ACTIVTY AND MOBILITY DURING THE TERMINAL ARCHAIC PERIOD IN THE EASTERN ANDES: A BIOARCHAEOLOGICAL ANALYSIS

by

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A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Arts in
Anthropology

Charlotte

2020

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ABSTRACT

ASHLEY J. SHULTS. Activity and Mobility During the Terminal Archaic Period in the Eastern Andes: A Bioarchaeological Analysis (under the direction of DR. SARA JUENGST)

The Archaic Period in the Andes is characterized as a time of increasing social complexity. Unfortunately, these mobile foraging groups have been understudied in the Eastern Andes, especially in Bolivia. This bioarchaeological analysis uses an embodiment-oriented theoretical perspective to address questions about the mobility and habitual activities of a sample of individuals from the Cordillera de Sama Biological Reserve, located between the Bolivian highlands and Chaco Lowlands. This research uses osteoarthritis (OA), entheseal changes (EC), and cross-sectional strength of long bones to investigate differences between age, sex, and burial groups. These data suggest that 1) females and males habitually participated in different types/levels of physical activities, 2) activity patterns were driven by age, and 3) those interred at PJ-1 were more mobile than those at LGT-1. By evaluating the degrees of OA, EC, and cross-sectional strength, the habitual workload of these individuals is addressed to help scholars understand the life experiences of Andean foragers during the Archaic Period.

DEDICATION

To my mother Jennifer Barnes, whose encouragement and support was imperative in finishing this work. Thank you for always believing in me.

AWKNOWLEDGEMENTS

I have many people to thank who were instrumental in the successful completion of this thesis. First, a heartfelt thank you to my advisor Dr. Sara Juengst. Without her guidance this would not have been possible; because of her thorough and helpful feedback I am a better archaeologist and scholar. I cherish my time under her mentorship in the department and in the field. May we share cangrejitos again one day! My sincere thanks also go out to Dr. José Capriles for the access to this research site, his lab in La Paz, and his encouragement and helpful feedback along the way. To Dr. Dennis Ogburn for providing helpful suggestions and asking thought provoking questions throughout this process, and to Dr. Lydia Light for help on the research proposal and general mentorship during my graduate career.

Thank you to Daniela Velasco, Meriel Chavez, Mirtha Gomez, Wendy Chavez, Gabriel Morales, Brian Cangre, and all other students who helped excavate, clean, and collect data for this thesis. I am grateful for these contributions and for the friendship and laughs we shared in the lab and in the field. Thank you to my parents Jennifer and Matt Barnes, my sister Breanna Kelly, and my grandmother Linda Shults for supporting me every step of the way. I could not have done it without them. To Luis Soto, Chelsea Ward, Mica Lewis, and Elizabeth Johnson for friendship and countless conversations about my research. They have kept me sane and grounded during this process and for that I will always be thankful.

This project would not have been possible without the support from the Thomas L. Reynolds Graduate Research Award, a Faculty Research Grant from UNC Charlotte, and funding secured by José Capriles and Sergio Calla Maldonado from the National

Geographic Society Committee for Research & Exploration Grant #HJ-052R-17, the Wenner-Gren Foundation Post-Ph.D. Research Grant Gr. 9778, and the Curtiss T. and Mary G. Brennan Foundation.

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LIST OF ABBREVIATIONS

EC: Entheseal Change

OA: Osteoarthritis

CSG: Cross Sectional Geometry

CHAPTER 1: INTRODUCTION

Anthropologists have focused on the importance of day to day life and how it shapes, and is shaped by, broader social structures (Bourdieu 1977; de Certeau, 1984; Weiss 2017; Schrader 2019). Bioarchaeology, the study of skeletal remains from archaeological contexts, is uniquely situated to study everyday life as lived experiences are embodied on the skeleton. Anthropological perceptions of the body have been used to understand how the body relates to lived experiences, and how it is interpreted in a larger social system (Scheper-Hughes and Lock 1987). While cultural anthropologists have framed their work within these ideas, it has only recently been applied to bioarchaeological studies (Knudson and Stojanowski 2008; Schrader 2012, 2019). Anthropological approaches to the body "increasingly view the body as a social construction that is contextually and historically produced, but hardly touch on the human remains themselves" (Sofaer 2006 p. xiii). This is surprising because bioarchaeological analyses have the capability to address both the individual and social body, especially when contextualized with archaeological data (Zuckerman et al. 2014; Shrader 2019). If we accept that skeletal remains are both biological and cultural, we can begin to conceptualize the human skeleton as an embodied artifact that can speak to lived experiences (Walker 2001).

Bioarchaeological analyses of everyday activities can contribute significantly to questions about foraging and preceramic societies, as skeletons are often the only remnants left behind in the archaeological record. This is of particular importance in Southern Bolivia during the Terminal Archaic Period, as the majority of South American studies on foragers have been focused on the Titicaca Basin and coastal regions and mountains of Peru. In order to contribute to the understanding of foraging societies in Bolivia, I analyzed a sample of individuals from two open-air sites in the Cordillera de Sama Biological Reserve, located between the Bolivian highlands and Chaco lowlands (Fig.1). I assessed biomechanical indicators of habitual activity including osteoarthritis, entheseal change, and long bone loading strength to compare the two burial groups, and address questions about age and sex-based differences in relation to everyday activities.

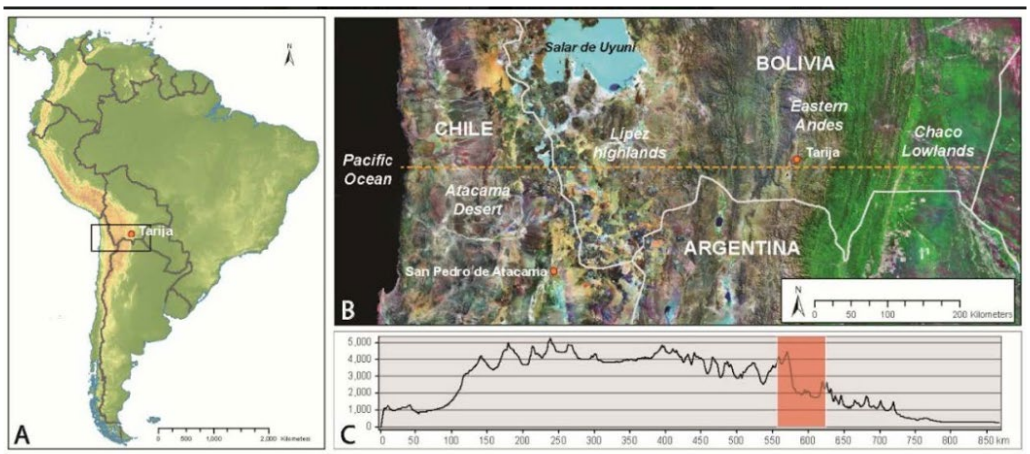

Figure 1: Map of Tarija, Bolivia in relation to important geographic areas (Capriles 2018)

CHAPTER 2: BACKGROUND INFORMATION

2.1: Archaic Period in the Andes

The Archaic period for the Andes refers to human occupations chronologically situated between 10950 and 3600 cal BP, ranging from the Late Pleistocene to the beginning of the Late Holocene. The Archaic period is further divided into four sub-phases: Early Archaic (9500-8000 BP), Middle Archaic (8000-6000BP), Late Archaic (6000-4500 BP) and the Terminal Archaic (4500-3600 BP) (Aldenderfer 2009). It is important to note that all dates have been converted to BP throughout this thesis for consistency.

The Archaic period in the Andes is characterized by resource intensification and specialization, population growth, differentiation of ethnicity, and changes in the frequency and types of mobility (Aldenderfer 1989). In conjunction with changes in mobility, new forms of power and competition were emerging during this time, exemplified by groups ritually marking the landscape through mortuary monuments, the development of new technologies, and increases in intergroup conflict (Aldenderfer 1989, 1990, 2005; Aldenderfer et al. 2008; Craig 2011; Haas and Viviano Llave 2015; Juengst et al. 2017; Marsh 2015, 2016).

Archaeological evidence found at Archaic sites in the Titicaca Basin suggest high residential mobility, and the exploitation of a wide variety of resources for these groups (Cipolla 2005; Klink 2005; Janusek 2008; Capriles 2014; Craig et al. 2010; Craig 2011, 2012; Haas and Llave 2015; Juengst et al. 2017). In the highlands, people exploited aquatic resources from lakes, gathered plants, and hunted wild fauna such as camelids and deer (Binford and Kolata 1996; Janusek 2008; Marsh 2015; Stanish, 2003). Cemetery and ritual monuments in this region suggest that the groups which inhabited these areas during the Terminal Archaic period were interested in marking their ranges and territories in obvious ritual ways (Aldenderfer 1989, 1990, 2005; Arnold and Hastorf 2008). The discovery of a gold and turquoise necklace dated to 3700 BP at Jiskarumoko, a Terminal Archaic site in the southwestern Titicaca Basin, provides evidence for the development of new technologies and suggests the possibility of increasing social power (Aldenderfer et al. 2008). The archaeological research conducted in the Titicaca Basin shows the presence of pit houses, storage pits, ground stones, and exotic goods, characterizing the period as one with increasing social complexity and low-level food production utilizing hunting, fishing, foraging, and agriculture (Aldenderfer et al. 2008; Aldenderfer and Flores Blanco 2011; Craig 2011). Hundreds of Archaic period components have been identified in this region; however, few well-preserved human skeletal remains have been excavated or analyzed (although see Haas and Llave 2015 and Juengst et al. 2017). The few bioarchaeological studies conducted in this region during this temporal span suggest a lack of nutritional stress and interpersonal conflict between mobile foraging groups, quite possibly due to their varied diet of lake resources, gathered plants, wild tubers, and wild and domesticated plants and mammals (Aldenderfer 2005; Juengst et al. 2017; Moore et al. 1999; Moore et al. 2007; Rumold and Aldenderfer 2016).

2.2 Archaeology in Bolivia

Archaeological research pertaining to the Archaic period in Bolivia outside of the Titicaca Basin is limited, and when conducted has typically consisted of surveys and systematic surface collections (Capriles and Albarracin-Jordan 2013). The first evidence for human occupation during the Archaic was reported at sites located in the southern *altiplano* (the high plateau between the eastern and western chains of the Andes) (Capriles et al. 2011). These sites contained lithic workshops, quartzite scrapers, and chert and jasper flakes (Courty 1910). Viscachani, a significant open-air site located in the central *altiplano* of Bolivia is associated with an adaption to highland hunting and gathering, and prompted systematic archaeological research in many highland sites of the Andes (Aldenderfer 1989; Lynch 1983; Rick 1980; Ravines 1972; Santoro and Núnez 1987).

Investigations in the southern *alitplano* of Bolivia resulted in the documentation of sites in Soniquera, Laguna Verde, and Laguna de Tara where artifacts made of black basalt and other local raw materials were found corresponding with the chronology of Archaic foragers identified in the Atacama Desert (Le Paige 1964; Capriles 2013). Additional archaeological explorations in Bolivia produced evidence of lithic artifacts, hearths, and camelid remains dating to the Archaic period (Coltorti et al. 2010, 2012). In the Bolivian highlands, rock shelter sites show evidence of human occupation since 4800 BP, and sites on the margins of lakes have produced stone tools, animal bones, trash pits, hearths, and lithics dating to the Early Archaic Period. Common faunal remains found consist of camelids, deer, wild guinea pigs, ducks, coots, and avocets which display clear evidence of human butchery and consumption (Capriles et al. 2018). While many individual sites have been excavated, there is a need for systematic survey and excavation to address questions regarding specific modes and patterns of mobility.

2.3 Mobility

For decades, archaeologists have studied mobility by characterizing activity patterns of human populations. Human behavioral ecology models have been used to address the mobility of foragers and their adaptation to harsh Andean environments (Osorio et al. 2017). Previous research from Archaic sites have proposed varying mobility strategies. Seasonal inter-ecological mobility has been used to understand the earliest foraging societies in the Atacama basin wherein groups would seasonally rotate between the highlands and lowlands depending on resource abundance (Núñez 1978; Núñez and Dillehay 1979; Núñez et al. 2002). In areas with less environmental fluctuation, a permanent inter-ecological mobility framework has been used to address foragers in the Peruvian central Andes. Here, groups would subsist primarily on highland resources by specializing in hunting wild camelids (Cardich 1964; Rick 1980). In highly variable environments such as southern Peru, opportunistic mobility has been used to explain the strategy where groups would occupy both residential and logistical camps as resources become available (Santoro and Núñez 1987; Santoro 1989; Aldenderfer 1998; Dillehay et al. 2003). Most frameworks and definitions of mobility focus on cumulative behavior with a focus on the lower limbs, however, for the purposes of this research, mobility will simply be defined as using the limbs to move, with a focus on daily activities (Weiss 2017).

Biology of Bone Tissue

In order to determine whether skeletal remains are shaped by activity or other external and internal factors, it is important to be familiar with bone biology.

Bone tissue is made up of around 70% mineral hydroxyapatite and 30% organic collagen. Collagen is a fibrous protein which gives bone the ability to slightly bend and adapt, whereas the hard-mineral makeup of hydroxyapatite provides rigidity and stability (Shrader 2019; White 2005). While bone might seem static, it is far from unchanging.

Skeletal material is constantly undergoing transformation through growth, modeling, remodeling, and repair (Marks and Odgren 2002; White 2005). Osteoblasts are cells that deposit bone when needed, and osteoclasts are cells that absorb or remove bone that has been damaged. The bones of an adult are estimated to completely remodel every ten years (Hedges et al. 2007; Schrader 2017). In addition to remodeling, bone adapts to its mechanical environment during life, shaping bone morphology over time (Ruff and Trinkaus 2006). This means that bone can be remodeled from strain or heavy loading associated with movement and is useful for reconstructing past activity patterns.

Theoretical Perspectives

In anthropological theory, embodiment is how humans biologically incorporate the world around them into their physical bodies. The skeleton can be viewed as a site of lived experience wherein the bioarchaeologist can explore the material and cultural world (Krieger 2005; Meskell 2000; Schrader 2019). By using an embodiment-oriented theoretical perspective, one can look at how diet, disease, and activity is exhibited on the skeleton to understand broader social, cultural, and environmental concepts (Schrader 2019; Sofaer 2006). These are observed through different indicators including muscle attachment sites, degenerative bone changes, and adaptive functional bone morphology. The skeleton is oftentimes the only remnants of the body left behind, making it valuable in answering archaeological questions.

Practice theory explains how everyday activities are vital to the creation and maintenance of social identities, because within human society, actions are regulated by rules and norms that make up its structure (Bourdieu 1977). By combining practice theory, embodiment theory, and bioarchaeological methods, everyday experiences can be interpreted from skeletal material allowing us to address what life may have been like for people in the past. The methods used to interpret activity are based on the premises that bone is constantly undergoing change and can be shaped by the biomechanical forces placed upon them. These methods are not without complications, as many external and internal factors need to be considered including age, sex, and genetics. If we take into consideration these limitations and look at the skeleton as the product of an embodied experience, we can infer information about everyday practices in the past.

Entheseal Change

Studying entheseal change has been a popular bioarchaeological method since the 1980s because it can be done macroscopically, therefore, it is inexpensive and does not require additional technology. You can collect this data quickly in the field for later analysis. Entheses are regions located on the bone where tendons, ligaments, or joint capsules (a membrane surrounding synovial joints) attach. These complex systems allow for physical motion and serve to dissipate stress away from the activity and into the bone itself (Benjamin et al. 2002). Entheses are commonly referred to as “muscle markers” because they can change muscle attachment sites in relation to different types of motion. Entheses are placed into two categories: fibrous, and fibrocartilaginous. Both act as attachments to bone but differ in how they connect. Fibrocartilaginous entheses have been studied more thoroughly in clinical literature, therefore they have been used more in bioarchaeological contexts (Schrader 2019; Weiss 2017). This type of tissue/bone connection is more prone to change, and there have been studies that show a strong correlation between fibrocartilaginous entheseal changes and activity, as long as bioarchaeologists pay attention to the entheses they choose and use appropriate methods (Villotte et al. 2010).

A typical entheses is characterized as a smooth, well defined mark on the bone without any porosity or irregular bone growth (Villotte and Knusel 2013). Irregular changes used to identify evidence of activity include porosity, osteophyte formation, and lytic activity (Fig. 2). In 1995, Hawkey and Merbs came up with the first skeletal scoring system that has been used broadly in bioarcheological studies. This method uses descriptive and photographic examples to score robusticity, lytic activity, and ossification at muscle attachment sites (Hawkey and Merbs 1995).

Figure 2: Examples of Entheseal Change at the. biceps brachii attachment site (Palmer et al. 2016)

Osteoarthritis

The most common condition found in archaeological skeletal samples is osteoarthritis, the degeneration of articular joint surfaces (Weiss and Jurmain 2007). Researchers describe and define osteoarthritis in many ways, but it is clear that osteoarthritis is a complex and multifactorial disease that has important applications to bioarchaeology. Osteoarthritis can be caused by two different processes described as either primary or secondary. Primary osteoarthritis is the most common type and occurs without an underlying cause. Secondary osteoarthritis comes from a genetic predisposition such as rheumatoid arthritis, or from trauma associated with a bone fracture or dislocation (Rogers and Waldron 1995). Bioarchaeologists are mainly interested in primary osteoarthritis, as it may be caused by the repetitive loading of habitual activities.

Osteological evidence of osteoarthritis may be seen in the form of porosity, lipping, or eburnation (Fig. 3). Lipping is caused by osteophyte formation that shows up as proliferative bone. This is evidence of joint space narrowing, caused by the deterioration of the cartilage between bones. Joint space narrowing is the body's initial response to strain and degeneration, and the formation of osteophytes, or lipping, is thought to be the bone's attempt to stabilize the joint (Felson et al. 2000; Waldron 2012). These growths may differ in frequency and severity and are variable in size. Porosity is a skeletal indicator of osteoarthritic joint damage characterized as small pits or holes which occur from the deterioration of the joint surface (Buikstra and Ubelaker 1994). The most diagnostic feature of osteoarthritis is eburnation. Eburnation occurs when the cartilage protecting joint surfaces is completely deteriorated, causing the bones to rub together. Skeletally, this manifests as a shiny appearance on the bone surface (Ortner 2003).

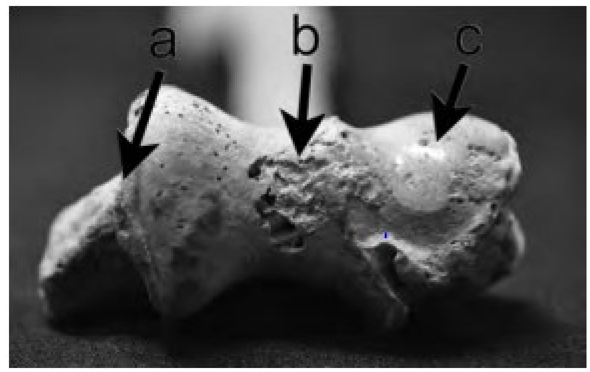

Figure 3: Skeletal evidence for osteoarthritis of the distal humerus (a) lipping; (b) porosity; (c) eburnation (Becker 2019)

According to clinical definitions, osteoarthritis only refers to synovial joints (freely mobile joints with a synovial membrane) and does not apply to most of the vertebral column (excluding the superior and inferior articular facets as they *are* synovial joints), even though it has been used in many bioarchaeological studies. Some simply refer to vertebral body porosity and lipping as “joint disease”, osteophytosis, or spondylosis (Ortner 2003; Pietrusewsky and Rona 2006; Novak 2011; Jurmain et al. 2012). Osteophytic growth concerning the vertebral column can range from tiny bone growths to the complete fusion of vertebra called ankylosis. Ankylosis has been attributed to bipedalism and is seen as one of the consequences of walking upright, as the distribution of force has been altered throughout our evolutionary history (Bridges 1994; Larsen 2000; 2015).

Spondylosis is a fracture in the small segment of bone that joins together the facet joints in the posterior spine (*pars interarticularis*). This causes detachment of the vertebral arch, and has been attributed to certain types of physical activities (Merbs 1996). Another skeletal pathology that affects the spinal column is referred to as a Schmorl’s node. Schmorl’s nodes are small, round depressions found in the middle of vertebral bodies that are likely caused by disc herniation and associated with spinal rotation and carrying heavy loads (Junghanns and Schmorl 1971). The cause of this lesion is commonly debated, but many studies have associated it with physical activity and demanding labor practices. As with most indicators of stress, the chances of getting a schmorl’s node are often affected by other factors such as genes, trauma, and body mass (Zhang et al. 2017).

Clinical Studies of Osteoarthritis

Clinical studies of osteoarthritis have examined the relationship between osteoarthritis and activity. Studies have shown differences in osteoarthritis prevalence between individuals with different occupations (Anderson et al. 1962; Croft et al. 1992; Waldron and Cox 1989; Weiss and Jurmain 2007). Someone who has an occupation that requires frequent lifting and squatting is twice as likely to develop knee osteoarthritis than someone who does not (Meiser et al 2009). Individuals whose jobs require them to stand for long periods of time have been noted to have higher frequencies of hip arthritis, while those who work in occupations that require hand dexterity show higher rates of osteoarthritis in their fingers and wrists (Croft et al. 1992; Hadler et al. 1978). These studies support the idea that osteoarthritis is correlated with certain types of activities, although age, sex, and genetics play a large role.

As you age, bone degeneration increases, and bone and soft tissue repair slows. Biological sex is another contributing factor to the development of osteoarthritis. Females over 50 years of age have a 50% higher chance of having osteoarthritis than men over 50. Some have attributed this to the decrease in estrogen levels after menopause, which tends to decrease bone density. However, clinical studies have yet to find a direct correlation between hormone levels and the progression of osteoarthritis (Jones et al. 2000; Hanna et al. 2004; Nevitt et al. 2010). Other contributing factors which may increase rates of osteoarthritis in females include bone composition, amount of cartridge, and the connection between nerves and muscles (Johnson and Hunter 2014).

Bioarchaeology of Osteoarthritis

Bioarchaeologists measure osteoarthritis in different ways, using different methods as no standardization has been agreed upon. Skeletal changes associated with osteoarthritis have been recorded for decades. Angel (1966) used these degenerative changes to illuminate life experiences of people in the past, suggesting that elbow osteoarthritis was caused by projectile throwing coining the term “atlatl elbow.” Since this innovative study, bioarchaeologists have been interested in reconstructing lifeways using osteoarthritis as a proxy. Methods of recording osteoarthritis differ from study to study, making cross cultural comparisons difficult when done by different observers. In standard methods, a simple present/absent was recorded for each joint surface considering lipping, porosity, and eburnation independently (Buikstra and Ubelaker 1994). Methods become increasingly difficult when numeric scores are added and averaged together instead of the simple present/absent. According to Larsen (2015), osteoarthritis is present if lipping, porosity, or eburnation are evident, whereas Rogers and Waldron (1995) suggest that either eburnation, or porosity and lipping together must be found in order to consider a joint arthritic. Some bioarchaeologists group together entire joint systems instead of each articular surface (Becker and Goldstein 2018). The potential and upwards trajectory of osteoarthritis as an important method for activity reconstruction in bioarchaeology is evident, however, one must always be sure to factor in age, sex, and other external factors while making sure to clearly explain how the data is being scored and analyzed.

Cross Sectional Geometry

Cross sectional geometric methodologies use functional bone morphology to reconstruct past activity patterns. Bones adapt to mechanical loading and the forces placed upon them in order to maintain structural integrity and strength over an individual's lifetime (Ruff et al. 2006). Archaeologists use the "beam theory" which states that like a beam, "the strength of a bone is a function of the amount of cortical bone present, and its distribution about the centroid of a diaphysis. The further away from the section centroid that skeletal mass is situated, the greater its importance in resisting bending and torsional loading" (Stock and Shaw 2007: 413).

New bone is created where it is needed and resorbed where it is not. Bone adapts to tension, compression, bending, shearing, and torsion forces. Tension refers to force at muscle insertion sites, compression is a downward force, and shearing refers to loads coming from two opposite directions (Fig. 4). Torsion is a twisting force, and bending is tension on one side with compression on the other (Swartz 1993; Weiss 2017). By looking at cross sections of long bones, bioarchaeologists can see how bone morphology has changed, and evaluate what type of stresses caused those changes. From there, they can infer what types or levels of activities the individual might have been engaged in habitually, in order

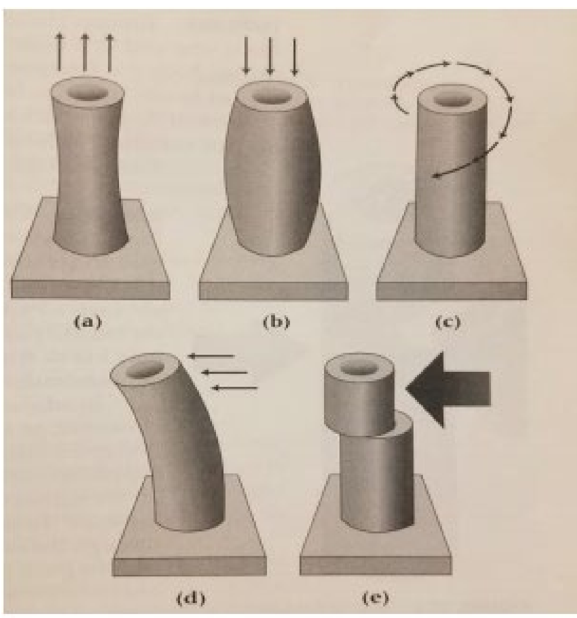

Figure 4: Directions of force. (a) tension; (b) compression; (c) torsion; (d) bending; (e) shearing (Ortner and Putschar, 1981)

to reconstruct past daily life. Early research on cross sections required cutting long bones in half with a saw to observe their shape (Ruff and Hayes 1982). While this allows for extremely accurate observations, it is a destructive analysis and it raises many ethical and problematic issues. Advances in imaging technology have allowed for methods using radiographs, computer tomography, and x-rays (Bridges et al. 2000; Marchi 2008; Weiss 2003). Other less expensive and invasive methods have calculated strength in bone according to anterior-posterior and medial-lateral measurements and standardizing the values with bone length (Bridges et al. 2000).

Multi-method Studies

Each of the methods discussed above have their own sets of limitations, usually dealing with age, sex, genes, and environmental factors. The most robust bioarchaeological studies of activity patterns use a combination of methods to avoid these complicating factors. The more information that can be extracted from an individual skeleton or skeletal sample, the more robust and complete inferences can be made about the past. Thus, using a combination of entheseal change, osteoarthritis, and cross-sectional properties in the same study is a productive way to answer questions about mobility, and determine if these changes are activity or age/sex related.

CHAPTER 3: MATERIALS AND METHODS

The skeletal sample for this project comes from archaeological excavations of two preceramic open-air sites in the Cordillera de Sama Biological Reserve (Fig. 5). These excavations in 2017 through 2019 were codirected by Dr. José M. Capriles and Lic. Sergio Calla Maldonado, authorized by the Bolivian Ministerio de Culturas y Turismo, supported by the Gobierno Autónomo Departamental de Tarija, the Gobierno Autónomo Municipal de Yunchará, the Servicio Nacional de Áreas Protegidas, the Instituto de Investigaciones Antropológicas y Arqueológicas of Universidad Mayor de San Andrés and the Museo Nacional de Arqueología y Paleontología de Tarija. The Cordillera de Sama is a protected area in the Tarija basin of Bolivia, located between the Andes and the Amazonian-Chaco lowlands.

Four individuals in this study were from LGT-1, a site located on the southern shore of Laguna Grande de Taxara. Taxara is the largest lake in the Cordillera de Sama, approximately 3,600 meters above sea level. Five individuals were excavated from PJ-1, a site located eight kilometers away on the southeastern shore of Laguna Pujzara. The seven individuals excavated in 2017 and 2018 were analyzed in July 2019 in La Paz, and the two individuals from the 2019 season were excavated and analyzed in the Cordillera de Sama during field work. Dr. Sara Juengst collected demographic information, pathology, and trauma as part of a separate study while I recorded and analyzed indicators of repetitive activity/mobility, including osteoarthritis, entheseal changes, and cross-sectional strength of long bones.

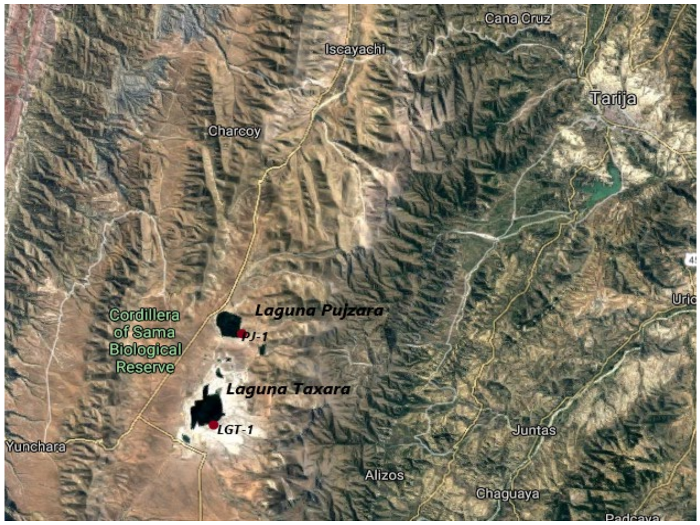

Figure 5: The Cordillera de Sama Biological Reserve in relation to Tarija

3.1 Excavation

Areas for excavation were identified by field reconnaissance and knowledge from local park rangers. For the individuals excavated during 2019, 2x1 units were excavated following natural stratigraphic levels, or 10 cm arbitrary levels whenever natural stratigraphy could not be determined. The grids were extended by 1x1 meter increments when necessary as burials and burial orientation were identified. Material and skeletal remains were mapped using a total station and prism rod, and the remaining sediment was screened through 5 mm meshes.

3.2 Age Estimation

Adult age estimation for the individuals in this study was based off morphological changes to the pubic symphysis (Todd 1921; Brooks and Suchey 1990), morphological changes to the iliac auricular surface, cranial suture closure (Lovejoy et al. 1985; Meindl and Lovejoy 1989; Buikstra and Ubelaker 1994), and rates of dental wear and attrition (Murphy 1959; Smith 1984). Juvenile age was estimated through different methods, including dental eruption, and degree of epiphyseal fusion (Buikstra and Ubelaker 1994; Sofaer 2006). Age categories used in this study include young adults (20-30), middle adults (30-45), and old adults (45+) (Juengst et al. 2017).

3.3 Sex Estimation

Sex estimation was obtained using pelvic and cranial nonmetric traits, with preference given to the pelvis as these traits are associated with reproductive function. Each individual was scored as 1= female, 2=probable female, 3=indeterminate, 4= probable male, or 5=male. Pelvic traits used to estimate sex were the ventral arc, subpubic concavity, ischiopubic ridge, and the greater sciatic notch (Buikstra and Ubelaker 1994). Cranial traits observed were the nuchal crest, mastoid process, supra-orbital margin, supra-orbital ridge, and mental eminence (White and Folkens 2005).

3.4 Height Approximation

Height approximation for each individual was assessed using an Andean regression equation for stature estimation (Pomeroy and Stock 2012). Preference was given to the bicondylar femur length (BLF) when possible (Female: 49.147 + (BLF x 2.6), and Male: 47.207 + (BLF x 2.705). If the bicondylar femur length could not be measured, the order of preference was as follows: maximum femur length, maximum tibia length, and maximum humerus length.

3.5 Osteoarthritis

The presence of osteoarthritis (OA) may indicate the repetitive use of the same joint and muscle groups causing skeletal change, which can be viewed macroscopically. Levels of OA were recorded for seven joint surfaces (shoulder, elbow, wrist, hip, sacroiliac, knee and ankle) using criteria from Buikstra and Ubelaker (1994). The skeletal responses to OA include lipping, porosity, osteophyte formation (growth of new bone), and eburnation (a polished area resulting from the removal of cartilage and bone on bone contact). Articulation surfaces were observed if at least 90% of the joint was intact. OA was marked as present if there was evidence of eburnation, or present if two of the other criteria (porosity, lipping, and osteophyte formation) appeared on the same surface.

3.6 Entheseal Change

Osteophytic (proliferative) and osteolytic (erosive characterized by pitting) entheseal changes of the upper arm, forearm, mid-body, hip, lower body, and knees were recorded and scored according to Hawkey and Merbs methodology (Hawkey and Merbs 1995). For each attachment point, presence or absence was noted and when present given an ordinal score from 1-3 for robusticity and stress.

3.7 Cross Sectional Strength

Cross sectional strength was used to reconstruct the mechanical loading history of long bone shafts. Anterior-posterior (AP) and medial-lateral (ML) measurements were taken from the proximal third, middle, and distal third diaphysis of each humerus, radius, ulna, femur, and tibia when possible. The polar second moment of area (J) estimates the section's strength under torsional or twisting forces, and was calculated by adding AP and ML values (J=AP+ML) (Bridges et al. 2000). Resistance is also influenced by bone length; therefore, size standardization was achieved by dividing J by bone length (Ruff et al 1993).

CHAPTER 4: RESULTS

Here, I present the results for the four individuals from LGT-1, and five from PJ-1. First, I present results for each burial in order to preserve the individual as a unit of analysis. Then, I present trends by overall prevalence of OA, entheseal changes, and CSG, followed by sections assessing the data according to demographic groups (age, sex, and burial location).

4.1 Individual Results

LGT-1-ENT 1 was a female individual around 25-35 years of age. Evidence of osteoarthritis appeared on the right shoulder, both elbows, right hip and knee, as well as the left ankle (Table A3). Entheseal changes of the shoulder show evidence of more lateral movements of the left arm and medial movements of the right arm (Fig. A4). Entheseal changes of the biceps brachii, which are associated with lifting, were more pronounced on the right arm, corresponding with the eburnation found on the right proximal ulna and radius. Lower body entheseal changes of the gluteus minimus, iliopsoas, and popliteus were observed. These muscles play a large role in walking and stabilizing the hips during motion and at rest. There was significant evidence of entheseal change in relation to the gastrocnemius muscle, which is involved in running and jumping. Upper body long bones were equal in loading strength, whereas the lower body was stronger on the right side. The tibial loading strength of this individual was higher than the average of the other individuals.

Individual LGT-1 ENT 2 was a male at least 45 years of age. Evidence of osteoarthritis appeared on the left shoulder, both elbows and hips, as well as the left knee (Table A5). Corresponding musculoskeletal markers were present on the left shoulder (subscapularis and deltoid) which are used for the internal rotation of the humerus and for support of the upper arm during abduction and adduction. There was also entheseal changes on the muscles of the left elbow used to lock the elbow in place and rotate the forearm (triceps brachii, brachialis, biceps brachii, and brachioradialis). Lower body entheseal changes were symmetrical on both sides and show evidence of hip extension and knee flexion, movements associated with walking on an incline. Both knees show significant robusticity at the gastrocnemius insertion site, which is a large and powerful muscle primarily involved in fast movements such as running and jumping (Fig. A6). Overall, bone strength is higher for the right side of the body (femur, tibia, and humerus) and higher compared to the average of the other individuals.

LGT-1 ENT 3 was a female aged 20-25 with evidence of osteoarthritis in both elbows, the lumbar vertebra and the left knee (Table A7). Entheseal changes were present on both clavicles and the left shoulder at insertion sites which are used primarily for the internal rotation and abduction of the arm (supraspinatus, subscapularis, and deltoid). Insertion sites of the semimembranosus and iliopsoas were present on the hips (Fig. A8). These muscles are associated with the extension, flexion, and rotation of the leg at the hip, and the flexion and internal rotation of the leg at the knee. The upper and lower long bones of this individual were stronger on the right side.

LGT-1 ENT 4 was a male around 30-35 years of age. Signs of osteoarthritis were present in both shoulders and elbows, the left hip, lumbar vertebra, as well as the right ankle (Table A9). Entheseal changes of the shoulder were more prevalent on the right side (pectoralis major and deltoid). Other pronounced musculoskeletal markers were on both gluteus maximus muscles, which are important in lower limb movements such as climbing and running (Fig. A10). Loading strength of the lower limbs of this individual were stronger on the left side, corresponding with the left hip osteoarthritis, whereas the upper limbs were stronger on the right side. The right humerus of this individual is well above the average strength for the others, and the lower left limbs are above the average of others.

PJ-1 ENT 1 was an adult male at least 45 years of age. Evidence of osteoarthritis was present in the left shoulder, both elbows, left knee, and right patella (Table A11). Entheseal changes of this individual were prevalent on the left shoulder, particularly at the insertion site of the subscapularis and deltoid muscles which are used primarily for the internal rotation of the humerus and for support of the upper arm during abduction and adduction. Both elbows had entheseal changes (biceps brachii and brachioradialis) (Fig. A12). The insertion point of the right brachialis muscle on the proximal ulna shows defined marginal bone growth. The brachialis muscle is the main flexor of the elbow joint and it is not affected by pronation or supination of the forearm. The left hip and knee also show entheseal changes at the gastrocnemius and popliteus. Upper body long bone strength was around average for the entire subsample, and the midsection of the femurs were slightly stronger than average.

PJ-1 ENT 2 was an individual of indeterminate sex at least 45 years of age. Only the left side of this individual was present. Signs of osteoarthritis were only present on the elbow and lower thoracic and lumbar vertebras (Table A13). Entheseal changes were prevalent in the elbow. The insertion site at the biceps brachii had an ordinal score of 5, suggesting extensive flexion and supination of the forearm at the elbow (Fig. A14), corresponding with a high strength value at the cross section of the mid humerus.

PJ-1 ENT 3 was an adult male around 28-32 years of age. This individual had signs of osteoarthritis on both shoulders, the right elbow, the right wrist, both hips, and the left knee (Table A15). The entheseal changes of this individual showed bilateral symmetry in the shoulders, elbows, and knees. Entheseal changes were more pronounced on the left hip (gluteus minimus and quadratus femoris) (Fig. A16). Humeral strength for this individual was lowest out of all the values recorded. Femoral mid-section strength was around the mean, although the tibial loading strength at the midsection was higher than average.

PJ-1 ENT 4 was an adult female around 35-40 years of age. The shoulders of this individual were not observable for osteoarthritis or entheseal changes. Evidence of osteoarthritis was present on the left elbow and hip (Table A17). Entheseal changes of the left elbow (brachialis) and right hip (gluteus minimus) were also present. These muscles control the flexion of the forearm at the elbow, and the abduction and internal rotation of the leg at the hip (Fig. A18). The only observable strength measurement for this individual was the midsection of the tibia, which was the lowest value and was significantly lower than all other observable values.

PJ-1 ENT 5 was an adult probable male around 20-25 years of age. Evidence of osteoarthritis was present in the right elbow and right hip (Table. A19). Entheseal changes were recorded for the shoulders (deltoid), the left elbow (brachialis and brachioradialis), and the left knee (popliteus) (Fig. A20). The upper long bones were not observable for cross sectional strength; however, the midsection of the femur had the highest strength value of all other observable values.

4.2 Osteoarthritis prevalence

Osteoarthritis was recorded for six joints (shoulder, elbow, wrist, hip, knee, and ankle) at 26 different articulation surfaces (13 on the left, and 13 on the right). Osteoarthritis sample distributions are included in the graphs below (Fig. 6). A joint is listed as having OA if it was present at any of its articulations, which does not automatically mean it was pervasive throughout the entire joint. Furthermore, some of the skeletons are incomplete, or have sustained taphonomic damage and the joint surfaces were unobservable. Therefore, OA prevalence is listed as the percent of articulations positive for OA out of the total number of articulations observable at a particular location. The most common joint affected by OA was the elbow (79%), followed by the knee (59%), hip (56%), ankle (50%), shoulder (43%), and wrist (35%). It is important to note the preservation bias in observable articulation surfaces (Fig. 7). Throughout all of the joints, the right side of the body had a higher prevalence of OA, with the exception of the ankles.

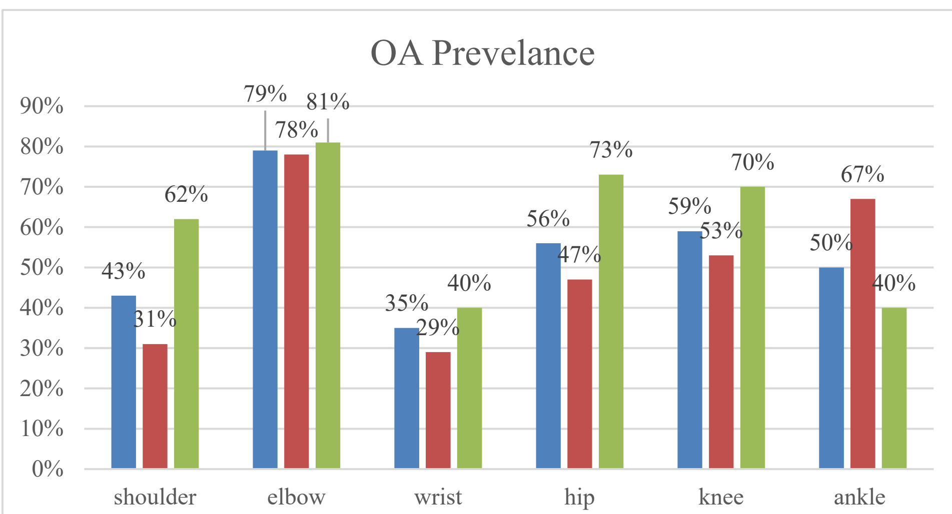

Figure 6: OA prevalence as the percentage of affected surfaces out of total observable surfaces

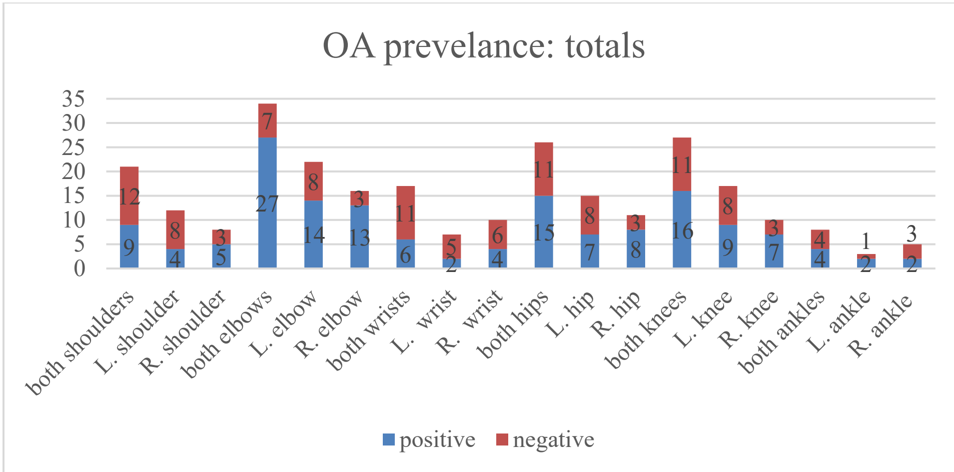

Figure 7: OA frequency as the number of joint surfaces positive for OA out of the total number of surfaces observable

4.3 Entheseal Change prevalence

Entheseal changes were recorded for five joints (shoulder, elbow, wrist, hip, and knee) at 40 different insertion sites (20 on the left, and 20 on the right) (Figs. A1&A2). EC sample distributions are included in the graphs below. A joint is listed as having EC if it was recorded at any of the insertion sites, which does not speak to the severity of EC throughout the entire joint. Some of the skeletons are incomplete, or have sustained taphonomic damage, and the insertion sites were unobservable. Therefore, EC prevalence is listed as the percent of insertion sites where EC is recorded, out of the total number of insertion sites observable at a particular location (Fig. 8). The highest prevalence for EC was recorded throughout the hips (92%), followed by the elbows (85%), shoulders (78%), knees (77%) and wrists (61%). EC was more common throughout the left side of the body in all joints excluding the shoulder.

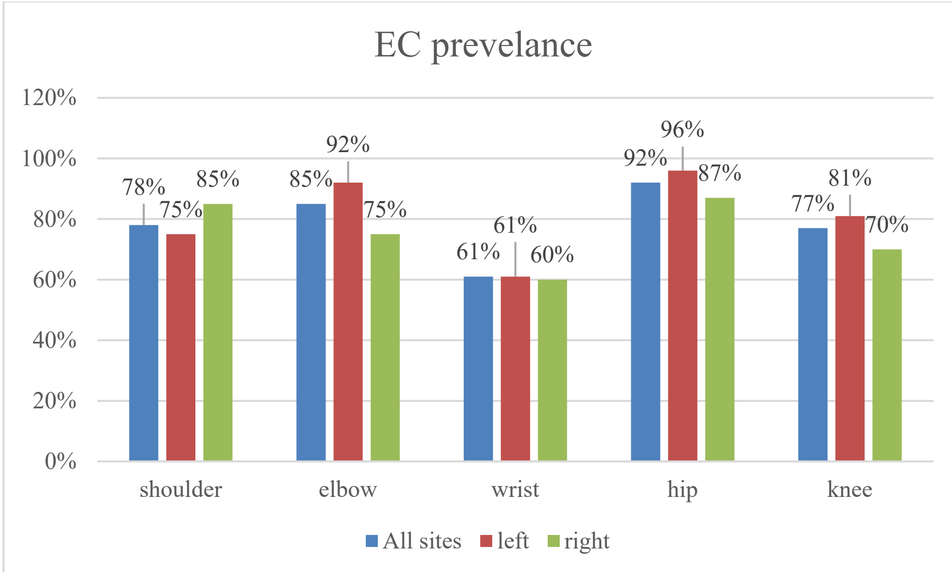

Figure 8: EC prevalence as a percentage of insertion sites affected out of the total sites observable

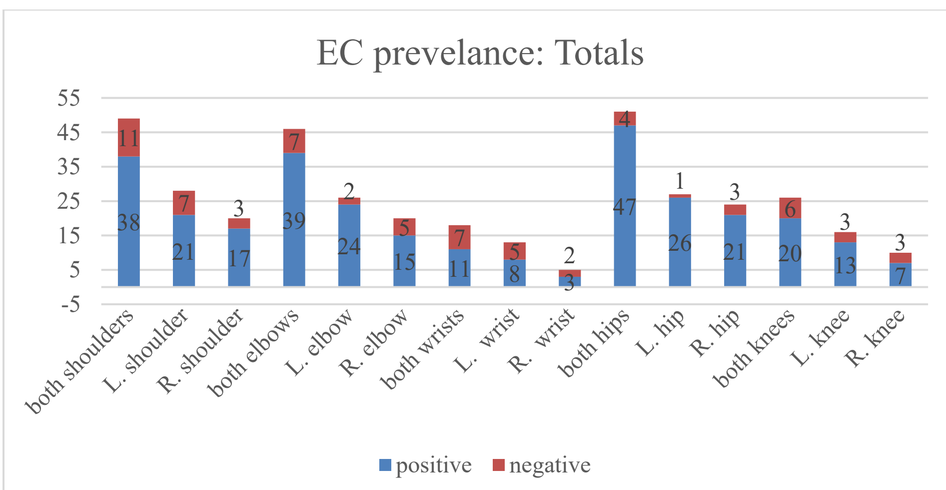

Figure 9: EC frequency as the number of affected insertion sites out of the total sites observable

<u>4.4 Cross Sectional Strength</u>

Strength values analyzed for this study are from three long bones (humerus, femur, and tibia) at the proximal third, middle, and distal third of each observable bone (Table 20A). Due to the small sample size, both right and left sides are combined. Mean strength scores (rounded to four decimal points) for the humerus were 0.1252 (proximal), 0.1215 (medial) and 0.1124 (distal). Mean strength scores for the femur were 0.1215 (proximal), 0.1179 (medial), and 0.1334 (distal). Mean scores for the tibia were 0.1432 (proximal), 0.1292 (medial), and 0.1263 (distal). When comparing left and right sides, mean scores for the humerus and tibia were higher for the right side, whereas scores for the femur were similar.

4.5 Results by Sex

OA

Due to the small sample size, probable males and probable females have been combined with males and females throughout this analysis (Fig. 10). This subsample included three females, five males, and one individual of indeterminate sex (not used in this analysis). Overall, males had a higher prevalence of osteoarthritis for each joint. For females, the most common joint affected was the elbow (67%), followed by the knee (46%), hip (44%), ankle (25%), wrist (20%), and shoulder (14%). The left elbows, wrists, and ankles have a higher prevalence of OA, whereas it is higher in the right shoulders, hips, and knees. For males, the most common joint affected was also the elbow (89%), followed by the knee (83%), ankle (75%), hip (73%), shoulder (67%) and wrist (50%). OA prevalence was higher on the right side of the body for all joints except the hip and ankle.

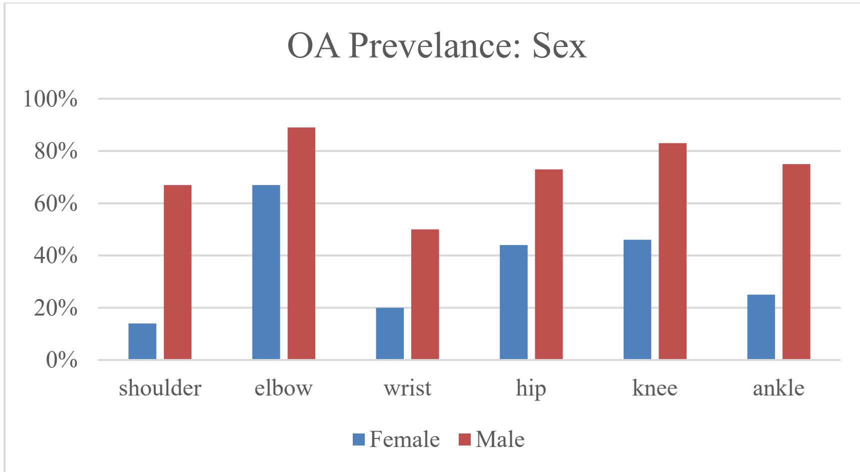

Figure 10: OA frequency distribution presented as the percent of affected articulations surfaces out of observable surfaces

Entheseal Change

To compare the severity of entheseal changes between the sexes, I calculated a mean score for each joint using all observable entheses (Fig. 11). Overall, males had higher EC scores than females, except for the hips. Female scores were highest for the hips (2.6), followed by the elbows (1.7), knees (1.5), shoulders (1.2), and wrists (1). Male EC scores for the elbows and hips were equal (1.9), followed by the knees (1.8), wrists (1.8), and shoulders (1.5).

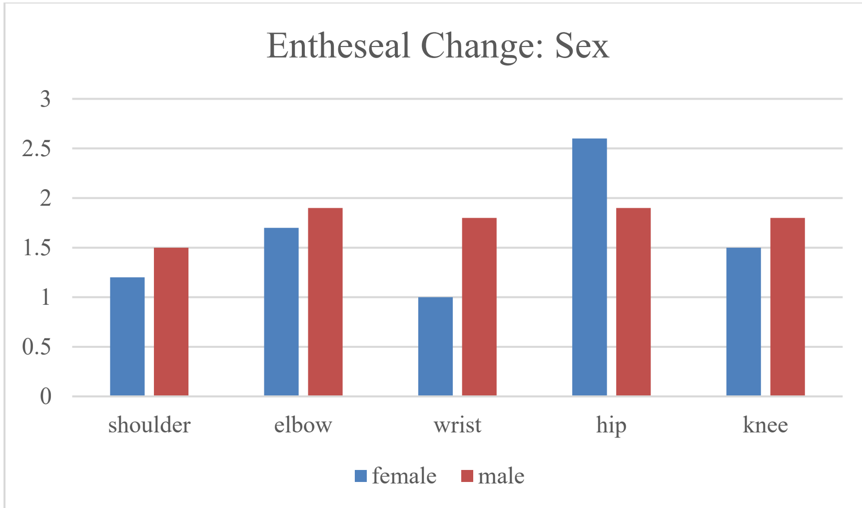

Figure 11: Entheseal change severity presented as the mean score of all observable enthesis sites

4.6 Cross Sectional Strength

On average, males had higher cross section strengths in the upper and lower body. Mean scores for the midsection of the humerus for females was 0.1198, and for males it was 0.1203. Average scores of the mid femur for females was 0.1109, and for males it was .01211. For the tibias, the female mean for the midsection was 0.1267 and for the males it was 0.1308.

4.7 Results by Age

OA

The age categories for this sample are young adult (20-30), middle adult (30-45), and old adult (45+). There were three young adults, three middle adults, and three old adults (Fig. 12). For young adults, the most common joints affected were the elbows (54%) and knees (54%), followed by the hips (44%), ankles (33%), wrists (25%) and shoulders (22%). OA was more prevalent on the right side of the body for all joints except the wrists and ankles. For middle adults, the most common joint affected was the elbow (75%), followed closely by the shoulder (71%), then the hip (60%), knee (50%), ankle (33%), and wrists (20%). For the upper body, OA was most prevalent on the right side, whereas it was symmetrical in the hips and knees. Older adults also had the highest prevalence of OA in the elbows (93%), followed by the hip (71%), knee (70%), wrists (50%), and shoulders (40%). Ankles were eliminated from this analysis as the only preserved articulation surfaces were from one individual.

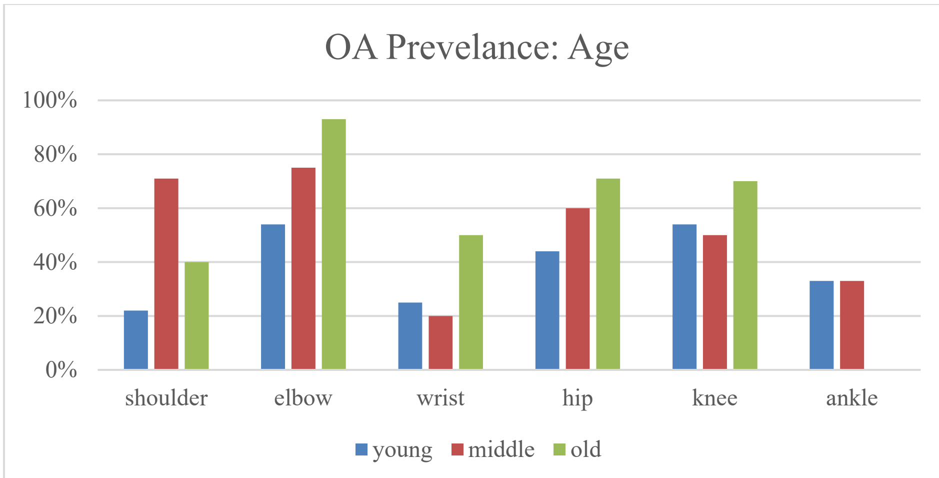

Figure 12: OA prevalence as the percentage of right and left articulation surfaces combined

Entheseal Change

To compare the severity of entheseal changes across the age categories, I calculated a mean score for each joint using each observable enthesis score. There is more variance in the severity of upper body entheseal change compared to the lower body. Young adults had the most severe entheseal changes in their hips (2.5), followed by the elbow (1.56), knee (1.5), shoulder (1.3), and wrists (.5). Mean scores for middle adults were highest in the elbow (2.3), followed by the knees (2), hips (1.9), shoulders (1.7), and wrists (1.1). Old adults had the highest scores for the wrists (2.8), followed by the elbows (2.26), hips (2.26), knees (1.77), and shoulders (1.4).

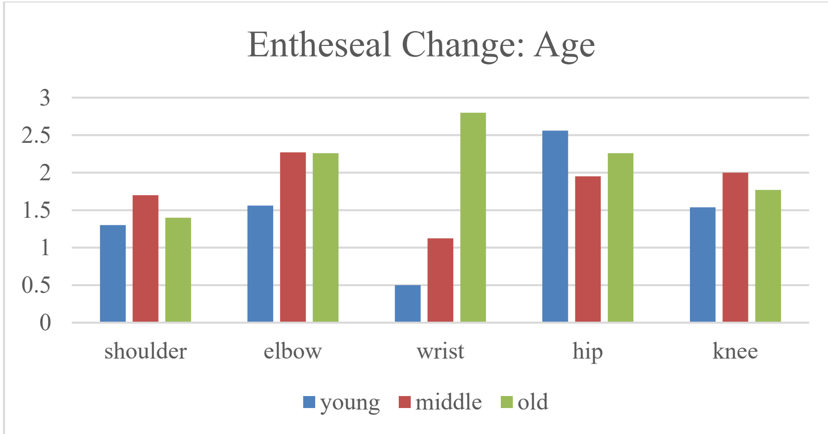

Figure 13: Entheseal change severity presented as the mean score of all observable enthesis sites

Cross Sectional Strength

Old adults had the highest humerus and femur mid-section strengths, whereas young adults had the highest mid-tibia strengths. The average humeral strength for young adults was 0.1198, femur strengths were 0.1157, and tibial strengths were 0.133. Middle adults had mean humeral strengths of 0.1147, femur strengths of 0.1181, and tibial strengths of 0.1265. Older adults had average humeral strengths of 0.1301, femoral strengths of 0.1205, and tibial strengths of 0.1288.

<u>4.8 Results by Burial Group</u>

OA

This sample consists of four individuals from Laguna Taxara, and five individuals from Laguna Pujzara. Osteoarthritis sample distributions by burial group are included in Figure 14. The individuals interred at LGT-1 had the highest OA prevalence in the elbow (83%), followed by the ankle (80%), knee (66%), hip (57%), shoulder (36%), and wrists (36%). The individuals interred at PJ-1 also had the highest frequency of OA in the elbows (75%), followed by the hip (54%), knee (50%), shoulders (50%), and wrists

(33%). The individuals from LGT-1 have a higher prevalence of OA throughout all joints excluding the shoulders.

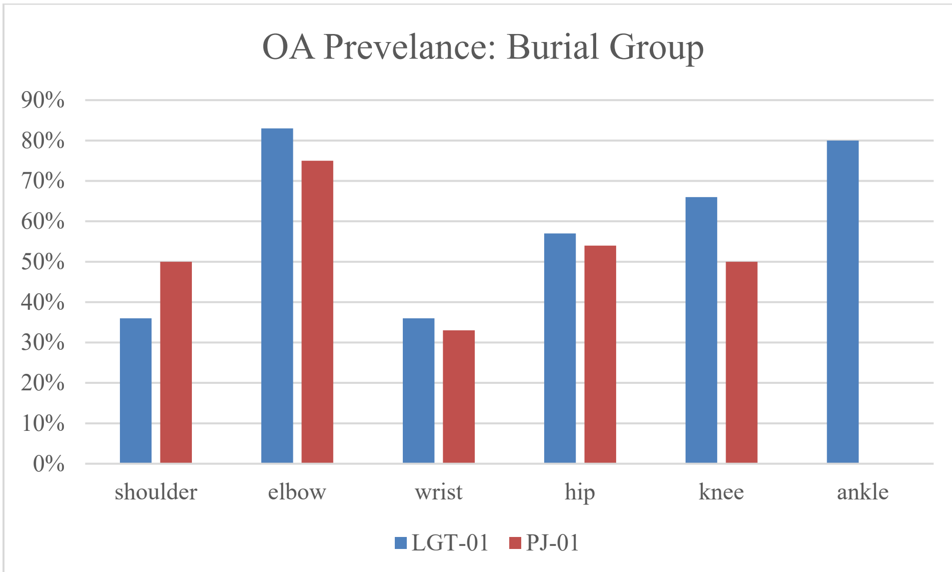

Figure 14: OA prevalence as the percentage of articulation surfaces affected out of articulation sites observable

Entheseal Change

To compare the severity of entheseal changes between the burial groups, I calculated a mean score for each joint using all observable entheses. Overall, those interred at Laguna Pujzara have higher scores for EC. The most severe entheseal changes are present in the elbows (2.4) and hips (2.4), followed by the wrists (2.3), knees (2), and shoulders (1.6). For the individuals from Laguna Taxara, the highest EC scores are present in the hips (2.1), followed by the elbows (1.8), knees (1.5), shoulders (1.5), and wrists (1.2).

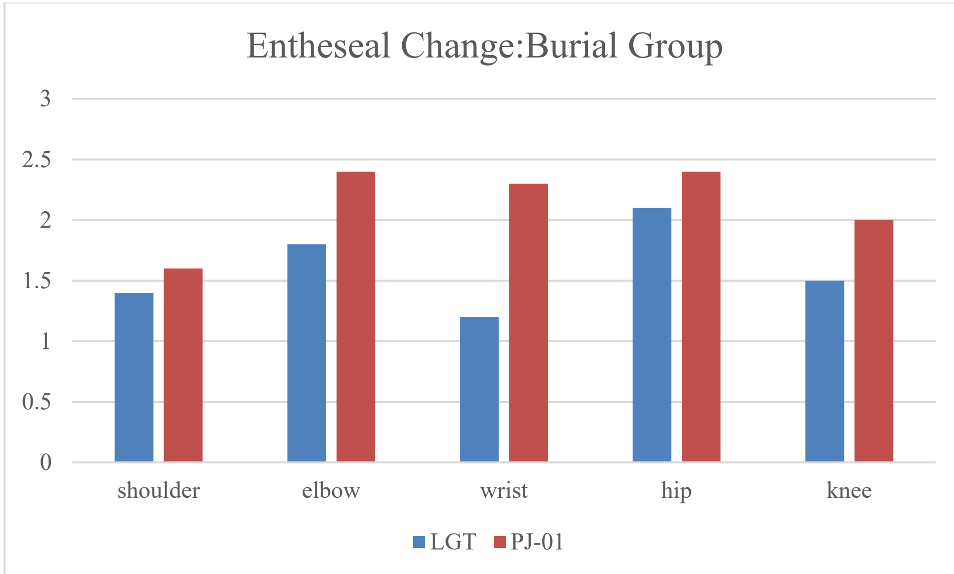

Figure 15: Entheseal scores by burial group

Cross Sectional Strength

The individuals interred at Laguna Pujzara had higher strength values for the tibia and the humerus, whereas the individuals interred at Laguna Taxara had higher strength values for the femur. Individuals interred at LGT-1 had the highest midsection strengths of the tibia (0.1231), followed by the femur (0.1218), and the humerus (0.1142). PJ-1 individuals had higher strength values for the tibia (0.1318), followed by the humerus (0.1252), and the femur (0.1155).

CHAPTER FIVE: DISCUSSION

Over the past few decades, bioarchaeologists have used biomechanical changes to understand and interpret the activities of ancient peoples. Previous research has found that differences between the development of osteoarthritis, entheseal changes, and cross section strength can address generalized patterns and levels of activity, although specific activities cannot be determined (Palmer et al. 2016; Schrader 2019; Villotte et al. 2010). I analyzed the variation of these indicators by comparing mean scores for joints and long bones. The purpose of this study was to investigate whether there were observable differences related to habitual activities between the sexes, across age groups, and between the burial groups associated with each site.

Overall, the individuals in this sample showed the highest rates of osteoarthritis (OA) in the elbows (79%). This is expected as archaeological populations are found to have a higher prevalence of elbow OA than modern populations, and it is interesting because stature and age are suspected to have less effect on the development of elbow OA when compared to other joints (Aufderheide and Rodríguez-Martín 1998; Bridges 1992; Jurmain 1980; Resnick 2002; Waldron 2009). This, accompanied with a high prevalence of elbow entheseal change (EC) (85%), suggests that these individuals habitually participated in activities involving the elbow (strong flexion of the forearm, and supination of the forearm) possibly related to projectile throwing and skin scraping and processing.

Over half the observable articulation surfaces of the hips (15/27) and knees (16/27) for these individuals had evidence of OA. Comparably, there was a high prevalence of EC at the observable insertion sites of the hips (92%) and knees (77%). The examination of these data suggest that these individuals had high rates of terrestrial mobility, consistent with the expected lifestyle of Archaic foragers in the Andes. They were likely subsisting on diverse resources provided by scheduled hunting trips and opportunistic foraging (Capriles 2014). Thus, they were prone to travel long distances across the diverse and rugged landscape as resources became available. Interestingly, only 43% of articulation surfaces for the shoulders presented evidence of OA, whereas 78% of enthesis insertion sites showed evidence of change. This may be explained by a preservation bias wherein the glenohumeral articulation surfaces of the scapula were often less preserved than the humeral head in this sample. Alternatively, it could mean that some of the young and middle adults had not yet succumbed to age-related OA development as it starts after the age of 45, whereas age-related EC begins in the mid-thirties. This would be an interesting avenue for further research in OA/EC correlation.

Cross sectional properties are thought to reflect the strength of long bones, indicative of the intensity and frequency of activities in which the individuals were engaged. The tibiae had the highest strength values for all long bones, further supporting the idea that these individuals participated in high levels of terrestrial mobility, specifically across inclined rugged terrain (Stock 2006). Cross sectional strength values of the humerus were higher for the right side of the body throughout this sample, suggesting a focus on the use and loading of the right arm. While we cannot narrow down the specific activities that these individuals participated in, it is interesting to see how loading strengths differ between certain demographic groups, or how they have changed overtime.

5.1 Evidence for sexual division of labor?

When data was divided by sex, males had a higher prevalence of OA in all joints, and more severe EC scores for all joints except the hips. Entheses observations were converted to mean scores in order to show general patterns of EC across the body, and to find any possible differences between females and males. While the sample size is limited, this analysis showed that there were differences between female and male scores, and these differences were more pronounced in the lower limbs compared to the upper limbs.

Females showed bilateral asymmetry in the upper and lower limbs, whereas males did not. This is possibly due to either sexual differences in logistical mobility, and/or that females may have engaged in a great diversity of tasks compared to males. Evidence from the archaeological record shows that the sexual division of labor in the Andes often increased with social complexity. During the Terminal Archaic Period, many socio-economic changes were taking place for the first time, including the herding and domestication of camelids, demarcating territory, and increasing competition with outside groups (Aldenderfer, 1989, 1990, 2005; Aldenderfer et al., 2008; Craig, 2011). Although there has been less investigation of these factors in Southern Bolivia, it is possible that the herding of camelids could have been adopted to develop and enhance male status competition. This may explain the change in female labor distribution (Aldenderfer et al. 2008).

Male individuals of this sample also had higher cross-sectional strengths in both the upper, and lower limbs. Males are expected to have higher cross-sectional strengths, and more severe entheseal changes due to their genetics and physiology, which is associated with stature and hormones (Bridges, 1995; Maggiano et al. 2008; Ruff and Hayes, 1982; Weiss 2003). This is interesting because the individuals analyzed for this study did not show sexual dimorphism in terms of height approximation, another result of hormonal growth trajectories between males and females, but also a marker of childhood nutritional health. These results suggest that females and males at LGT-1 and PJ-1 may have participated in different habitual activities, but do not show signs of preferential treatment, or unequal access to resources during development. This indicates that while a sexual division of labor may have been nascent during the Terminal Archaic, these roles had not been codified into social structures, nor impacted people in terms of access to resources, although due to the small sample size, further research on this is needed.

5.2 Did age drive activity patterns?

Bioarchaeologists recognize that age is a confounding factor in the development of OA, EC, and cross-sectional strength. Therefore, it is important to look at how age distributions affect the sample population in this research. There was an even distribution of young adults (20-30), middle adults (30-45), and old adults (45+) across the two sites. Old adults had the highest OA prevalence for all joints, except the shoulders. This is not surprising, as individuals get older, they are more susceptible to joint deterioration (Felson et al. 2000; Jurmain et al. 2012; Weiss and Jurmain 2007). However, 71% of the joint articulations in the shoulders of the middle adults showed signs of OA, compared to old adults with 40%, and young adults with 22%. This is interesting because one would expect old adults to have higher OA frequencies throughout. This may indicate a shift in age driven activity patterns from the time the older adults were considered middle adults, to the time they were interred. Additionally, it could be a result of the osteological paradox that addresses selective mortality and hidden heterogeneity as a skeletal sample does not reflect all individuals in a population, only those who died (Wood et al. 1992). However, it has been proposed that OA of the shoulder is typically the result of occupational stress (Aufderheide and Rodríguez-Martín 1998). This combined with the higher severity scores for shoulder EC in middle adults may indicate that they were regularly participating in activities using the upper limbs (climbing, carrying heavy loads, etc.) at a higher frequency than older adults.

In contrast to OA, EC data did not show increasing changes with age. Young adults showed less severity in EC throughout most joints. Interestingly, young adults had higher hip EC scores than middle and older adults, which is not expected as age related EC begins around the mid-thirties (Bard 2003, Rodineau 1991). The muscles that correlate to these entheses insertion points (gluteus medius, gluteus minimus, and iliopsas) are used in the abduction, flexion, and internal and external rotation of the leg at the hip, all of which are associated with walking. Young adults also had higher mid-tibia cross sectional strengths. The tibia is considered the best bone to reconstruct mobility because it is more mechanically optimized when moving along rugged terrain (Stock 2006). Thus, the EC changes of the hip and cross-sectional strength of the tibia for young adults suggest differences in logistical mobility for this demographic group that resulted in particularly well-developed lower limb muscles.

<u>5.3 Are there differences between sites?</u>

The individuals interred at LGT-1 have higher rates of OA in all joints except for the shoulder, whereas those interred at PJ-1 have more severe entheseal changes throughout the entire body, suggesting heavier labor patterns overall. Individuals from

PJ-1 have higher cross-sectional strengths at the mid-tibia indicating a higher frequency of movement across a rugged terrain. This is interesting because both samples come from open-air sites in close proximity to each other, however, LGT-1 is slightly older. Small differences in local ecology and site use are possible causes for differences in the experiences reflected here. Alternatively, we can imagine that this may reflect growing differences in identity or increasing power structures linked to labor. Differences in subsistence strategies could also explain this trend. Shoulder OA has been linked to projectile throwing and hunting, therefore, the individuals interred at LGT-1 may have subsisted by hunting wild camelids whereas those interred at the slightly older site of PJ-1 may have practiced a subsistence strategy involving less physical labor or travel, possibly pointing to the beginnings of camelid domestication which arose independently in different areas throughout the Andes from around 6000 to 4000 BP (Baied and Wheeler 1993; Mengoni-Goñalons 2008; Mengoni-Goñalons and Yacobaccio 2006; Wheeler 1995; Wing 1986) Due to the limited sample sizes, it is currently impossible to test these hypotheses without further archaeological and zooarchaeological information, but they provide a tantalizing question for future research.

5.4 Andean site comparisons

Previous investigations of Archaic and Formative sites on the western slope of the Puna de Atacama show evidence of a cultural transition from highly mobile hunting and foraging groups to large campsites with camelid domestication, the emergence of pottery, and ceremonial architecture (Núñez 1992; Núñez et al 2006; Grosjean et al. 2005). Tambillo-1 is an Early Archaic site characterized by highly mobile groups located in the lowlands with circular structures (Núñez et al. 2002). Towards the end of the site's occupation, population density increased and by the Late Archaic period the Puripica-Tulan tradition from Puripica-1 and Tulan-52 show evidence of a more sedentary lifestyle with increasing diversification of lithics and microliths suggesting increased sociocultural complexity and the beginning of camelid domestication (Núñez et al. 1999; Núñez et al 2006). By the Formative period, large settlements with complex architecture and technologies emerge, evidenced by sites such as Tulan-54 and Tulan-122 (Nunez et al. 2005; 2006). Based on differences in activity, the analysis of individuals from LGT-1 and PJ-1 may show an interesting glimpse into the transition from the Archaic period. These differences in terrestrial mobility and activity patterns, paired with the division of tasks/labor between females and males suggest varied subsistence strategies and lifestyles, adding to the evidence that this was a time of growing sociocultural complexity.

CHAPTER 6: CONCLUSION

By studying how everyday activities are embodied on the skeleton, we can learn about the lifestyles of individuals and populations in the past. Overall, the individuals presented in this study display biomechanical indicators of a mobile lifestyle, with emerging trends of difference between demographic groups. When addressing these differences, these data suggest that: 1) females and males habitually participated in different types/levels of physical activities, 2) activity patterns were driven by age, and 3) those interred at PJ-1 were more mobile than those at LGT-1, although due to the small sample size more research is needed to solidify these hypotheses. By evaluating the degrees of OA, EC, and cross-sectional strength, the habitual workload of these individuals can shed light on the life experiences of Andean foragers during the Archaic period.

Female and male division of labor is a commonly studied phenomenon in anthropology. Generally, it is situated in terms of inequality wherein one sex is offered preferential treatment or access to different types of resources. Preliminarily, it seems that the individuals in this study may have participated in different types and frequencies of activity, but evidence of inequality does not seem to exist. Similarly, age seems to have been a driving factor of habitual activity wherein certain age groups may have performed different tasks. Understanding how populations divided tasks is interesting as it may speak to their socially constructed ideas about age. Site specific differences between similar populations are an interesting avenue to study how local ecology and identity may be embodied in different ways. Although this study was unable to speak to the exact reasons for these differences, it is an interesting start.

This research is of particular importance as it contributes to an area and time period which has been sparsely investigated and has proposed exciting questions and avenues for future research. This is the first systematic bioarchaeological study of foragers in this area, and as we learn more about the Andean Archaic and the transition into the Formative Period, we gain knowledge about how increasing social complexity is embodied on the skeleton, and how everyday activities are interpreted in a larger social system. Future archaeological and bioarchaeological investigations in this area are sure to expand our knowledge of Andean foragers.

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APPENDIX: TABLES AND FIGURES

Enthesis	Insertion (I)/Origin (O)	Function/Action
Supraspinatus	Greater tubercle of humerus (I)	Abduction of arm
Infraspinatus	Greater tubercle of humerus (I)	External rotation of arm
Subscapularis	Lesser tubercle of humerus (I)	Internal rotation of arm
Deltoid	Deltoid tuberosity of humerus (I)	Clavicular origin: flexion and internal rotation of arm Acromion origin: abduction of arm Scapula spine origin: extension and external rotation
Teres minor	Greater tubercle of humerus (I)	External rotation and adduction of arm
Triceps brachii	Olecranon of ulna (I)	Extension of forearm; extension and adduction of arm at shoulder
Brachialis	Coronoid process of ulna; ulnar tuberosity (I)	Strong flexion of forearm
Biceps brachii	Radial tuberosity (I)	Flexion and supination of forearm
Brachioradialis	Proximal to styloid process of radius (I)	Forearm flexion at elbow
Common extensors	Phalanges (I) lateral epicodyle of humerus (O)	Extension of hand at wrist
Common flexors	Phalanges, carpals, and distolateral radius (I)	Flexion of hand at wrist

Table A1: Upper body entheses to be recorded and their function

Enthesis	Insertion (I)/ Origin (O)	Function/Action
Semimembranosus	Medial condyle of tibia	extension and internal rotation of leg at hip; flexion and internal rotation of leg at knee
Biceps femoris	Head of fibula (I) ischial tuberosity and linea aspera (O)	extension and external rotation of leg at hip; leg flexion and external rotation at knee
Gluteus medius	Greater trochanter of femur	abduction and internal rotation of leg at hip
Gluteus minimus	Greater trochanter of femur	Abduction and internal rotation of leg at hip
Iliopsoas	Lesser trochanter of femur	Flexion and external rotation of the leg at the hip; lateral flexion of the trunk at the hip
Quadratus femoris	Femoral neck (I) Ischial tuberosity (O)	External rotation of leg at hip
Gastrocnemius	Calcaneus (I) lateral and medial condyles of femur, popliteal line of femur (O)	Foot plantar flexion and leg flexion at knee
Patellar ligament	Patella and tibial tuberosity	Works with quadratus femoris as a lever for external rotation and adduction of leg at the hip
popliteus	Proximal surface of tibia (posterior) (I) Lateral condyle of femur (O)	Unlocks knee

Table A2: Lower body entheses to be recorded and their function

Table A3: OA scores for LGT-1-ENT1

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	0	0	0	-	-	-
	Prox. Humerus	0	1	0	1	2	0
Elbow	Dist. Humerus	1	3	0	-	-	-
	Proximal ulna	1	2	0	1	1	2
	Prox. Radius	0	1	0	0	2	2
Wrist	Dist. Ulna	-	-	-	0	2	0
	Dist. Radius	1	1	0	0	0	0
Hip	Acetabulum	1	1	0	2	2	0
	Prox. Femur	0	2	0	1	2	0
Knee	Dist. Femur	0	0	0	1	2	0
	Patellar surface	-	-	-	-	-	-
	Prox. Tibia	0	0	0	0	0	0
Ankle	Dist. Tibia	1	1	0	0	1	0

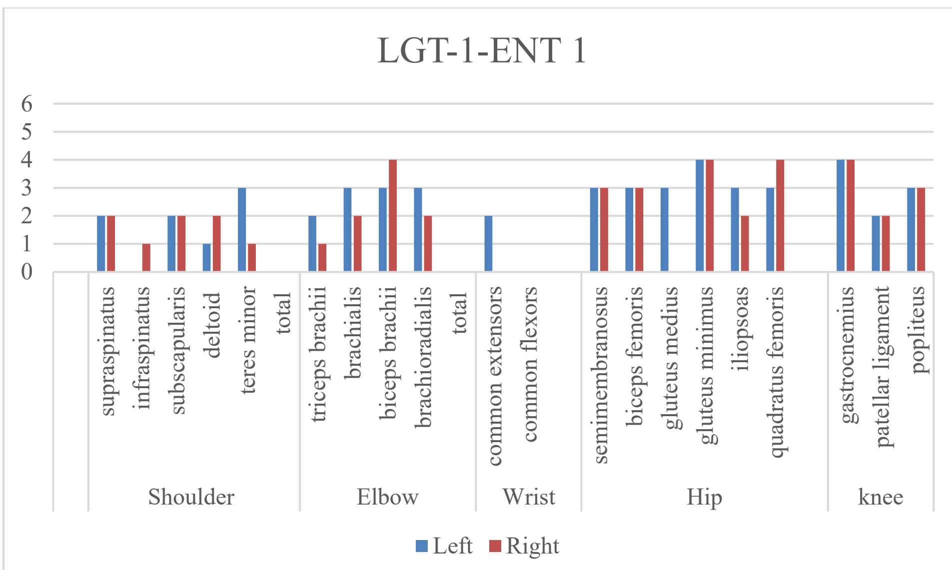

Figure A4: Entheseal change scores for LGT-ENT 1

Table A5: OA scores for LGT-1-ENT 2

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	-	-	-	-	-	-
	Prox. Humerus	2	3	0	-	-	-
Elbow	Dist. Humerus	2	3	0	2	3	0
	Proximal ulna	1	2	0	2	3	0
	Prox. Radius	1	3	0	1	3	0
Wrist	Dist. Ulna	0	2	0	1	3	0
	Dist. Radius	1	3	0	1	2	0
Hip	Acetabulum	2	3	0	1	3	0
	Prox. Femur	2	3	0	1	3	0
Knee	Dist. Femur	1	3	0	1	1	0
	Patellar surface	1	1	0	-	-	-
	Prox. Tibia	0	3	0	1	3	0
Ankle	Dist. Tibia	1	2	0	2	2	0

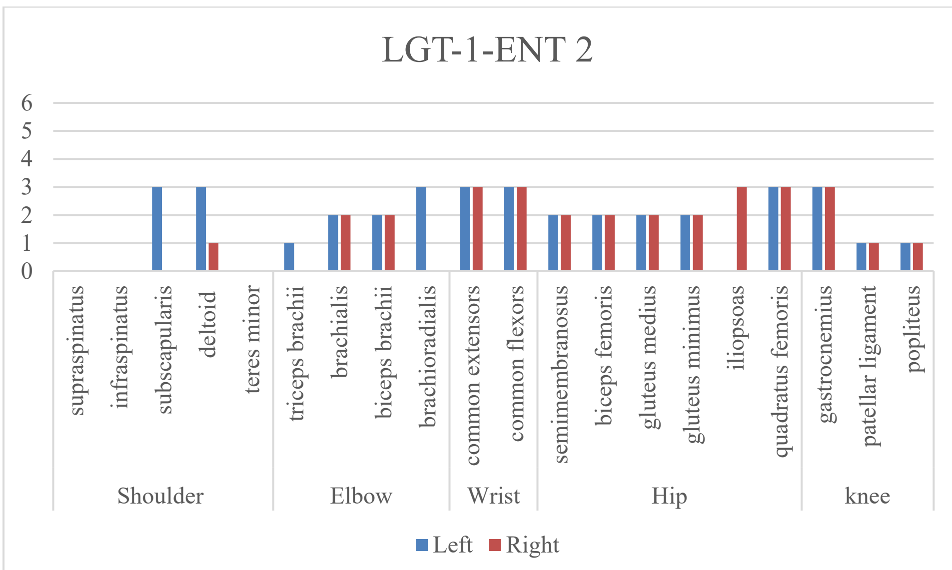

Figure A6: Entheseal change scores for LGT-1-ENT 2

Table A7: OA scores for LGT-1-ENT 3

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	0	0	0	0	1	0
	Prox. Humerus	0	3	0	0	1	0
Elbow	Dist. Humerus	2	3	0	1	1	0
	Proximal ulna	-	-	-	-	-	-
	Prox. Radius	0	1	0	0	1	0
Wrist	Dist. Ulna	-	-	-	-	-	-
	Dist. Radius	-	-	-	0	1	0
Hip	Acetabulum	-	-	-	-	-	-
	Prox. Femur	0	0	0	0	0	0
Knee	Dist. Femur	1	2	0	1	1	0
	Patellar surface	1	1	0	1	1	0
	Prox. Tibia	1	1	0	1	1	0
Ankle	Dist. Tibia	-	-	-	-	-	-

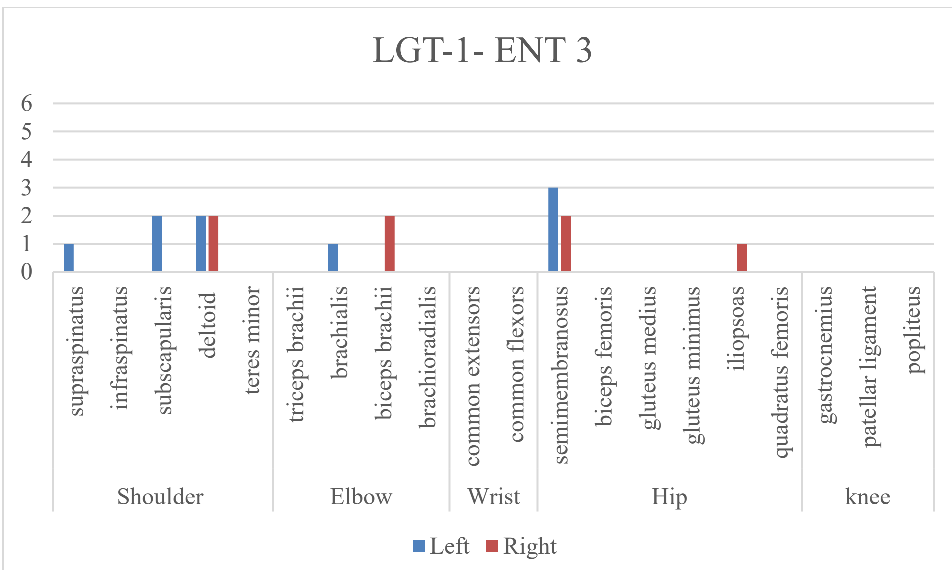

Figure A8: Entheseal change scores for LGT-1-ENT 3

Table A9: OA scores for LGT-1-ENT 4

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	1	1	0	0	1	0
	Prox. Humerus	-	-	-	1	2	0
Elbow	Dist. Humerus	-	-	-	1	1	0
	Proximal ulna	-	-	-	-	-	-
	Prox. Radius	1	1	0	1	2	0
Wrist	Dist. Ulna	0	1	0	-	-	-
	Dist. Radius	0	1	0	0	1	0
Hip	Acetabulum	1	1	0	0	1	0
	Prox. Femur	-	1	-	0	3	0
Knee	Dist. Femur	-	-	-	-	-	-
	Patellar surface	-	-	-	-	-	-
	Prox. Tibia	-	-	-	-	-	-
Ankle	Dist. Tibia	-	-	-	1	1	0

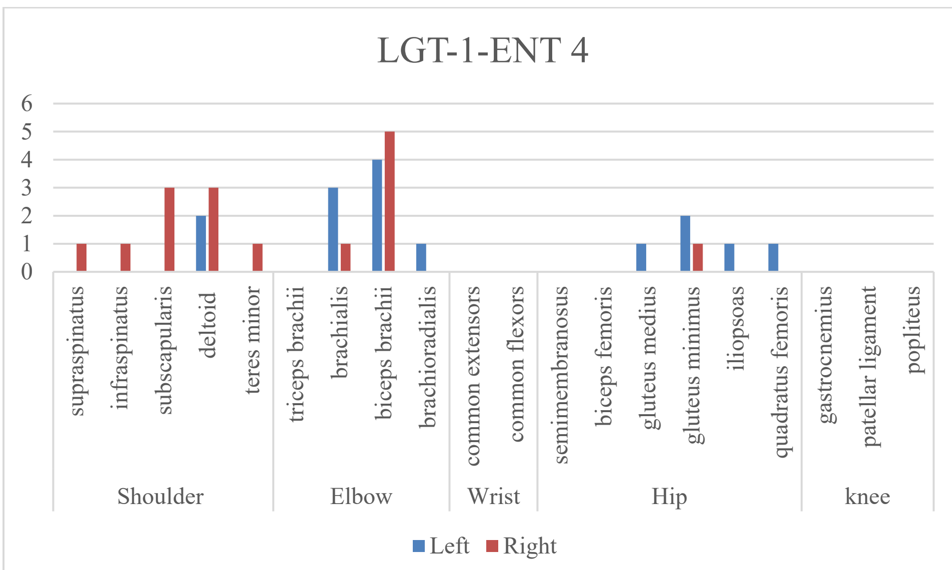

Figure A10: Entheseal change scores for LGT-1-ENT 4

Table A11: OA scores for PJ-1 ENT 1

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	1	1	0	-	-	-
	Prox. Humerus	0	2	0	-	-	-
Elbow	Dist. Humerus	2	1	0	1	2	0
	Proximal ulna	3	3	0	2	3	0
	Prox. Radius	1	1	0	2	1	0
Wrist	Dist. Ulna	-	-	-	0	1	0
	Dist. Radius	-	-	-	1	2	0
Hip	Acetabulum	-	-	-	-	-	-
	Prox. Femur	1	2	0	-	-	-
Knee	Dist. Femur	2	1	0	-	-	-
	Patellar surface	-	-	-	2	2	0
	Prox. Tibia	2	3	0	-	-	-
Ankle	Dist. Tibia	-	-	-	-	-	-

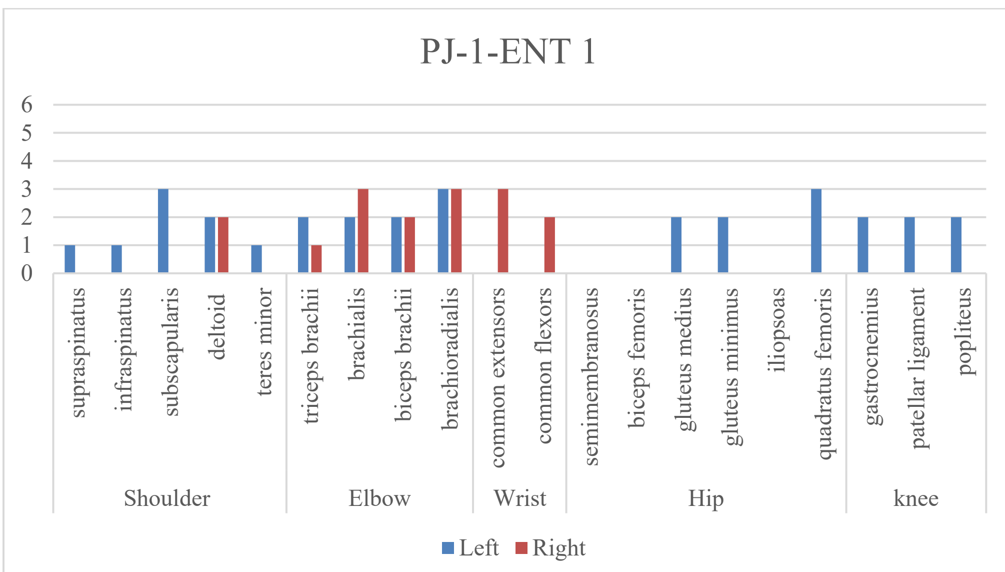

Figure A12: Entheseal change scores for PJ-1-ENT 1

Table A13: OA scores for PJ-1-ENT 2

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	-	-	-	-	-	-
	Prox. Humerus	-	-	-	-	-	-
Elbow	Dist. Humerus	1	1	0	-	-	-
	Proximal ulna	2	0	0	-	-	-
	Prox. Radius	2	1	0	-	-	-
Wrist	Dist. Ulna	0	1	0	-	-	-
	Dist. Radius	0	1	0	-	-	-
Hip	Acetabulum	1	0	0	-	-	-
	Prox. Femur	0	2	0	-	-	-
Knee	Dist. Femur	0	0	0	-	-	-
	Patellar surface	0	0	0	-	-	-
	Prox. Tibia	-	-	-	-	-	-
Ankle	Dist. Tibia	-	-	-	-	-	-

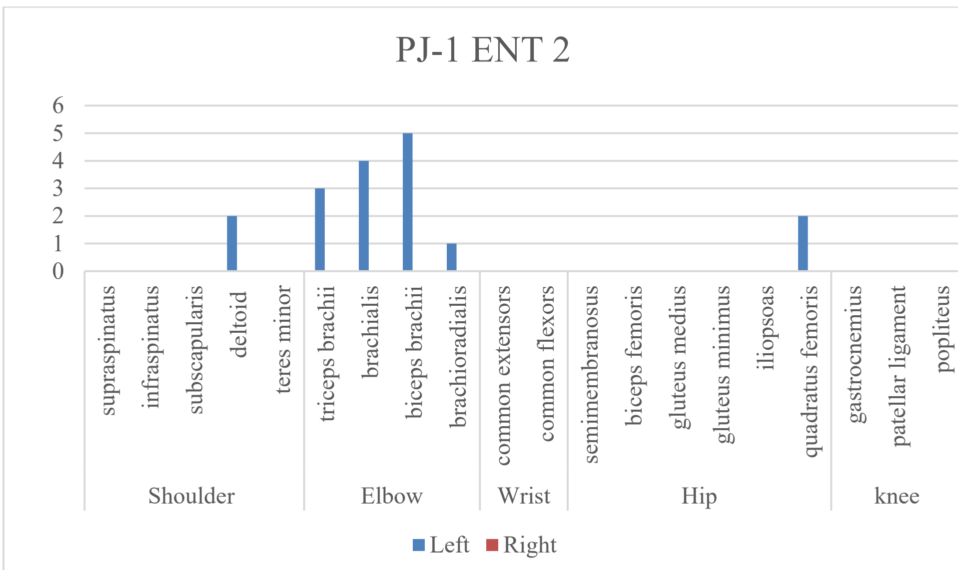

Figure A14: Entheseal Change scores for PJ-1-ENT 2

Table A15: OA scores for PJ-1-ENT 3

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	0	0	0	2	1	0
	Prox. Humerus	2	3	0	1	3	0
Elbow	Dist. Humerus	-	-	-	2	3	0
	Proximal ulna	-	-	-	1	1	0
	Prox. Radius	-	-	-	-	-	-
Wrist	Dist. Ulna	-	-	-	2	1	0
	Dist. Radius	-	-	-	-	-	-
Hip	Acetabulum	2	3	0	2	3	0
	Prox. Femur	1	1	0	1	1	0
Knee	Dist. Femur	1	1	0	1	1	0
	Patellar surface	-	-	-	-	-	-
	Prox. Tibia	1	3	0	-	-	-
Ankle	Dist. Tibia	-	-	-	-	-	-

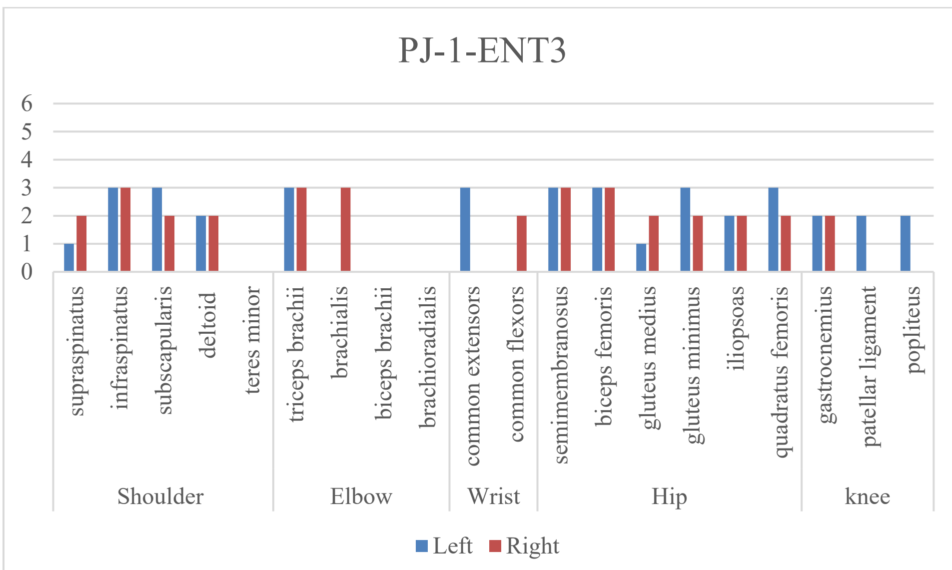

Figure A16: Entheseal Change scores for PJ-1- ENT 3

Table A17: OA scores for PJ-1-ENT 4

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	-	-	-	-	-	-
	Prox. Humerus	-	-	-	-	-	-
Elbow	Dist. Humerus	1	0	2	0	1	0
	Proximal ulna	1	1	0	-	-	-
	Prox. Radius	-	-	-	-	-	-
Wrist	Dist. Ulna	-	-	-	-	-	-
	Dist. Radius	-	-	-	0	1	0
Hip	Acetabulum	0	1	0	-	-	-
	Prox. Femur	1	0	0	1	0	2
Knee	Dist. Femur	1	0	0	-	-	-
	Patellar surface	-	-	-	1	0	0
	Prox. Tibia	0	1	0	-	-	-
Ankle	Dist. Tibia	0	0	0	0	0	0

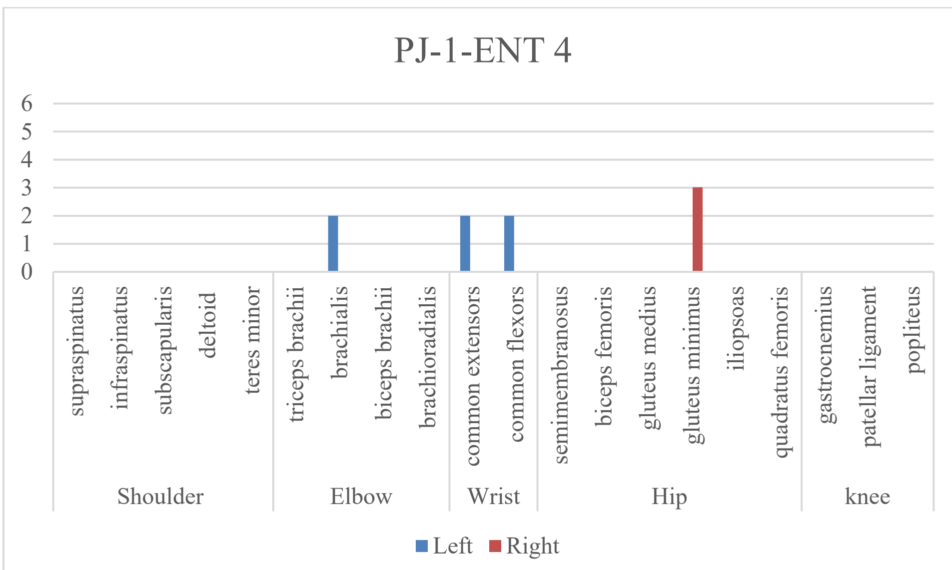

Figure A18: Entheseal change scores for PJ-1-ENT 4

Table A19: OA scores for PJ-1-ENT 5

		Left			Right		
		L	P	E	L	P	E
Shoulder	glenoid fossa	-	-	-	-	-	-
	Prox. Humerus	1	0	0	1	1	0
Elbow	Dist. Humerus	-	-	-	1	0	0
	Proximal ulna	1	0	0	-	-	-
	Prox. Radius	-	-	-	-	-	-
Wrist	Dist. Ulna	-	-	-	-	-	-
	Dist. Radius	-	-	-	-	-	-
Hip	Acetabulum	2	0	0	1	1	0
	Prox. Femur	0	0	0	-	-	-
Knee	Dist. Femur	0	0	0	-	-	-
	Patellar surface	-	-	-	-	-	-
	Prox. Tibia	-	-	-	-	-	-
Ankle	Dist. Tibia	-	-	-	1	0	0

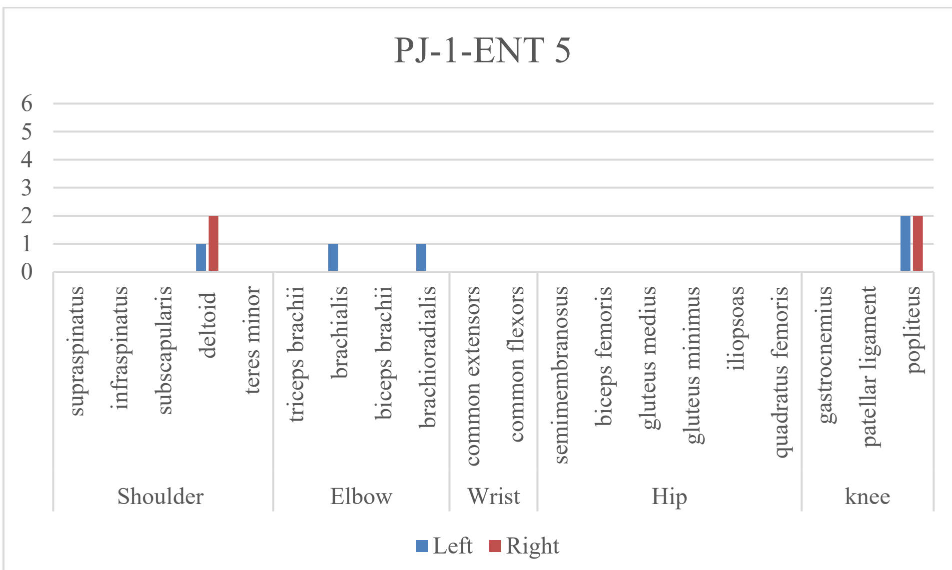

Figure A20: Entheseal change scores for PJ-1-ENT 5

Table 20A: Cross-section strength values

	Mid humerus		Mid Femur		Mid Tibia	
	L	R	L	R	L	R
PJ E1	0.12297	.	0.1238	.	.	0.13142
PJ E2	0.13636	.	0.12064	.	.	.
PJ E3	0.10266	0.09464	0.11471	0.11511	0.13012	.
PJ E4	.	.	.	.	0.10777	.
PJ E5	.	.	0.13475	.	.	.
LGT E1	0.11333	0.11	0.10256	0.115	0.13142	0.13264
LGT E2	0.12226	0.1389	0.11493	0.12276	.127102	0.12801
LGT E3	0.12508	0.13066	0.10749	.11850	0.13498	.
LGT E4	0.12367	0.13782	0.12494	0.11794	0.1381	0.13