998). Because muscles are attached to bone and are responsible for movement, they, too, contribute to the process of marker formation (Weiss 2007). Furthermore, Parfitt (2004) notes that only a few months of habitual activity are required before a visible change to the structure of bone takes place.

Muscles place strain on bones when contracted; therefore, bones must have considerable resistance to deformation under bending and torsional stress (Larsen 1997; Martin 2007; Weiss 2007). Wolff's law of bone remodeling, proposed in 1892, has served as a foundation for research on the relationship of MSMs and bone biomechanics to mechanical loading (Stock and Pfeiffer 2001). Although Wolff erroneously believed that "strict mathematical rules" governed

the process of bone remodelling (Ruff et. al. 2006: 485), the general idea that bone responds to strain over time holds true. Ruff et. al. (2006: 485) suggest that a more appropriate name for Wolff's law should be "bone functional adaptation." The purpose of bone remodeling is twofold. First, remodeling allows bone to adjust and reconstruct bone mass and geometry in response to strain. Second, remodelling continuously removes fatigued bone, that is, bone that has acquired micro-fractures due to habitual use (Martin 2007). Niinimaki (2011) points out that if repetitive activity stimulates osteon remodeling, then one should expect the diaphyseal cross-sectional properties and muscle-marker morphology to reflect the mechanical environment.

Bone resists the strain applied by muscle contraction by incorporating hydroxyapatite into the bone matrix. Hydroxyapatite is a stiffening mineral composed of calcium and phosphor-us ions; also, hydroxyapatite contributes to overall bone mass as it is a heavy and dense mineral (Martin 2007). Bone mass is determined by both the volume and density of the bone under review. Males typically have a higher bone mass than females due to the larger volume and size of the male skeleton. In a controlled situation in which males and females share the same levels of activity, the bone densities between the two sexes are equal (Parfitt 2004). Only in situations in which either of the sexes uses a particular bone more intensively than the other do densities begin to deviate (Parfitt 2004). Furthermore, bone tends to strengthen with age as the peak bone mass is typically reached between late adolescence and the age of 30 (Bonjour et al. 2003). Afterwards, degenerative processes reduce mass as the individual's metabolic and osteo-blastic activities decline (Niinimaki 2011, 2012; Parfitt 2004).

MSMs occur at entheses, that is, the sites at which soft tissues, including tendons and ligaments, attach to the periosteum and the bony cortex (Cardoso and Henderson 2010; Hawkey and Merbs 1995; Lieverse et al. 2009; Molnar 2006; Molnar et al. 2011; Niinimaki 2011; Steen

and Lane 1998; Villotte et al. 2010; Wilczak 1998). Entheses are either fibrous or fibro-cartilaginous, depending on the location at which they attach to the bone. Fibrous entheses attach to the diaphyses of long bones (e.g., pectoralis major, deltoid, teres major, and latissimus dorsi) and are characterized as having a large surface area with minimal soft tissue movement (Cardoso and Henderson 2010; Niinimaki 2012). Cardoso and Henderson (2010: 551) explain that "the margins of fibrous entheses are difficult to define macroscopically." Furthermore, fibrous entheses can be divided into bony or periosteal attachments depending upon to which surface the soft tissue adheres (Niinimaki 2012). Conversely, fibrocartilaginous entheses are found in close proximity to the joints (e.g., supraspinatus, infraspinatus, teres minor, and subscapularis). Due to their smaller area of attachment, a more localized strain is applied during muscle contraction, thereby allowing for a more pronounced expression of the MSM. Fibro-cartilaginous entheses are the ones on which most studies focus (Cardoso and Henderson 2010). The use of entheses for reconstructions of past behaviors has been questioned because they display a range of responses to stress, including smooth protrusions, rough protrusions, pitting, exostoses, and combinations of these features (Molnar 2006).

Hawkey and Merbs (1995: 324) noted that "the use of MSM for habitual activity analysis operates under the assumption that degree and type of marker are related directly to the amount and duration of habitual stress placed on a specific muscle." However, the mechanisms involved in MSM development are multifactorial and include age, body size, genetic predisposition, sex (i.e. hormones), diet and nutrition, health and disease, and activity patterns and muscle use (Lieverse et al. 2009; Molnar 2006; Niinimaki 2012; Ruff et al. 2006; Wilczak 1998). While understanding the extent to which each of these factors contributes to MSMs has eluded anthropologists thus far, many studies have established a strong correlation between age and

body size to MSMs (Cardoso and Henderson 2010; Molnar et al. 2011; Niinimaki 2011; Weiss 2007). Age has been established as a key factor in MSM formation based on the rationalization that the extensive use of a muscle over the span of many years gives the bone plenty of time to adjust to the stress. Therefore, older individuals typically have higher MSM scores than younger individuals. In fact, juveniles rarely exhibit noticeable MSMs as the entheses 'migrate' along the axes of long bones until biological maturity is reached and the entheses become fixed in one location (Niinimaki 2011). However, Cardoso and Henderson (2010) note that, if repetitive activities begin at earlier ages, then one can expect earlier MSM formation, which may negate age-related increases.

Past studies have examined the variation of MSM scores between males and females and have suggested that they can be indicative of a sexual division of labor in which males, with larger MSM scores, practice more strenuous activities. However, when controlled for size, sex differences in MSM scores disappear (Niinimaki 2011; Weiss 2007). This fact has led anthropologists to conclude that the sexual dimorphic values of MSMs are more closely correlated to the size of the skeleton and not the sex of the individual (Molnar et al. 2011). Larger skeletal structures require larger muscles for adequate locomotion; therefore, more stress is applied, which causes larger MSMs to develop.

2.1.1: Scoring Musculoskeletal Stress Markers

Hawkey and Merbs (1995) proposed a scoring method for recording the degree of development of MSMs which serves as the standard methodology used by many researchers; a detailed description of the scoring criteria is discussed later (pg. 34). Before scoring skeletal remains, Hawkey and Merbs (1995) describe ideal criteria that one should follow. First, remains

should be relatively well preserved and free from alterations caused by disease. One must be cautious when scoring MSMs near articular surfaces, as pathological lesions or trauma can skew or hide their development (Molnar et al. 2011). Second, the sample should be comprised of individuals in a relatively narrow temporal window, as subsistence strategies and activity patterns are in constant flux (Hawkey and Merbs 1995). For example, results would be skewed if a pre-agricultural population was grouped with a population from the same region after the implementation of agricultural practices. The MSM scores and robusticity of the lower limbs are typically higher in mobile hunter-gatherers (Holt 2003), while those of the upper arms are higher among agriculturalists (Eshed et al. 2004). Since the purpose of this study is to compare the variation of humeral MSMs between the two populations, this second caveat does not apply.

Hawkey and Merbs (1995) conclude that anthropologists should confine their studies to genetically-isolated and geographically-confined populations. In the case of my analysis, the populations are not separate genetic populations. Indeed, the analysis of nonmetric cranial traits by Byers and Saunders (in press) of remains from four sites indicates that migration of foreign peoples did not occur in Louisiana; therefore, the remains from the two sites analyzed in this study should not have genetic variation that would result in anomalous skeletal morphologies. Finally, Hawkey and Merbs (1995) argue that, when possible, one should have a general idea of any specialized activities, whether through written records or postulated from archaeological materials (Hawkey and Merbs 1995).

2.1.2: Musculoskeletal Stress Markers and Activity Patterns, Past and Present

Modern clinical studies of individuals with known occupations have helped establish the relationship between MSM, bone biomechanics, and activity patterns, and are vital in under-

standing the roles of activity on MSM development. Also, such studies are beneficial in that the age and sex of the individuals are typically known. If these studies can show a relationship between activity levels and MSM development, then the same relationships can be applied to archaeological samples for activity-level and subsistence pattern reconstructions (Cardoso and Henderson 2010; Niinimaki 2012). Analyses have demonstrated that individuals who exercise regularly develop thicker cortical bone, a fact which supports the localized effects of habitual behaviors on bone (Stock and Pfeiffer 2001). Furthermore, athletes are great examples of individuals who practice habitual activities and, thus, provide data which are helpful for inter-preting behaviors of past peoples. A general thickening of the cortical bone of the proximal, middle, and distal humeral diaphysis noted in multiple studies "provide[s] evidence that the influence of strenuous and intense upper limb biomechanical loading is associated with variation in bone structural properties" (Shaw and Stock 2009: 161).

Niinimaki (2011) analyzes 108 individuals of known age, sex, and occupation (character-ized as either heavy or light labor) from the early 20th Century. She scores the MSMs of the pectoralis major, teres major, and biceps brachii entheses of the humerus and then uses analysis of covariance (ANCOVA) to discern the relationships between age, sex, occupation, body size, laterality, and MSM scores. Her results indicate that age and muscle size are the only significant covariates for MSM development. Also, since muscle size and body size are strongly correlated to one another, Niinimaki argues that body size should be considered in future studies of MSM. Males typically have higher MSM scores; however, when adjusted for muscle size, she finds that the difference between sexes disappears, suggesting that the 'strenuous' activities associated with males are not as influential on MSM development as previously believed. Her analysis shows that heavy labor in early adulthood does, indeed, increase the rate in which MSMs develop and

that they 'plateau' sooner than in the light labor group. However, the light labor group's scores eventually catch up, thereby making levels of labor intensity in older individuals (approximately > 50 years) indistinguishable from each other. She also finds that laterality has little impact on MSM scores because heavy labor typically requires both hands, while light labor and hand dominance are associated with precision tasks. This finding is mirrored in Steen and Lane's (1998) study of two Alaskan Eskimo populations in which bilateral asymmetry is not evident due to the use of both arms during most of their subsistence activities. Niinimaki (2011) concludes that biomechanical factors, such as bone distribution in shafts and bone mineral density, should be considered alongside MSM scores.

Villotte et al. (2010) analyze humeral entheses of 367 historic individuals of known age, sex, and occupation (enumerated into four categories: one 'non-manual' labor and three of varying degrees of manual labor) and find that age, laterality, and occupation are all significant factors in MSM expression. Similar to Niinimaki's 2011 study, Villotte et al. (2010) find that MSM scores increase with age and become less indicative of physical activity in older individuals as labor groups become indistinguishable. Further, they find that body size also is an important factor. While their study shows a strong correlation with MSM to laterality and occupation (only in the two more strenuous categories), the authors caution that other factors such as genetics may have biased the sample. However, they offer an alternate explanation. They note that fibrous and fibrocartilaginous entheses experience different stress loads. Specifically, fibrocartilaginous entheses are more directly influenced by habitual activity (Villotte et al. 2010).

Cardoso and Henderson (2010) analyze four humeral entheses (subscapularis, supra-spinatus, infraspinatus, and teres minor) of 111 historic males of known age and occupation

(divided into manual and non-manual groups). They find a strong correlation to age and, also, that manual laborers have slightly higher MSM values; however, the numbers are not statistically significant. They suggest that MSM studies of past populations can give insight into the socio-economic status as the more strenuous subsistence activities are those of the lower classes. However, they also caution that the age at which these work related activities began in their population is unknown, and that the types of activities in which these individuals participated outside of work are unknown as well. Cardoso and Henderson (2010) conclude that these factors (age in which work began and non-work activities) should be taken into consideration when interpreting MSM scores and applying them to activity patterns.

Modern clinical studies provide essential data when attempting to reconstruct past behavior and subsistence activities. Niinimaki (2012) conducts a comparative analysis doing just that. She looks at humeral size, MSMs (pectoralis major, teres major, and deltoid), and the bending and torsional rigidity (i.e. biomechanical strength) of the humerus in two archaeological samples and one modern sample to see how these osteological features change over time. She uses analysis of variance (ANOVA) to find correlations between age, sex, and laterality. Niinimaki's (2012) results indicate that habitual use of the humerus decreased over time as evidenced by decreases in the biomechanical strength and MSM prevalence. This shift is expected as modern populations generally participate in less strenuous activities compared to the agriculturally based economies of the two Medieval England samples included in this study. As with modern clinical studies, Niinimaki (2012) finds that age is the key factor in determining MSM expression and biomechanical strength. She also found a strong relationship between MSMs and the biomechanical strength in the dominant side (right) in males but not in females. Niinimaki (2012) argues that the strong correlation in males only is due to more strenuous

activities, which leads her to suggest that future studies should consider both MSMs and bio-mechanical strength in the male's dominant arm. Finally, she found that MSMs show little bilateral asymmetry; however, biomechanical values are more asymmetrical, leading her to conclude that biomechanical factors may be better indicators of handedness than MSMs (Niinimaki 2012).

Eshed et al. (2004) also conduct a comparative analysis; however, they review 21 MSMs of the humerus, clavicle, scapula, radius, and ulna of two archaeological samples from the Levant. The first sample belongs to the Natufian culture of the early Holocene and represents a complex hunter-gatherer society. Some argue that these peoples were close to becoming agricul-turalists, but their progress was interrupted by unknown factors. The second group is that of Neolithic agriculturalists. Eshed et al. (2004) find that both sexes have higher mean MSM values in the agricultural Neolithic peoples. Like the previous study, this shift is expected because activities associated with agriculture (e.g., tilling, plowing, harvesting, etc.) are more strenuous on the upper limbs than those associated with hunting and gathering. The authors also suggest that the incorporation of mud brick manufacturing for building construction in the Neolithic society would also have influenced physical activity levels, ergo, MSM development. The scores of the humerus are higher in males than in females in both populations which, again, are more a result of size than sex. Finally, with regard to the lower arm, the authors find that MSM scores are higher in females than males. They conclude that these MSMs are a result of precision tasks typically associated with females' activities such as skinning and preparing hides for clothing, as well as weaving, basketry, and cooking. Also, the females from the Neolithic collection have higher MSM scores than the Natufian women, leading the authors to conclude

that the workload for women in the agricultural society had been more strenuous (Eshed et al. 2004).

The final archaeological case study discussed is one in which specific activities are postulated and reviewed. Molnar (2006) analyzes the remains of hunter gatherers near the Baltic Sea whose diet, supported by isotopic analyses, was marine-based. Molnar (2006) hypothesizes that three activities would have been practiced: archery in terrestrial hunting, harpooning marine life, and kayaking. All of these activities are supported by material recovered from the archaeo-logical record. The muscles used in archery are the supraspinatus and infraspinatus in the string-arm, and the deltoid and triceps in the bow-arm. The muscles associated with harpooning include the deltoid, pectoralis major, teres minor, supraspinatus, infraspinatus, and the sub-scapularis. As harpooning would have been practiced by the dominant arm, higher MSM scores would be expected on that one side. Finally, kayaking muscles include the latissimus dorsi, triceps, and the deltoid. As the three proposed activities use similar muscles, Molnar (2006) ultimately was unable to attribute a specific activity to the development of particular MSMs. Similar to other studies, Molnar (2006) notes that MSM values are strongly correlated to age and size. The MSM scores show little bilateral asymmetry, which also is consistent with other studies. The males in this study have scores consistent with practicing archery and harpooning with the right arm, which likely is indicative of handedness. However, no strong correlations can be made with the kayaking muscles because paddling techniques (one-sided, two-sided, kneel-ing, sitting, etc.) vary from situation to situation and between individuals. Females in this study do not have any MSM values that were suggestive of the proposed activities, a fact which is not unexpected as males typically perform these activities in these populations (Molnar 2006).

2.1.3: Summary

As Wolff's Law suggests, bone develops where it is needed, that is, in response to stress. Since muscles place strain on bone when contracted, anthropologists assume the development of MSMs is related to activity patterns. Indeed, many studies have addressed this assumption (Chapman 1997; Churchill and Morris 1998; Eshed et al. 2004; Hawkey and Merbs 1995; Lieverse et al. 2011; Molnar 2006; Molnar et al. 2011; Niinimaki 2012; Steen and Lane 1998; Weiss 2007), following a standardized scoring method proposed by Hawkey and Merbs (1995); however, discernment of a direct relationship between the two has eluded researchers. Most studies agree that age and body size have the greatest influence on MSM development (Cardoso and Henderson 2010; Eshed et al. 2004; Molnar 2006; Niinimaki 2011, 2012; Villotte et al. 2010). Other factors, such as bilateral asymmetry and workload, have provided mixed results. Niinimaki (2011, 2012), Steen and Lane (1998), and Molnar (2006) do not find a statistically significant relationship between MSMs and bilateral asymmetry; however, Villotte et al. (2010) does find a relationship between bilateral asymmetry and MSMs among males from a modern population whose occupation is categorized as strenuous. Eshed et al. (2004) also finds a relationship between heavy workloads and MSM development in modern populations. These studies indicate that our understanding of the relationship between MSMs and activity patterns is incomplete. Too many factors can contribute to MSM development, including age, body size, genetics, sex, diet, and health; therefore, more studies are needed to elucidate said relationship.

2.2: Culture History and Site Review

Louisiana archaeological excavations have advanced since the mapping and profiling efforts of 19th century enthusiasts. The naturalist William Dunbar was commissioned by the

United States government in 1804 to document and describe the mounds of Louisiana. His

discovery of the Troyville site (16CT7) drew the attention of photographers, artists, and amateur

excavators (Neuman 1984). Nevertheless, archaeology did not concern itself with formal studies

of culture history until the early 20th century when more systematic excavation strategies were

adopted (Byrd and Neuman 2010). During the 1930s, the Great Depression prompted President

Franklin Roosevelt to implement federal relief programs, one of which, the Works Progress

Administration (WPA), funded extensive archaeological excavations. In conjunction with

Louisiana State University (LSU), WPA projects promoted such systematic excavations and the

recording of past cultures from Louisiana (Byrd and Neuman 2010; Ford 1951; Ford and

Quimby 1945; Neuman 1984; Rees 2010). Beginning in 1938, these LSU-WPA excavations

yielded the data necessary to construct a chronology of Louisiana's culture history (Table 1).

The osteological remains from two LSU-WPA archaeological sites, the Tchefuncte (16ST1) and

Greenhouse (16AV2) sites (Figure 1), are analyzed in this study. Therefore, the scope of the

culture history review is narrowed to the Tchefuncte and Coles Creek cultures, and these

respective sites.

2.2.1: The Tchefuncte Culture

The Tchefuncte culture (1,000 B.C. – A.D. 1) is one of the earliest for which we have

data on human remains and burial practices, subsistence patterns, and the widespread production

and use of pottery. Tchefuncte sites extend northward to southeast Arkansas, westward to the

mouth of the Sabine River, and eastward to the Pearl River (Neuman 1984). In south Louisiana,

Tchefuncte sites are characterized by large shell middens located along the Gulf Coast and

extensive earth middens located along the tributaries of the Mississippi River (Ford and Quimby

Table 1. Chronology of Louisiana's Culture History.

Date	Period	Culture	Site(s)
11,500 - 8,000 BC	Paleoindian	-	-
8,000 - 1,000 BC	Archaic	-	-
1,000 BC - AD 1	Tchefuncte	Tchefuncte	Tchefuncte, Big Oak Island
AD 1 -400	Marksville	Marksville	Marksville
AD 400 - 700	Baytown	Troyville	Troyville
AD 700 - 1,200	Coles Creek	Coles Creek	Greenhouse
AD 1,200 - 1,700	Mississippian	Plaquemine	Medora

Figure 1. Location of Sites.

1945). Since the Middle Archaic (6,000 – 2,000 BC), the climate and environment of the region

had stabilized, allowing for increased sedentism, regional specialization of subsistence activities,

and population growth (Lewis 1991; Saunders 2010). Early 20th century excavations of the

Little Woods Middens (16OR1-5) site near the south shore of Lake Pontchartrain, the Big

Oak Island site (16OR6) near New Orleans, and the Tchefuncte site (16ST1) near Mandeville,

provide the bulk of data regarding Tchefuncte culture and subsistence in south Louisiana (Ford

and Quimby 1945; Neuman 1984). Settlement patterns of scattered camps, floral and faunal

remains, and cultural materials are indicative of specialized hunter-fisher-gatherers with limited

trade networks (Hays and Weinstein 2010; Lewis 1991; Neuman 1984). Typically, human

burials from Tchefuncte sites are of flexed individuals that lack associated grave goods (Ford and

Quimby 1945; Hays and Weinstein 2010; Lewis 1991; Neuman 1984). The absence of grave

goods, or other specialized burial practices, is indicative of an egalitarian society.

In early culture histories, the prominence of *Rangia cuneata* (a brackish-water clam) in

the middens led to the assumption that the gathering of shellfish was the primary subsistence

strategy of the Tchefuncte people. However, faunal analysis has shown that the nutritional value

of the small clam could not have supported local populations (Byrd 1977). Floral and faunal

remains from Tchefuncte sites indicate a diverse diet representing procurement of resources from

variable environmental niches (Lewis 1991). Remains of deer, raccoon, opossum, muskrat, bear,

and fox are indicative of terrestrial hunting while those of water fowl, alligator, turtle, otter, cat-

fish, and black drum, along with *Rangia*, are indicative of exploitation of riverine and marine

resources (Hays and Weinstein 2010; Lewis 1991; Neuman 1984). Saunders (2013, personal

communication) notes that small fish may be under-represented in the archaeological record

from Tchefuncte sites due to the large screen size typically used in previous excavations (i.e.,

Byrd 1977). Analysis of botanical remains from Louisiana sites indicates that hickory nuts,

acorns, plums, grapes, and persimmons were also important components of Tchefuncte subsis-

tence (Neuman 1984).

Artifact assemblages from Tchefuncte sites support a subsistence economy based on

hunting-fishing-gathering and include stone points, plummets, awls, hammerstones, mortars, and

boatstones, or atlatl weights, along with harpoon heads and fish hooks fashioned from bone

(Ford and Quimby 1945; Hays and Weinstein 2010; Lewis 1991; Neuman 1984). Shell tools are

also common (Saunders 2014, personal communication).

2.2.2: The Tchefuncte Site (16ST1)

The LSU-WPA excavations of the Tchefuncte site (16ST1) began in 1938, and were

directed by Clarence L. Johnson, an historian with the Civilian Conservation Corps. The site is

located in Fontainbleau State Park in St. Tammany Parish, approximately four miles east of

Mandeville, LA. The site is composed of two elongated, oval-shaped, shell middens, designated

Midden A and Midden B; these measure approximately 250 by 100 feet and 150 by 100 feet at

the base, respectively. The long axes of the middens parallel the present shoreline of Lake

Pontchartrain, located half a mile south of the site (Ford and Quimby 1945). Johnson's excava-

tions of Midden B yielded a significant amount of cultural remains. His subsequent report

prompted a second LSU-WPA-funded expedition to continue excavations on Mound B and begin

excavations of Mound A (Lewis 1991). In 1941, Edwin B. Doran, Jr. returned to the site and

excavated a portion of both mounds to their base. The combined efforts of Johnson and Doran

yielded approximately 50,000 artifacts, including pottery sherds, stone and bone tools, floral and

faunal remains, ornamental shell and ceramic objects, and human burials (Ford and Quimby 1945; Neuman 1984).

The Tchefuncte site is located on the edge of dry land surrounded by marsh (Ford and Quimby 1945). During the Tchefuncte Period (1,000 BC – AD 1), the site was located at the convergence of four ecosystems (brackish-water lake, salt marsh, fresh water bayou, and terrestrial woodlands) which allowed the Tchefuncte people to exploit a variety of faunal resources. All four ecosystems are represented in the 44 taxa Lewis (1991) identified in her reevaluation of the faunal remains. Like today, the site was near the shore of Lake Pontchartrain and surrounded by salt marsh. Doran's trench profiles and soil borings from Mound A indicate that the "middens were deposited on a sloping sand beach which overlaid the clay Prairie Terrace formation" (Ford and Quimby 1945: 13). The sandy beach indicates the site was located near the shore of the lake. The large number of *Rangia cuneata* that comprise the middens, accompanied by sheepshead and black drum remains, attests to the importance of brackish-water fishing activities in the lake and the surrounding salt marsh. Fresh water riverine species' remains, such as alligator, catfish, turtle, otter, and beaver, recovered from the site suggest utilization of nearby fresh water bayous (Lewis 1991). Upon consultation with a geologist, Ford and Quimby (1945: 13) note that "at the time of Tchefuncte occupancy there was a large bayou of fresh water which emptied into the lake east of the site;" the bayou has since shifted further east. Finally, Lewis (1991) notes the presence of white tail deer, bear, fox, cougar, raccoon, and squirrel bone among the faunal remains recovered from the Tchefuncte site, with white tail deer comprising 60% of the non-human vertebrate remains. This data indicate that the Tchefuncte people occupying the site were well adapted to hunting in a forested environment. The faunal remains support Lewis' (1991: 178-179) concluding statement: "that the Tchefuncte Indians were a hunting/gathering

society well adapted to the estuarine/river-ine/terrestrial/marine ecosystems…becomes clear when looking at the fauna they exploited."

During the 1941 excavations, Edwin B. Doran, Jr. uncovered 43 human burials from Midden A of the Tchefuncte site. Twenty-one individuals were buried in a flexed position while 22 were secondary, bundle burials. Eleven of the flexed burials were oriented with the skull towards the east. The burials were probably placed in shallow pits; however, the color and consistency of the midden did not allow for the delineation of the pits. All burials lacked grave goods (Ford and Quimby 1945).

Lewis (1991) provides a review and paleopathological analysis of the human burials excavated from the Tchefuncte site. Numerous pathologies were considered, including trepone-matoses, osteomyelitis, anemia, and osteoarthritis. The most frequent pathological skeletal manifestation was found on the tibiae (22 of 75, or 29%), the lesions of which were consistent with the responses to infection caused by the bacterium *Treponema pallidum*. Due to the dearth of evidence supporting the pre-Columbian existence of venereal syphilis in the New World and the lack of cranial involvement among the Tchefuncte remains (i.e. *caries sicca*), Lewis (1991) argues that these pathological responses are the result of endemic syphilis or yaws. Despite the presence of endemic syphilis, the population appears to have been healthy, as evidenced by the age at death of the remains. Approximately two-thirds of the population was aged over 40 at the time of death. Furthermore, Lewis (1991: 192) notes that "several of the more diseased individu-als are aged over 40. Three [individuals] are aged at 30-40 years." The presence of the disease does not appear to have affected the people's daily activities significantly. The well-developed muscle attachment sites from pathological bone, as noted by Lewis (1991: 56), are indicative of "excessive physical activity." Finally, Lewis (1991) records the presence of ear exostoses in 6 of

28 individuals (21%). This osteological response is associated with water-oriented activities, such as swimming or diving, and is consistent with what one would expect to find in an estuarine/riverine/marine adapted society, much like the Tchefuncte.

2.2.3: The Coles Creek Culture

The Coles Creek Period (A.D. 700 – 1,200) is characterized as a time in which population increased and centralized polities emerged (Kidder and Fritz 1993). Indeed, sites containing platform mound complexes became larger and more numerous, suggesting some kind of control over regional labor (Brown 1984). These mound complexes served as political and/or religious centers, and possibly were the residences for elite members of society (Kidder and Fritz 1993). The combination of centralized power and population growth may have been the impetus for the adoption of intensive maize agriculture during the subsequent Mississippian Period (A.D. 1,200 – 1,700) (Kidder and Fritz 1993; Roe and Schilling 2010).

Most of the Coles Creek people lived in scattered hamlets, and their subsistence econo-mies, like those of their predecessors, focused on hunting and gathering wild resources. Indeed, bioarchaeological (Harmon and Rose 1989; Listi 2008, 2011), faunal (Roe and Schilling 2010), and archaeological (Neuman 1984) data support this categorization. Harmon and Rose (1989) note arthritic lesions from skeletal remains that are similar to manifestations seen on hunter-gatherers. Also, the results of isotopic and oral pathology analyses of Coles Creek skeletal remains indicate a diet consistent with other hunter-gatherer societies (Listi 2008, 2011). Faunal remains from the mound complexes contain more deer, and better cuts of deer than outlying sites. Excavations from village sites and middens are dominated by marine and riverine species, indicating the utilization of various ecosystems (Roe and Schilling 2010). While not conclusive,

this pattern of faunal remains may be indicative of differential distribution of food resources,

further supporting the notion of social stratification. This pattern may also be indicative of

regional variation of subsistence practices. Kidder and Fritz (1993) observed an increase in fresh

water marine exploitation at the Osceola (16TE2) site when compared to the neighboring, and

contemporaneous, Reno Brake (16TE93) site, which was dominated by deer remains.   Finally,

Brown (1984) notes a reliance on marine resources along the Louisiana coast and the Mississippi

Delta. He refers to these Coles Creek peoples as a "marsh-adapted culture" (Brown 1984: 101).

Subsistence data, along with utilitarian pottery, and stone and bone artifacts from Coles Creek

site are suggestive of a hunting/gathering society well adapted to their regional environments,

much like the Tchefuncte (Neuman 1984).

The timing of the arrival of intensive maize agriculture in the Lower Mississippi Valley

has been addressed in previous studies (Belmont 1967a; Brain 1976; Brown 1984; Kidder and

Fritz 1993; Rose et al. 1984). While bioarchaeological data indicate the increased consumption

of starchy foods, as evidenced by stable isotope analysis oral pathology frequencies (Listi 2008,

2011), the archaeological record does not indicate intensive maize agriculture until the

Plaquemine-Mississippian Period (Neuman 1984).

2.2.4: The Greenhouse Site (16AV2)

The WPA-funded excavations of the Greenhouse site (16AV2) began in 1938, and were

directed by Robert S. Neitzel and Edwin B. Doran, Jr. The site, located near Marksville, LA, in

Avoyelles Parish, consists of seven earthen mounds designated Mounds A through G. Three

large mounds (A, E, and G) form a right triangle around a plaza measuring approximately 300

feet on one side (between A and E), and 200 feet on the other sides (between A and G, and E and

G). Mounds B, C, and D are between Mound A and Mound E, while Mound F is between

Mound E and Mound G (Ford 1951). Mounds A and B, and Mounds E and F are connected to

each other by a low ridge (Ford 1951; Kassabaum 2011; Neuman 1984). Mounds C and D are

connected and were labeled as mounds by Gerard Fowke, the first archaeologist to visit the site

in 1926; however, Ford (1951) notes that these two "mounds" were merely a one foot elevation

in which the deceased were interred. For the sake of continuity, archaeologists have continued to

refer these two as mounds. The lack of satellite buildings or a nearby village site indicates that

the Greenhouse site was strictly a ceremonial center (Ford 1951). The site yielded approximate-

ly 125,000 pottery sherds and artifacts, marking one of the largest collections attributed to the

Troyville and Coles Creek cultures (Neuman 1984). The site sits atop an ancient natural levee

approximately 300 feet east of a steep bluff exposing the eastern edge of the Prairie Terrace. The

area is subject to annual flooding of the Red River, as evidenced by the upper layer of soil. Ford

(1951) suggests that the conditions during the Coles Creek period would not have differed,

which would explain why the site was a ceremonial center lacking an adjacent village. Trench

profiles and soil borings performed by Neitzel and Doran indicate that during occupation of the

site, "an open lake of Mississippi origin" lay directly to the east (Ford 1951: 16). The side of the

plaza between Mounds A and E was parallel to the shore.

Excavation of a 25 by 30 foot area of Mound C uncovered 84 human burials. The major-

ity of the interred were secondary burials in the extended, supine position (Belmont 1967b; Ford

1951; Kassabaum 2011; Neuman 1984). Four flexed burials were uncovered as well. Mound A

yielded eight human burials in either the supine or flexed position. The Mound A burials were

probably of higher status individuals, as burials within the mounds were usually reserved for the

elite members of society (Saunders 2014, personal communication). Finally, one juvenile burial

was excavated from below Mound F. No grave goods were associated with any of the burials from the site (Ford 1951).

Ford (1951) attempted to construct a chronology of site occupancy and the interments. Cultural refuse excavated from below Mound A were diagnostic of the Troyville culture; therefore the site was occupied and utilized prior to the Coles Creek period. The exploration trenches and analysis unit near Mounds C and D provide cultural material consistent with the latter half of the Coles Creek period. However, Ford (1951) believed that most of the burials were dated to the Baytown Period (A.D. 400 – 700) (i.e., Troyville culture). Reanalysis of ceramics from the Greenhouse site led Belmont (1967b) to conclude that Ford's estimation was incorrect. All the burials came much later than Ford surmised. A few burials from Mound C can be assigned to the Troyville culture, while the remaining burials, including those from Mounds A and F, are from the Coles Creek culture (Belmont 1967b).

2.2.5: Summary

Both the Tchefuncte (1,000 B.C. – A.D. 1) and Coles Creek (A.D. 700 – 1,200) cultures were hunting-fishing-gathering societies; however, the location of the sites and the utilization of different ecosystems resulted in variable faunal, botanical, and artifact assemblages. The middens from the Tchefuncte site yielded a large quantity of marine resources, along with terrestrial faunal remains. Coupled with faunal remains, tools fashioned from stone, bone, antler, and shell indicate a people well-adapted to the various environments in the area. The site served as a location ideal for Tchefuncte subsistence activities. Although paleopathological analysis indicates the presence of endemic syphilis, the human burials from Midden A included in this study represent a population of relatively healthy individuals, as evidenced by their age at death.

The lack of grave goods from these burials suggests as egalitarian society. Conversely, the Greenhouse site of the Coles Creek period was a ceremonial mound center, suggesting some form of politically organized society. While the site was not used for subsistence activities, evidence from the archaeological record in similar environmental contexts of the area supports the assertion of a riverine/terrestrial hunting-fishing-gathering society. The majority of burials from Mound C are comprised of non-elite Coles Creek people and, therefore, should represent individuals that participated in everyday subsistence behaviors. The burials from Mound A were probably individuals of higher status; for this reason, these humerii were not considered in this analysis. The differences between the Tchefuncte and Coles Creek people (i.e., exploitation of different environments, contrasting socio-political organization, and temporal variation in subsistence behaviors) were considered by examining and scoring the MSMs of the proximal humerii from both skeletal populations.

CHAPTER 3: MATERIALS AND METHODS

The purpose of this study is to test the MSM scores of the humerii from the Tchefuncte (16ST1) and Greenhouse (16AV2) sites from Louisiana for bilateral asymmetry, sexual dimorphism, and inter-populational variation. Specifically, this study tests the MSM scores of synergistic muscle groups to make inferences about subsistence-based activity patterns related to handedness, the division of labor, and diachronic changes in subsistence activities. Since the populations from both sites utilized different subsistence behaviors, the expression of humeral MSMs should be different as well. The analyses of MSM scores will also take into consideration body size, as previous studies have shown that the size of the individual affects the expression of MSMs. The following section discusses the materials used for this analysis and the methods by which the results were produced.

3.1: Materials

The two archaeological sites chosen for this analysis are the Tchefuncte site (16ST1) and the Greenhouse site (16AV2). The Tchefuncte site was occupied and used by the Tchefuncte culture (~800 B.C. – A.D. 1) (Neuman 1984), while the Greenhouse site was first occupied during the Marksville Period (A.D. 1 – 400) and mostly abandoned at the terminus of the Coles Creek Period (A.D. 700 – 1200) (Belmont 1967b). The skeletal remains from both sites are fragmented, but they are in relatively good condition. All humerii are curated at the Louisiana State University Museum of Natural Science (LSUMNS), and the humeral counts are listed below in Tables 2 and 3.

A total of 57 humerii from 36 individuals represents the available humeral specimens from the Tchefuncte site (Table 2). Based on calculations of the humeral head dimensions

(discussed below), 23 individuals are male, eight are female, and five remain unsexed. Of the

humeral count, 41 belong to males (20 left and 21 right), 10 belong to females (six left and four

right), and six belong to individuals whose sex could not be determined (two left and four right).

Table 2. Humeral Count from the Tchefuncte Site.

Sex (MNI)	Left				Right				Total
	Complete	Proximal	Distal	Shaft	Complete	Proximal	Distal	Shaft	
Male (23)	1	2	8	9	1	4	7	9	41
Female (8)	0	1	2	3	1	1	0	2	10
Unknown (5)	0	0	0	2	0	0	0	4	6
Total	1	3	10	14	2	5	7	15	57

A total of 45 humerii from 29 individuals represents the available humeral specimens

from the Greenhouse site (Table 3). Based on calculations of the humeral head dimensions, 15

individuals are male, 12 are female, and two remain unsexed because they belong to juveniles.

Of the humeral count, 22 belong to males (11 left and 11 right), 21 belong to females (10 left and

11 right), and two belong to juveniles (both left).

Table 3. Humeral Count from the Greenhouse Site.

Sex (MNI)	Left				Right				Total
	Complete	Proximal	Distal	Shaft	Complete	Proximal	Distal	Shaft	
Male (15)	4	1	3	3	3	2	5	1	22
Female (12)	0	1	5	4	2	3	3	3	21
Unknown (2)	0	0	0	2	0	0	0	0	2
Total	4	2	8	9	5	5	8	4	45

3.2: Methods

Before the statistical tests could be conducted, the side and sex of the humerii had to be determined for tests of bilateral asymmetry and sexual dimorphism, respectively. The NAGPRA inventory housed at the LSUMNS was consulted to sex the individuals analyzed; however, for unknown reasons, numerous entries were not sexed at the time the inventory was compiled. To increase the sample size, a sexing method of humeral measurements developed by France (1983, 1985) from a study of the Pecos Pueblo population was implemented (discussed below). Age also has been shown to have a strong correlation to MSM development. However, due to the fragmentary nature of the skeletal remains, age could not be determined for many of the burials; therefore, the humerii were placed into one of two categories: juvenile or adult. Only nonpathological adult humerii were considered in this analysis.

Following estimates of sex, MSMs of eight muscles that move the upper arm were scored in each specimen. Various statistical analyses were then used to examine MSM scores for bilateral asymmetry, sexual dimorphism, the relationship to skeletal robusticity, and inter-populational variation.

3.2.1: Sexing the Humerii

To estimate sex in the humerus, a method using humeral measurements developed by France (1983, 1985) was used. The measurements used in France's (1983, 1985) methodology include the transverse and vertical diameters of the humeral head, and the biepicondylar and articular width of the humerii (using the standard measurements outlined in Buikstra and Ubelaker (1994)). All measurements were taken with a sliding caliper. For specimens that were

too fragmentary, all measurements and observations possible were recorded. The measurements

of the proximal and distal humerus are depicted in Figure 2 below.
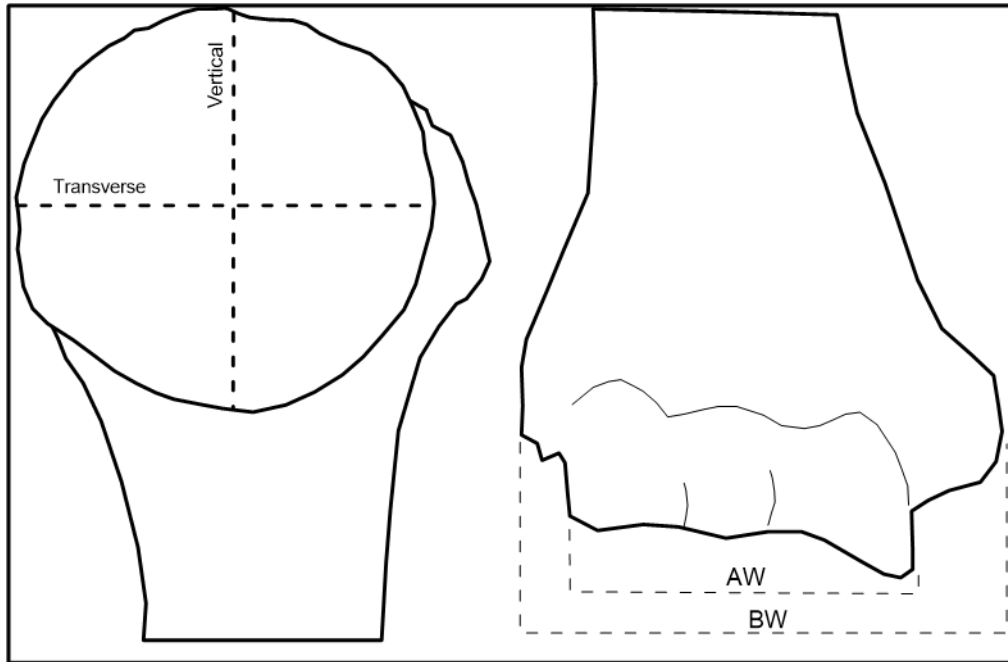
Figure 2. Sexing Measurements: On the left is the medial view of the humeral head showing the vertical and transverse measurements. On the right is the anterior view of the distal humerus showing the articular (AW) and biepicondylar (BW) width measurements.

The calculations for estimating the sex of the humerii are summarized in Table 4 below. After the humeral head measurements are entered into the formulae and calculated, the result is compared to a cutoff value for sexing. The cutoff value for both measurements is 1.477. The humerii with values below this number are indicative of males, and those with values above are indicative of females. France's studies (1983, 1985) of the Pecos population show that sex is correctly identified 89.63% of the time for the vertical humeral head measurement, and 91.61% for the transverse humeral head measurement.

Table 4. Sexing Equations of Humeral Measurements.

	Measurement (x)	y=	Cutoff Value (< = male)	% Accurately Identified
Proximal	Transverse humeral head	$6.475 - 1.299x$	1.477	91.61
	Vertical humeral head	$6.2388 - 1.1645x$	1.477	89.63
Distal	Biepicondylar (x) and articular width (z)	$7.526 - 0.8193x - 0.3719z$	1.52	89.19
	Articular width	$6.827 - 1.3559x$	1.52	87.33
	Biepicondylar width	$7.337 - 1.047x$	1.52	86.54

When the humeral head measurements were not available, the distal end of the bone was used. France (1983, 1985) provides slightly less accurate sex estimation equations using the biepicondylar (BW) and articular widths (AW), individually and together. The cutoff value for all three calculations is 1.52 and, like the measurements of the humeral head, those individuals with values below the cutoff are male, while those above are female. These equations have an accuracy rate of 86.54% for biepicondylar width, 87.33% for articular width, and 89.19% when the measurements are considered together (France 1983, 1985).

Using France's methods (1983, 1985), sex was estimated in this study for all the humerii from both populations, and then compared to the sexes indicated in the NAGPRA inventory. Of the 31 individuals from the Tchefuncte site (16ST1) for which sex could be estimated, 25 were consistent with the sex indicated in the NAGPRA inventory. Of the 20 individuals from the Greenhouse site (16AV2), 18 were consistent with the sex indicated in the inventory. These findings indicate that France's sexing method agreed with the NAGPRA inventory 80.6% of the time for the Tchefuncte population and 90% of the time for the Greenhouse population. The

high consistency rate allowed for the conclusion that individuals without an indicated sex in the NAGPRA inventory could be sexed using France's method.

3.2.2: Musculoskeletal Stress Markers of the Proximal Humerus

The eight muscles of the proximal humerus analyzed in this study include pectoralis major, subscapularis, deltoid, supraspinatus, teres major, latissimus dorsi, infraspinatus, and teres minor. These muscles' attachment sites and their associated movement of the humerus are depicted in Figures 3 and 4 and summarized in Table 5, below.

Table 5. Muscle Attachment Sites and Movement.

Muscle	Origin	Insertion	Movement
Pectoralis major	Sternal end of clavicle	Crest of the greater tubercle	Flexion
Subscapularis	Subscapular fossa of scapula	Lesser tubercle	Flexion and medial rotation
Deltoid	Acromial end of clavicle, acromion, and scapular spine	Deltoid tuberosity	Abduction
Supraspinatus	Supraspinous fossa of scapula	Greater tubercle	Abduction
Teres major	Inferior angle of scapula	Medial border of the crest of the lesser tubercle	Extension and adduction
Latissimus dorsi	Medial iliac crest	Lateral border of the crest of the lesser tubercle	Extension and adduction
Infraspinatus	Infraspinous fossa of scapula	Greater tubercle (infero-posterior to supraspinatus)	Extension and lateral rotation
Teres minor	Lateral border of scapula	Greater tubercle (infero-posterior to infraspinatus)	Extension and lateral rotation

Pectoralis major originates near the sternal end of the clavicle and inserts into the crest of the greater tubercle of the anterior humerus. Subscapularis originates from the subscapular

fossa, as its name suggests, and inserts into the lesser tubercle of the humerus. Both of these

muscles serve to flex the arm; however, subscapularis flexes the arm to a lesser degree than
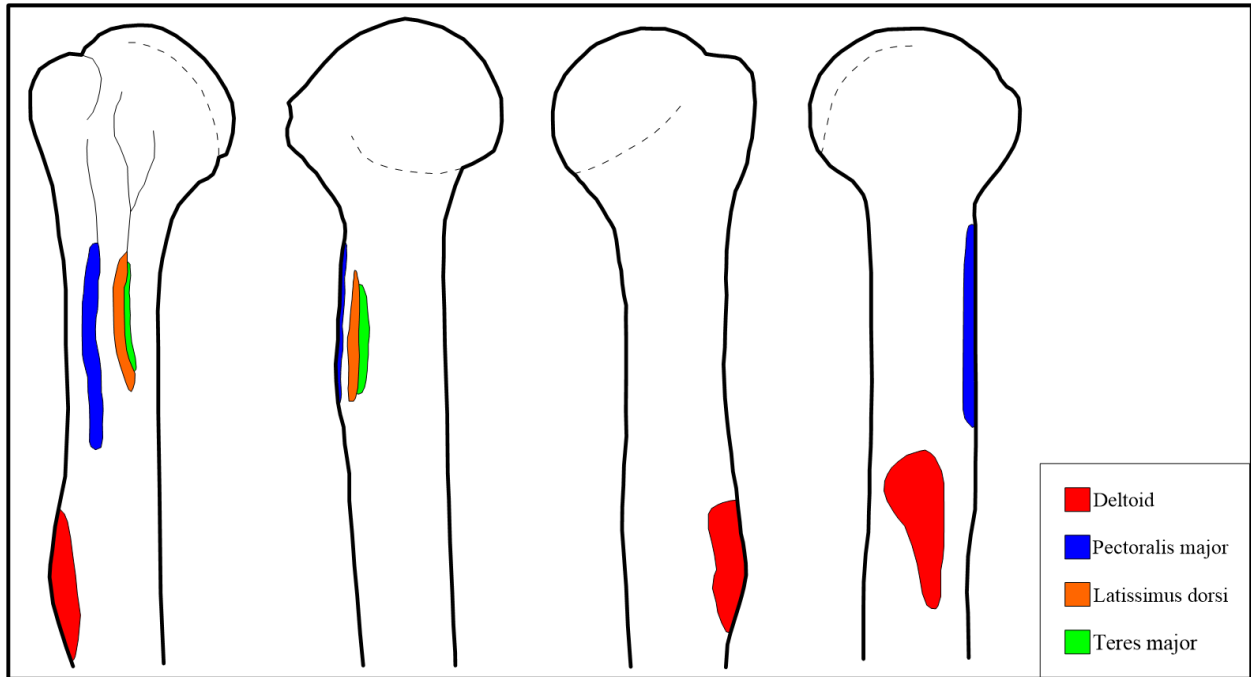

Figure 3. MSM Attachment Sites of the Humeral Shaft: From left to right, the anterior, medial, posterior, and lateral views of the humerus are depicted.
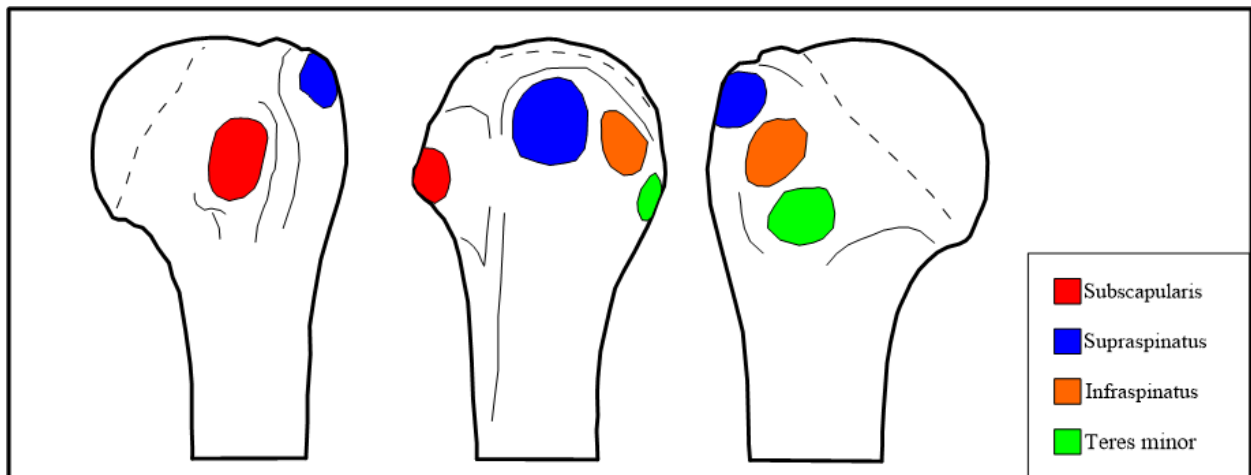
Figure 4. MSM Attachment Sites of the Humeral Head: From left to right, the anterior, lateral, and posterior views of the humerus are depicted.

pectoralis major. Subscapularis also assists in medially rotating the arm. Deltoid is composed of three bodies of muscle originating near the acromial end of the clavicle, along the acromion of the scapula, and along the scapular spine; all of these bodies insert into the deltoid tuberosity of the lateral shaft of the humerus. Supraspinatus originates from the supraspinous fossa of the scapula, as its name suggests, and inserts into the greater tubercle of the humerus. The deltoid and the supraspinatus work synergistically to abduct the arm. Teres major originates from the inferior angle of the scapula and inserts along the medial border of the crest of the lesser tubercle. Latissimus dorsi originates along the medial iliac crest and inserts into the lateral border of the crest of the lesser tubercle of the anterior humerus. Teres major and latissimus dorsi both serve to adduct and extend the arm. Infraspinatus originates from the infraspinous fossa of the scapula, as its name suggests, and inserts into the greater tubercle, just infero-posterior to the insertion site of supraspinatus. Teres minor originates from the lateral border of the scapula and inserts into the greater tubercle, just infero-posterior to the insertion of infraspinatus. Like teres major and latissimus dorsi, infraspinatus and teres minor both serve to extend the arm, however, these muscles also work synergistically to laterally rotate the arm (White et al. 2012).

The eight MSMs (pectoralis major, latissimus dorsi, teres major, deltoid, subscapularis, supraspinatus, infraspinatus, and teres minor) were scored using the method outlined by Hawkey and Merbs (1995) and amended by Molnar (2006) and Weiss (2007). In this method, the development of three features, including robusticity, stress lesions, and ossification (Table 6), are scored on a scale of 0-3, where 0 = absent, 1 = faint, 2 = moderate, and 3 = strong (Hawkey and Merbs 1995).

In the context of MSM analysis, robusticity is defined as the "ruggedness of muscle attachment, which is represented by sharp edges and ridges of bone" (Niinimaki 2011: 293).

Table 6. MSM Scoring.

		Robusticity Scoring
Score	Category	Description
0	absent	
1	faint	cortex is slightly rounded; no distinct crests or ridges; slight indentation and no well-defined surrounding margin of bone
2	moderate	uneven cortical surface; easily observable mound-shaped elevation; no sharp crests or ridges; roughening of attachment site with well-defined surrounding margin of bone
3	strong	distinct, sharp crests or ridges; slight depressions between crests (especially those of the pectoralis major and teres major); deep indentation with a clearly defined margin of bone
		Stress Lession Scoring
Score	Category	Description
0	absent	
1	faint	shallow 'furrow' and pitting into the cortex yielding a lytic-like appearance; pitting less than 1mm in depth
2	moderate	pitting is deeper and covers more surface area; pitting is greater than 1mm but less than 3mm in depth
3	strong	marked pitting; pitting is greater than 3mm in depth
		Ossification Scoring
Score	Category	Description
0	absent	
1	faint	slight exostosis, rounded in appearance; exostosis extends less than 2mm from cortical surface
2	moderate	distinct exostoses, varied in shape; exostoses extends more than 2mm but less than 5mm from cortical surface
3	strong	exostosis extends more than 5mm form cortical surface or covers an extensive amount of cortical surface

Stress lesions are characterized and scored by the amount of pitting present at the site. Finally,

ossification is scored by the expression of exostoses and new bone growth (Hawkey and Merbs

1995). The authors note that exostoses are also formed as a response to bone proliferative pathologies and trauma. Therefore, Hawkey and Merbs (1995) suggest caution when interpreting the ossification score, as it may not be an indicator muscle-use. As a result, subsequent studies have focused only on the robusticity and stress lesion scores. Since the robusticity and stress lesion scores are affected by the strain placed on bone by muscles, Molnar (2006) and Weiss (2007) propose that the two scores should be combined to create a single, ordinal category of total muscle-use, ranging from 0-6. The authors argue that this method allows for easier statistical testing and is more reflective of activity patterns. The current study also combines the robusticity and stress lesion scores, and uses the total muscle-use scale for all statistical analyses.

3.2.3: Length Measures and Robusticity Index

MSMs are affected by the body size of the individual, that is, larger individuals typically have higher MSM scores. Therefore, measurements used for calculating the robusticity of the humerii were taken to run statistical tests that account for body size. The robusticity index is calculated by multiplying the least circumference of the shaft (LC) by 100, and then dividing by the maximum length (MaxL):

$$RI = (LC \times 100) / MaxL \text{ (Bass 2005).}$$

Using the standard measurements outlined in Buikstra and Ubelaker (1994), the maximum length was measured with an osteometric board and the least circumference of the shaft, typically located below the nutrient foramen of the distal shaft, was measured with a soft tape measure (Figure 5).

Only twelve specimens allowed for the maximum length measurement. Therefore, a length measurement from the surgical neck of the proximal humerus (referred to as the proximal
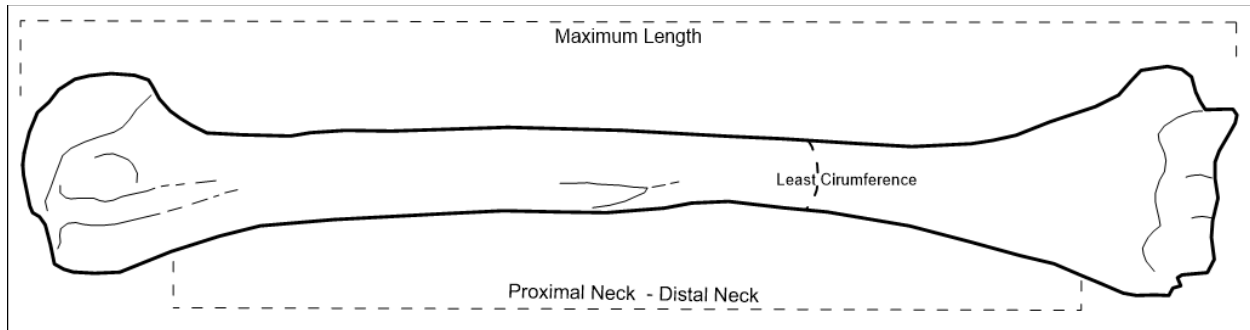
Figure 5. Measurements of the Humerus for Calculating the Robusticity and Relative Robusticity Index.

neck, or pN) to the midpoint of the crest of the medial epicondyle (referred to as the distal neck, or dN) was recorded (Figure 5). The pN-dN length was substituted for the maximum length measurement (increasing the sample size to 40) in the RI equation to calculate the relative robusticity index (rRI). When assessing the relationship between MSM scores and body size, the rRI statistic was used.

3.2.4: Statistical Methods

After all humerii were sided, sexed, measured and scored, the data were grouped into three muscle groups based on the primary motions associated with each group (Table 5, above): extensor-adductors (latissimus dorsi, teres major, infraspinatus, and teres minor MSMs), flexor-adductors (pectoralis major and subscapularis MSMs), and abductors (deltoid and supraspinatus MSMs). For each muscle attachment site, the total muscle-use score was the numerical value used in all statistical calculations. All statistical tests considered the muscle groups individually, as well as in an aggregate muscle group, in which the MSM scores from the three muscle groups were combined. Summary statistics and intra-observer error were calculated using SAS 9.3 computer software. The remaining statistics were calculated using Microsoft Excel.

The MSM scores from the left and right humeral muscle groups were tested for bilateral asymmetry using the Wilcoxon matched-pair signed-rank test. Only the individuals with both left and right humerii were included in this statistical analysis. These tests may allow for inferences about the populations' subsistence activities and handedness. The male and female MSM scores from both sites were tested for sexual dimorphism with the Mann-Whitney U test. The Mann-Whitney U test was also used to test for sex-specific inter-populational variation in the MSM score. Because this test is intended for samples no larger than 30, the U statistic was transformed to a z score and compared to the critical value from the z table when appropriate. Sexually dimorphic MSM scores both within and between sites could be indicative of a sexual division of labor during subsistence activities and may elucidate any change in those activities through time. To test for the relationship between MSM scores and body size, using rRI, the Spearman correlation was used. This test will help to determine whether body size impacted MSM development in these two populations. Finally, to determine intra-observer error in the application of the scoring method, a subsample of 13 humerii were scored twice and a chi square was run to assess consistency. For all analyses, the α-level was set at 0.05.

CHAPTER 4: RESULTS

4.1: Summary Statistics

The summary statistics of the MSM scores for the Tchefuncte (Table 7) and Greenhouse (Table 8) sites are provided below. For each site, the information is presented by sex, muscle group, and side.

Table 7. Summary Statistics of MSM Scores from the Tchefuncte Site (16ST1).

Sex	Muscle Group	Side	n	Mean Score	Standard Deviation	Variance	Standard Error
Male	Abductor	Left	18	2.17	0.804	0.647	0.190
		Right	22	2.50	0.772	0.595	0.165
		Combined	40	2.35	0.794	0.631	0.126
	Extensor-Adductor	Left	26	2.17	0.927	0.859	0.182
		Right	26	2.17	0.812	0.659	0.159
		Combined	52	2.17	0.863	0.744	0.120
	Flexor-Adductor	Left	15	3.37	0.896	0.802	0.231
		Right	16	3.09	0.821	0.674	0.205
		Combined	31	3.23	0.855	0.731	0.154
	Aggregate	Left	59	2.47	1.015	1.030	0.132
		Right	64	2.52	0.868	0.754	0.109
		Combined	123	2.50	0.938	0.879	0.085
Female	Abductor	Left	5	1.30	0.447	0.200	0.200
		Right	5	1.40	0.742	0.550	0.332
		Combined	10	1.35	0.580	0.336	0.183
	Extensor-Adductor	Left	4	2.13	0.629	0.396	0.315
		Right	2	2.25	0.354	0.125	0.250
		Combined	6	2.17	0.516	0.267	0.211
	Flexor-Adductor	Left	3	2.33	0.764	0.583	0.441
		Right	3	2.83	0.577	0.333	0.333
		Combined	6	2.58	0.665	0.442	0.271
	Aggregate	Left	12	1.83	0.718	0.515	0.207
		Right	10	2.00	0.882	0.778	0.279
		Combined	22	1.91	0.781	0.610	0.167

Table 8. Summary Statistics of MSM Scores from the Greenhouse Site (16AV2).

Sex	Muscle Group	Side	n	Mean Score	Standard Deviation	Variance	Standard Error
Male	Abductor	Left	15	2.40	1.070	1.150	0.277
		Right	12	2.58	0.821	0.674	0.237
		Combined	27	2.48	0.956	0.913	0.184
	Extensor-Adductor	Left	21	1.57	0.912	0.832	0.199
		Right	24	1.90	0.752	0.565	0.153
		Combined	45	1.74	0.837	0.700	0.125
	Flexor-Adductor	Left	13	2.96	0.900	0.811	0.250
		Right	11	2.77	0.720	0.518	0.217
		Combined	24	2.88	0.811	0.658	0.166
	Aggregate	Left	49	2.19	1.108	1.227	0.158
		Right	47	2.28	0.846	0.715	0.123
		Combined	96	2.23	0.984	0.968	0.100
Female	Abductor	Left	9	1.67	0.707	0.500	0.236
		Right	12	2.08	0.848	0.720	0.245
		Combined	21	1.90	0.800	0.641	0.175
	Extensor-Adductor	Left	9	1.33	1.090	1.188	0.363
		Right	20	1.45	0.916	0.840	0.205
		Combined	29	1.41	0.955	0.912	0.177
	Flexor-Adductor	Left	5	2.40	0.962	0.925	0.430
		Right	11	3.09	0.889	0.791	0.268
		Combined	16	2.88	0.940	0.883	0.235
	Aggregate	Left	23	1.70	0.974	0.949	0.203
		Right	43	2.05	1.101	1.212	0.168
		Combined	66	1.92	1.064	1.133	0.131

4.2: Bilateral Asymmetry of MSM Scores

Results of the Wilcoxon matched-pair signed-rank test assessing bilateral asymmetry are presented below (Table 9). The test statistic (W), critical value, and p value of n are provided. The test cannot be run on samples where $n \leq 6$. If the W statistic is less than the critical value, then the null hypothesis is rejected. None of the tests are statistically significant; therefore, the remaining tests combine left and right humeral scores to increase the sample size.

Table 9. Results of the Wilcoxon Test for Bilateral Asymmetry.

Tchefuncte (16ST1)						
Sex	Muscle Group	n	W	Critical Value	p	Reject/ Accept H0
Male	Abductors	13	21	17	0.211	Accept
	Extensor-Adductor	14	18	13	0.646	Accept
	Flexor-Adductor	11	27.5	10	0.335	Accept
	Aggregate	40	186	137	0.090	Accept
Female	Abductors	1	-	-	-	-
	Extensor-Adductor	0	-	-	-	-
	Flexor-Adductor	1	-	-	-	-
	Aggregate	2	-	-	-	-
Greenhouse (16AV2)						
Sex	Muscle Group	n	W	Critical Value	p	Reject/ Accept H0
Male	Abductors	5	-	-	-	-
	Extensor-Adductor	8	12	3	0.314	Accept
	Flexor-Adductor	5	-	-	-	-
	Aggregate	20	86	52	0.299	Accept
Female	Abductors	6	-	-	-	-
	Extensor-Adductor	6	-	-	-	-
	Flexor-Adductor	3	-	-	-	-
	Aggregate	15	53.5	25	0.483	Accept

4.3: Sexual Dimorphism of MSM Scores

Results of the Mann-Whitney U test assessing sexual dimorphism in MSM scores are presented in Table 10. The U statistic, critical value, and p value of n are provided in the table. The U statistic had to be transformed to a z score several times due to larger sample sizes; thus, z scores and their corresponding critical and p values are provided when appropriate. If the smaller U statistic is less than the critical value, then the null hypothesis is rejected. For the z score, if the value is outside of the ± 1.96 range, then the null hypothesis is rejected. The

differences between the male and female abductor and aggregate muscle groups from the

Tchefuncte site are the only statistically significant results.

Table 10. Results of the Mann-Whitney U Test for Sexual Dimorphism (* indicates significance).

	Muscle Group	Sex	n	U	Critical Value	z Score	Critical Value	p	Reject/ Accept H0
Tchefuncte (ST1)	Abductors	Male	40	62.5*	-	-3.33	±1.96	0.001	Reject
		Female	10	337.5					
	Extensor-Adductor	Male	52	154.5	-	-0.04	±1.96	0.969	Accept
		Female	6	157.5					
	Flexor-Adductor	Male	31	54.5	-	-1.59	±1.96	0.113	Accept
		Female	6	131.5					
	Aggregate	Male	123	869*	-	-2.67	±1.96	0.008	Reject
		Female	22	1837					
Greenhouse (AV2)	Abductors	Male	27	192.5	188	-	-	0.059	Accept
		Female	21	374.5					
	Extensor-Adductor	Male	45	480.5	-	-1.90	±1.96	0.057	Accept
		Female	29	824.5					
	Flexor-Adductor	Male	24	193.5	120	-	-	0.967	Accept
		Female	16	190.5					
	Aggregate	Male	96	2761	-	-1.39	±1.96	0.165	Accept
		Female	66	3575					

4.4: Inter-populational Variation of MSM Scores

Results for the Mann-Whitney U test for the sex-specific inter-populational variation

between the Tchefuncte and Greenhouse sites are presented in Table 11. The U statistic, critical

value, and p value of n are provided in the table. The z scores and their corresponding critical

and p values are provided as needed. The tests of both the male and female extensor-adductor

muscle groups are statistically significant. Additionally, the aggregate muscle group of the

males is significantly different.

Table 11. Results of the Mann-Whitney U Test for Inter-populational Variation (* indicates significance).

Sex	Muscle Group	Site	n	U	Critical Value	z Score	Critical Value	p	Reject/ Accept H0
Male	Abductors	ST1	40	575	-	-0.45	±1.96	0.655	Accept
		AV2	27	505					
	Extensor-Adductor	ST1	52	837*	-	2.41	±1.96	0.016	Reject
		AV2	45	1503					
	Flexor-Adductor	ST1	31	283.5	-	1.50	±1.96	0.133	Accept
		AV2	24	460.5					
	Aggregate	ST1	123	4985*	-	1.98	±1.96	0.048	Reject
		AV2	96	6823					
Female	Abductors	ST1	10	147.5	58	n/a	n/a	0.073	Accept
		AV2	21	62.5					
	Extensor-Adductor	ST1	6	39.5*	42	n/a	n/a	0.038	Reject
		AV2	29	134.5					
	Flexor-Adductor	ST1	6	56	21	n/a	n/a	0.555	Accept
		AV2	16	40					
	Aggregate	ST1	22	707.5	-	0.18	±1.96	0.859	Accept
		AV2	66	744.5					

4.5: MSMs and Body Size

Results for the Spearman correlation test assessing MSM score and body size (based on rRI) are presented in Tables 12 and 13. The Spearman statistic (r_s) and the corresponding critical and p values of the degrees of freedom (df) are provided. None of the tests were statistically significant.

4.6: Intra-observer Error

Results from the chi square test for intra-observer error in scoring indicates no significant differences ($X^2 = 8.4597$, $p = 0.4890$).

Table 12. Results for the Spearmen Correlation between MSMs and Body Size among the Tchefuncte Remains.

Sex	Muscle Group	n	df	r_s	Critical Value	p	Accept/Reject
Male	Abductor	18	16	0.058	0.468	0.820	Accept
	Extensor-Adductor	34	32	0.188	0.349	0.287	Accept
	Flexor Adductor	19	17	0.384	0.456	0.105	Accept
	Aggregate	71	69	0.138	0.323	0.252	Accept
Female	Abductor	4	2	0.550	0.950	0.450	Accept
	Extensor-Adductor	4	2	0.150	0.950	0.650	Accept
	Flexor Adductor	4	2	-0.350	0.950	0.650	Accept
	Aggregate	12	10	0.062	0.576	0.848	Accept

Table 13. Results for the Spearmen Correlation between MSMs and Body Size among the Greenhouse Remains.

Sex	Muscle Group	n	df	r_s	Critical Value	p	Accept/Reject
Male	Abductor	14	12	-0.082	0.514	0.780	Accept
	Extensor-Adductor	29	27	0.039	0.367	0.841	Accept
	Flexor Adductor	15	13	0.020	0.497	0.944	Accept
	Aggregate	58	56	0.000	0.250	0.998	Accept
Female	Abductor	11	9	0.198	0.602	0.560	Accept
	Extensor-Adductor	21	19	-0.087	0.433	0.709	Accept
	Flexor Adductor	12	10	0.260	0.576	0.414	Accept
	Aggregate	44	42	0.049	0.304	0.751	Accept

CHAPTER 5: DISCUSSION

The goal of this study was to score and compare eight humeral MSMs from two Louisiana archaeological populations to make inferences about subsistence-based activity patterns. The humeral MSM scores were segregated into muscle groups based on the motions associated with the muscles and were tested for bilateral asymmetry (comparing left to right), sexual dimorphism (comparing males to females), and inter-populational variation (comparing Tchefuncte to Greenhouse). The MSM scores were also tested for a correlation to body size. Making inferences about behavioral and subsistence-based activities requires consideration of the many factors that contribute to MSM development. The test for a correlation to body size will be considered alongside the tests for sexual dimorphism, as males are typically larger and, therefore, have higher MSM scores. Bilateral asymmetry and inter-populational variation will be considered individually.

5.1: Bilateral Asymmetry

The MSMs of the left and right humerii were tested for bilateral asymmetry to make inferences about handedness and activity patterns. Previous studies, with the exception of a few cases, indicate that MSMs do not display bilateral asymmetry and are not good indicators of handedness. MSMs are affected by habitual use and strenuous activities, which typically require the use of both arms. Conversely, precision tasks may favor the side-dominant hand, but the strain applied to bone during these activities is not sufficient to trigger a skeletal response. The current study expected the results to follow this pattern. Indeed, none of the tests for bilateral asymmetry are statistically significant. These results justified the grouping of the left and right humeral MSM scores to increase the samples for the remaining statistical analyses.

5.2: Sexual Dimorphism and Body Size

Male and female MSM scores were tested against each other for evidence of sexual dimorphism. Ethnohistoric data suggest that pre-Columbian native societies practiced a sexual division in labor. Males typically were responsible for dealing with heavier loads and participating in more strenuous tasks, while females were responsible for less strenuous domestic activities. Also, males are generally larger than females. Studies have shown a positive correlation between larger individuals and higher MSM scores, suggesting that larger body size results in the development of heavier scores. Therefore, the males should have higher MSM scores than females as a result of both the division of labor and their larger body size. Generally, teasing out which of the two has a greater effect on MSM development is difficult; however, the results of the Spearman correlation (Tables 12 and 13, pg. 42) indicate that MSM development in all muscle groups (individually and aggregate) is not significantly correlated to body size, as approximated by rRI. Therefore, the sexually dimorphic values in this study are attributed to the division of labor during subsistence activities.

As expected, the male MSM scores are significantly different than female scores among the abductor and aggregate muscle groups in the Tchefuncte population (Table 10, pg. 40). The summary statistics (Table 7, pg.37) support this assertion, as the mean MSM scores are higher for males in the two muscle groups (2.35 vs. 1.35 and 2.50 vs. 1.91, males vs. females, respectively). However, one must note that the sample of female MSM scores is small. Therefore, the results from this analysis may not be valid. Nevertheless, the results of the aggregate muscle group suggest that males, in general, had a heavier workload than females. Along with the statistically significant scores for the abductor muscle group, one can postulate that lifting and carrying heavier items was a task reserved for the men in the population. The tests for sexual

dimorphism of the extensor-adductor and flexor-adductor muscle groups are not significant. These results indicate that either these muscle groups were not used during strenuous activities of the males or, more likely, that the load applied to these muscle groups was negligible to MSM development.

Contrary to expectations, none of the muscle groups are statistically significant between the sexes at the Greenhouse site. This result does not indicate that the Coles Creek culture did not practice the division of labor; instead, these results suggest that the general workload between the sexes were similar. The Greenhouse females' workload may have been more strenuous than the females from Tchefuncte population due to different environmental demands during subsistence activities, thereby reducing the difference between males and females. Conversely, the duration and load of the males' overall activity levels may have decreased, when compared to the Tchefuncte males, as a result of their involvement in a more socio-politically organized society. Since the results from the tests for inter-populational variation indicate that the Tchefuncte males have significantly higher scores for the aggregate muscle group, the latter explanation seems more likely.

5.3: Inter-populational Variation

The sex-specific MSM scores from the Tchefuncte and Greenhouse sites were tested for inter-populational variation. As several MSM studies have shown, the amount and duration of loads during subsistence-based activities can be reflected in MSM development. Both populations were hunter-gatherers; however, the two cultures utilized different environmental ecosystems and the latter was probably less egalitarian. The expectation was that Tchefuncte males would have higher scores in the aggregate muscle group than the Coles Creek males due to the

latters' increased involvement in sociopolitical activities, ergo, a decrease in overall activity levels. Also, the males from each population should differ in specific muscle groups associated with the different tools used during hunting activities. Specifically, Tchefuncte males used the atlatl, affecting the flexor-adductor muscle group, while the Greenhouse males used the bow and arrow, affecting the extensor-adductor and abductor muscle groups. As a result, the respective muscle groups would show higher MSM scores. No differences were expected among the female MSM scores, as the domestic tasks usually practiced by women, likely, are not strenuous enough to cause noticeable changes in MSM expression.

As expected, the MSMs from the aggregate muscle group of the Tchefuncte males were statistically significantly heavier than the MSMs from the Greenhouse males, as evidenced by the mean scores (2.50 vs. 2.23, Tchefuncte vs. Greenhouse, respectively). The reduction of MSMs in the latter group may have been a result of the males' reduced levels of activity, possibly associated with an increased role in socio-political practices. These results may also be a response to the nature of the subsistence activities related to the environments in which these populations lived. The demands from a marine-based subsistence lifestyle (i.e., Tchefuncte) may have been more strenuous, or may have required more frequent participation, than those of a terrestrial/riverine subsistence economy, as practiced by the Greenhouse population. Finally, these results also may be explained as a combination of the two.

The expectations of the development of MSMs of the individual muscle groups associated with specific hunting activities (i.e., use of atlatl vs. use of bow and arrow) were not met. Therefore, any change in the load and duration of these activities through time had a negligible effect on MSM development. Contrary to expectations, the extensor-adductor muscle group of the Tchefuncte males was significantly higher than those of the Greenhouse males, as evidenced

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by the mean MSM scores for this muscle group (2.17 vs. 1.74, Tchefuncte vs. Greenhouse, respectively; Table 7, pg. 37). Additionally, the MSMs from the same muscle group of the women were statistically significantly greater among the Tchefuncte population (2.17 vs. 1.41, Tchefuncte vs. Greenhouse, respectively; Table 8, pg. 38). These results indicate that activities affecting the extensor-adductor muscles were more strenuous during the Tchefuncte period, perhaps best explained by the practice of marine-based fishing practices, such as pulling in fishing lines or nets. Since the Tchefuncte were a more egalitarian society, the inter-populational difference among the females may be a result of the Tchefuncte females' participation in said fishing activities. Indeed, Tchefuncte sites are located along shorelines, both riverine and marine. Since women's domestic tasks typically were carried out around the village, one can postulate that the village's close proximity to the water allowed for the women's increased role in meat acquisition.

5.4: Summary

In concurrence with other studies, the results from the statistical analyses indicate that MSMs are not bilaterally asymmetric and, therefore, are not good indicators of handedness. The lack of bilateral asymmetry allowed for the grouping of left and right humerii in subsequent tests to increase the sample sizes, thereby increasing the power of these statistical analyses.

Contrary to previous studies, the tests for a correlation between MSMs and body size in this study are not significant for any of the muscle groups. Therefore, when considering sexual dimorphism within each population, significant differences of the MSM scores are considered to be more reflective of activity patterns associated with the division of labor rather than body size. The Tchefuncte males have significantly higher MSM scores in the aggregate muscle group

indicating that, among the Tchefuncte population, males had a more strenuous set of physical activities possibly associated with subsistence. The Tchefuncte males also have significantly heavier scores of the abductor muscle group. This result is probably associated with tasks involving heavy lifting and carrying.

Considering the aggregate MSM scores, the inter-populational analysis suggests that the Tchefuncte males may have had a heavier workload than the Greenhouse males. This result may be due to the latter populations' increased involvement in socio-political activities, or it may be a response by the former to an environment that requires more strenuous subsistence activities. The results also indicate that specific activities, such as using a bow and arrow versus an atlatl, are not distinguishable in MSM development. These activities may be too short-lived to cause a noticeable change in the expression of MSMs. The extensor-adductor muscle group of both males and females from the Tchefuncte site is significantly greater than those from the Greenhouse site. Not only could this pattern be an indicator of fishing activities among the men, but also among the women, as the Tchefuncte society was more egalitarian and the sex-specific roles in the division of labor may have been blurred compared to later populations. Age has been shown to be associated with MSM expression; therefore, the observed variation between these populations could be due to demographic differences of these skeletal collections.

CHAPTER 6: CONCLUSION

The goal of this research project was to elucidate any trends in MSM development and expression in order to infer subsistence-based activity patterns in two Louisiana archaeological populations. Using Hawkey and Merbs (1995) scoring method, eight MSMs of the proximal humerii from the Tchefuncte and Greenhouse sites were examined. The robusticity and stress lesion scores were combined into a category representative of total muscle use, as practiced by Molnar (2006) and Weiss (2007). The total muscle use scores of the MSMs were segregated into three muscle groups based on the motions associated with the muscles. Multiple statistical tests were used to examine bilateral asymmetry, sexual dimorphism, and inter-populational variation of these muscle groups. A correlation between MSMs and body size was also tested.

The results indicate that MSMs are not bilaterally asymmetric and, therefore, cannot provide insight into the side-dominant arm of these populations. Also, body size was shown to have no correlation to MSM expression in both populations for all muscle groups. The sexually dimorphic expression of the aggregate and the abductor muscle group MSMs is statistically significant among the Tchefuncte remains, with males having heavier scores. Also, the MSMs of the aggregate muscle group of Tchefuncte males are significantly more expressed than those of the Greenhouse males. Finally, the MSMs of the extensor-adductor muscle group of both males and females from the Tchefuncte population are significantly higher than the scores from the Greenhouse site.

These results can be used to make inferences about subsistence-based activity patterns. Since MSMs do not have a positive correlation to body size in this analysis, the expression of MSMs are assumed to be a result of subsistence behaviors. Male MSM scores of the aggregate and abductor muscle groups from the Tchefuncte population are significantly larger than female scores indicating that the males' general workload may have involved tasks of heavy lifting and

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carrying. None of the tests for sexual dimorphism from the Greenhouse remains are significant.

This outcome may be explained by the males' increased involvement in socio-political activities

and decreased time spent on subsistence behaviors. The results from the tests for inter-

populational variation support this assertion. Indeed, the Tchefuncte males' MSM scores from

the aggregate muscle group are significantly higher than the Greenhouse males' scores. Perhaps

this pattern reflects a reduced workload during the latter's subsistence activities or, possibly, this

indicates that the environment from which the Tchefuncte lived required a more strenuous set of

subsistence behaviors. If this were the case, then the Tchefuncte females' scores should be

significantly higher than those from the Greenhouse site. Unfortunately, the small sample of

female humerii from the Tchefuncte site may have precluded the testing of this hypothesis.

Finally, the Tchefuncte population's extensor-adductor muscle groups (males and females) are

significantly more expressed than the Greenhouse population's scores, possibly a reflection of

fishing activities, such as pulling in fishing lines and nets. These results may suggest that

Tchefuncte females participated in fishing activities alongside the males. Indeed, the Tchefuncte

culture was more egalitarian; therefore, the sex-based division of labor may not have been as

well defined as in later cultures.

This analysis provides insight on two Louisiana archaeological populations' subsistence-

based activity patterns. The mixed results of similar tests in numerous MSM studies indicate that

regional differences exist in MSM expression. Such differences may be related to subsistence-

based activity patterns associated with environmental diversity, to populational (i.e. genetic)

variation in response to muscular and skeletal loading, or to a combination of these factors.

Despite the limited understanding of MSM development, data from this study complement the

archaeological record which shows diachronic variation in subsistence activities and provide

patterns of MSM expression in skeletal populations from the southern Lower Mississippi Valley.

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VITA

Brian M. Thibodeaux, a native of Sulphur, Louisiana, received his Bachelor of Arts degree in anthropology at Louisiana State University in December 2005. Afterwards, he moved to Houston, Texas where he earned his certification to teach social studies from grades 8 to 12. He worked in the Cypress Fairbanks Independent School District for three years before making the decision to return to graduate school at Louisiana State University. During his tenure as a graduate student, Brian participated in archaeological excavations at the Hare Hammock site near Panama City, Florida. He also had the opportunity to work for the Forensic Anthropology Computer Enhancement Services (FACES) Laboratory identifying human skeletal remains from a colonial cemetery from New Orleans, Louisiana. Brian expects to graduate in May 2014 and receive his Master of Arts degree in anthropology with an emphasis in bioarchaeology. He has accepted a position as head bioarchaeologist and crew chief on excavations to be held in Peru during the summer of 2014. Afterwards, he plans on working as an archaeologist and cultural resource manager for the National Park Service with the intention of one day returning to school to earn his doctoral degree.